Journal of Tropical Environment

2025
December
Volume 5 Issue I & II

Edited and published by
Department of Environmental Management
Faculty of Social Sciences and Humanities
Rajarata University of Sri Lanka

Journal of Tropical Environment

Department of Environmental Management
Faculty of Social Sciences and Humanities,
Rajarata University of Sri Lanka, Mihintale

Journal of Tropical Environment

The Refereed Journal of the Department of Environmental Management,
Rajarata University of Sri Lanka
Volume 5 Issue I and II,2025

ISSN 2950-6808

Published by the Department of Environmental Management,
Faculty of Social Sciences & Humanities
Rajarata University of Sri Lanka

All communications should be addressed to:
The Editor in Chief, The Journal of Tropical Environment
Department of Environmental Management, Faculty of Social Sciences & Humanities,
Rajarata University of Sri Lanka, Mihintale

Tel/Fax: 0252266268

Email: doem@ssh.rjt.ac.lk

Journal of Tropical Environment

Department of Environmental Management Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka, Mihintale

Volume 5, Issue I and II, December 2025

Journal of Tropical Environment

Department of Environmental Management Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka, Mihintale.

Volume 5, Issue I and II, December 2025

Editorial Note - Journal of Tropical Environment

I am pleased to present Volume 5, Issue I and II of the *Journal of Tropical Environment*, a biannual publication dedicated to advancing scholarly discourse on environmental management, particularly within tropical ecosystems. The journal embraces an interdisciplinary approach, drawing from natural sciences, social sciences, management, and philosophy to address the pressing environmental challenges of our time. Our focus remains on research that engages with the complexities of managing tropical environments, encouraging innovative perspectives that span traditional academic boundaries. This issue showcases a diverse range of articles that have undergone a rigorous double-blind peer review process, ensuring the highest standards of scholarly integrity.

I extend my heartfelt gratitude to the authors, reviewers, and editorial board members, whose expertise and commitment have been crucial to the success of this journal. Their contributions have ensured that the *Journal of Tropical Environment* continues to be a valuable resource for researchers and practitioners alike. I hope this issue will inspire meaningful dialogue and inform sustainable development initiatives across both public and private sectors.

Prof. DMSLB Dissanayake - Editor in Chief
Journal of Tropical Environment- Volume 5 Issue I and II 2025

Contents

ARTICLES

JOURNAL OF TROPICAL ENVIRONMENT
Vol. 5, Issue i and ii, (December) 2025

Department of Environmental Management
Faculty of Social Sciences & Humanities
Rajarata University of
Sri Lanka

A Bibliometric Analysis of Evolution Trends in Air Pollution Researches (1964 - 2024)

Harischandra D.M.G.K.U.*

Department of Environmental Managemen[1],
Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka
* udayangiharischandra@gmail.com

Abstract

Clean air is essential for the health and well-being of all living things. But today, air pollution is a pressing global problem, posing significant risks to health and ecosystems worldwide. The overall objective is to examine the evolution and trends of research on air pollution from 1964 to 2024. Specific objectives are to assess the growth and distribution of air pollution research over time, to identify the most effective authors, institutions and countries of air pollution research, and to identify emerging trends in air pollution research as well as key research areas. 12300 articles were selected for analysis using the SCOPUS database. A comprehensive bibliometric analysis was conducted using the R Biblioshiny. The results show a steady increase in publications. It reflects the growing recognition of air pollution as a critical problem, especially after 2019. China, the USA, and India are the leading contributors. High international co-authorship rates emphasize collaborative research. This analysis indicates that air pollution and air quality are central themes for future research. This study provides valuable insights into the state of air pollution research while guiding future efforts to address these global challenges and protect environmental sustainability.

.

Key Words: Air pollution; Bibliometric analysis; Research Trends; Scopus; R biblioshiny

1. Introduction

Clean air is essential for the health and well-being of all living organisms, including humans, animals and plants. Good air quality supports ecosystems, preserves biodiversity, and maintains the balance of the environment. Air pollution is a pervasive environmental issue affecting countries worldwide.

A substance in the air that can be adverse to humans and the environment is known as an air pollutant. Pollutants can be in the form of solid particles, liquid droplets, or gases (Sierra-Vargas & Teran, 2012). Criteria and toxic air pollutants represent two classes of air pollutants with diverse chemical and physical properties. Criteria pollutants, as designated under the Clean Air Act of 1971, include pollutants that are ubiquitous in the United States and are known or strongly suspected to be harmful to public health and the environment (Suh et al., 2000.).Currently, six pollutants are designated as criteria pollutants: particles with aerodynamic diameters under Particulate Matter 10 and Particulate Matter 2.5, Ozone, Sulfur Dioxide, Nitrogen Dioxide, Carbon Monoxide, and Lead. For each of these pollutants, a primary health-based National Ambient Air Quality Standard (NAAQS) under the Clean Air Act has been established, which sets the "safe" amount of the pollutant that can be present in the air (Suh et al., 2000.)

Natural events that pollute the air include forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds and natural radioactivity (Sierra-Vargas & Teran, 2012).Moreover large increases in population, causing loss of forest and advancement of modern technology have resulted in the air pollution problem in recent years (Rahman et al., 2024).Industrial Activities such as Manufacturing, Energy production, Mining, and Construction are major manmade causes of Air Pollution. Especially in urban areas, Transportation, Inadequate waste management practices, and Residential heating and cooking practices are significant sources of air pollution. Also, some agricultural practices like the use chemical, Livestock farming release, Crop residue burning release harmful pollutants to the air.

Many recent studies have indicated some negative impacts of air quality. Air pollution is a significant risk factor for multiple health conditions including respiratory infections, heart disease, and lung cancer, according to the WHO (Sierra-Vargas & Teran, 2012). According to the global estimates by the United Nations Environment Programme (UNEP), a lot of persons amounting to over one billion breathe unhealthy air (Obiefuna et al., 2021). Poisonous air pollutants (toxic chemicals in the air) can form acid rain. It can also form dangerous ground - level ozone. These destroy trees, crops, farms, animals and continue to make water bodies harmful to humans and animals that live and depend on water (Sierra-Vargas & Teran, 2012). Air pollution reduces agricultural crop and commercial forest yields

by billions of moneys each year. This in addition to people staying off work for health reasons can costs the economy greatly (Sierra-Vargas & Teran, 2012).

Bibliometric analysis, a well-established research method in information and library science, has been commonly used for revealing research outputs (Sun et al., 2020). Bibliometric analyzes are important tools to evaluate and quantify the growth of literature for a particular subject. The bibliometric method has been used in different contexts to investigate data showing increases in the number of publications and identification of the main authors, research institutions, and countries (Sun et al., 2020).

In this study, we retrieved 60 years of relevant papers from the main bibliographic database. We analyzed them from the point of view of literary expression. This will help researchers in this field identify areas of research that can be focused on for the future. Bibliometrics is a useful method to explore the most impactful authors, countries/regions, construct collaboration networks, and identify research key topics in particular areas. In the present study, it is possible to identify the evolution of global research production on air pollution, to identify the core sources of this field, to identify the contribution and cooperation of each country and authors, and to explore future hot topics and developments in this field.
The general objective of this study is to conduct a comprehensive bibliometric analysis to examine the evolution and trends in air pollution Research.

The specific objectives of this study are:

a. To assess the growth and distribution of air pollution research publications over time.
b. To determine the most prolific authors, institutions and countries in air pollution research.
c. To identify the main research areas emerging trends within air pollution research.

2. Materials and Methods

In this study, Bibliometric Analysis focuses on the evolution and trends of air pollution research. This contributes to a comprehensive literature review. This bibliometric literature review uses a systematic and explicit methodology proposed by Garza-Reyes (2015). Scopus is the largest comprehensive information resource in the world. In this paper, we used the Scopus core set as the data source.

This literature search was done in the time frame from 1964 to 2024 and the keywords "Air" AND "Pollution" AND "Trends" have been used. As noted by Goodman and Deis (2005), the Scopus database was chosen as the platform for searching due to its relationship with Elsevier as one of the world's leading publishers. An initial search was conducted by entering the keywords "Air" AND "Pollution" AND "Trends" into the Scopus web interface. A total of 12300 articles were identified as a result of this search criteria. The results were saved in ".csv" format to get essential information from these articles. This csv

format includes crucial information like Paper title, Author names, sources, Year, DOI, Abstract, Author keywords etc. Different types of Documents such as Articles, Books, Book chapters, Conference papers, Conference reviews were considered for Analysis. This csv file will then be used for later stages of data analysis, enabling a more detailed examination of the content and characteristics of the articles in relation to the evolution and trends of air pollution research. In this study, bibliometric networks were visualized using R Biblioshiny software.

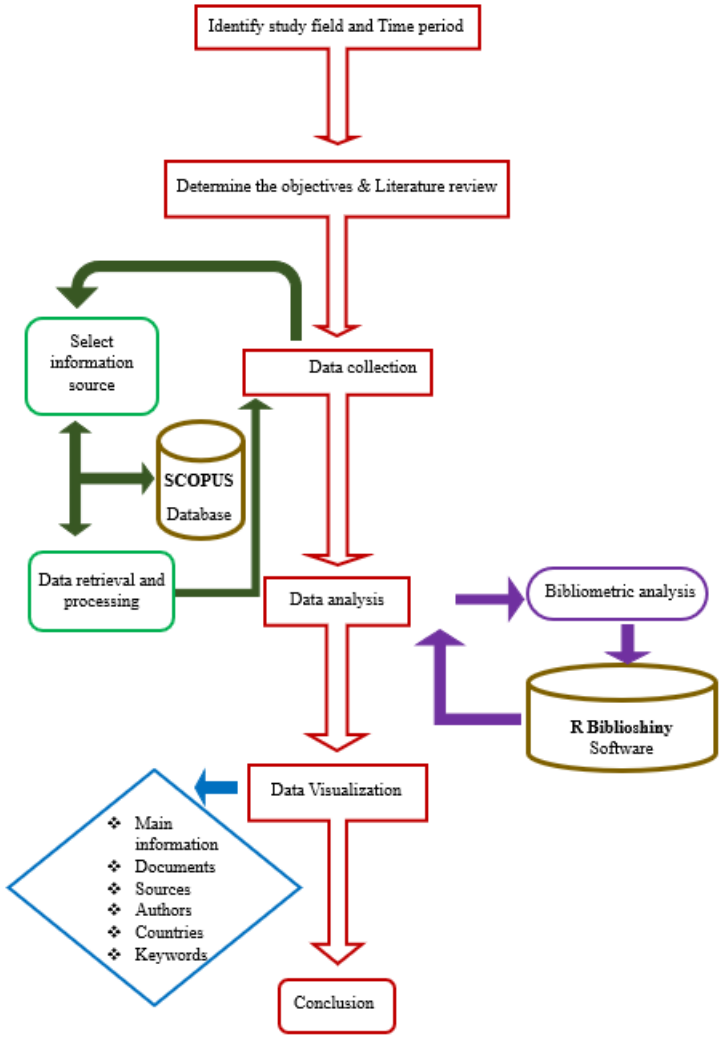

Figure 1: Flow chart of this study

3. Results

The section shows the main results found in our bibliometric analysis of the articles found in the Scopus databases - which identify the evolution and trends in air pollution research.

3.1. Main information

In figure 2, The steady increase in the number of documents and the high annual growth rate of 8.29% highlight the growing recognition of air pollution as a critical area of study. Expanding research institutes indicate greater awareness and importance of addressing air pollution problems.

Figure 2: Main information

The high average number of co-authors per paper (4.22) and the significant percentage of international co-authorship (13.56%) reflect the collaborative nature of air pollution research. This collaboration is essential to finding solutions to global environmental challenges and sharing knowledge across borders. With 550 Sources and 3584 Unique Keywords, research on air pollution is diverse and multifaceted, covering various aspects from health effects to mitigation strategies. The large number of references (49,694) indicates that the field is building on a substantial base of existing knowledge. Relying on recent studies, the average document age suggests 8.68 years. It is very important for such a rapidly developing field of research.

3.2. Evolution of Air Pollution Research

Figure 3 below shows the evolution in Global Research publications from year 1964 to 2024. The minimum publication activity was seen from 1964 to 1970 and most years saw less than 5 articles. 1989 (13 Articles), 1994 (13 Articles), and the number of publications began to increase slightly, with a significant peak in 1998 (23 articles). It remained stable from 2000 to 2010. There has been a significant increase in annual production since 2011 (Articles 35). By 2019, the annual production will reach 37 articles. From 2020, the growth

rate picked up rapidly. 51 Articles in 2020, 68 Articles in 2021, 106 Articles in 2022, 211 Articles in 2023 and 475 Articles in 2023. Research on Air pollution grows at a much faster rate, especially after the year 2019. Detailed annual data and graphs clearly show a significant increase in air pollution figures over the past decade. This trend emphasizes that air pollution is increasing as a critical environmental and public health problem.

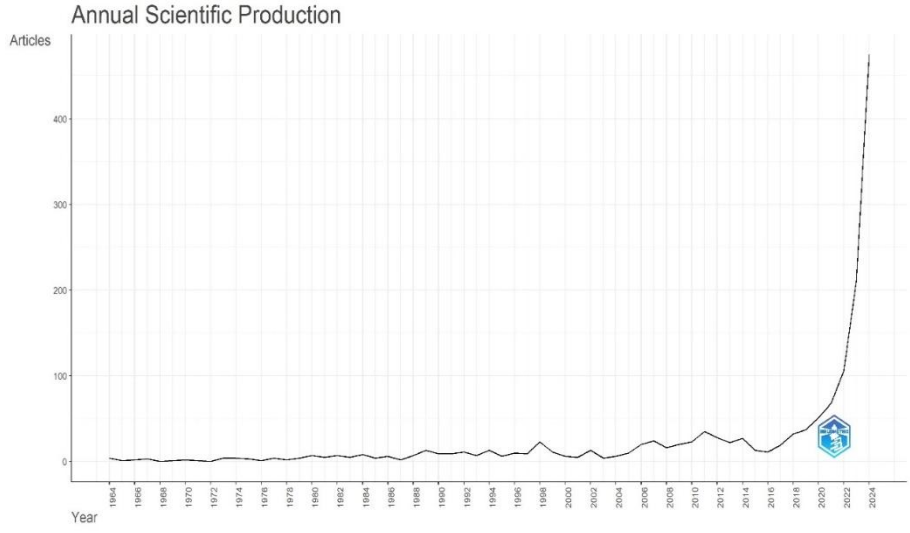

Figure 3: Annual Scientific Production

3.3. Analysis of Core Sources

A total of 550 scholarly sources have published articles regarding the research on evolution and trends of Air pollution. According to the Bradford law, Literature on a topic is often concentrated in Core sources. The top 20 sources are presented in figure 4.

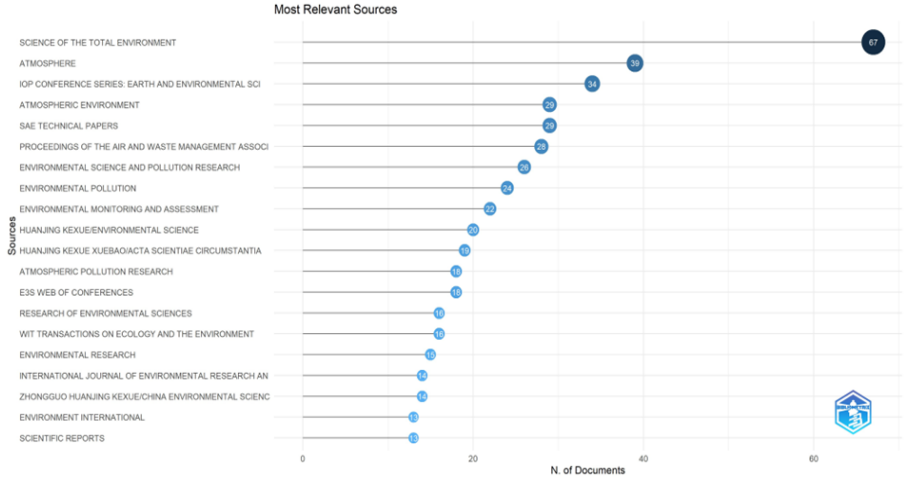

Figure 4: More relevant sources

The top 20 sources contributed 474 articles. Science of the Total Environment published the highest number of articles (67 articles), indicating its significance in the field. Also, Atmosphere (39 articles) is another key journal focusing specifically on Atmospheric Sciences. Sources and conferences with fewer articles like Environmental Research Letters (8 articles), Ecotoxicology and Environmental Safety (7 articles), Aerosol and Air Quality Research (6 articles) indicate more specialized or emerging areas of research within air pollution.

3.4. Most relevant affiliations

Research universities were the mainstay of knowledge innovation in terms of affiliations; the institution most frequently associated with the published documents is the "Nanjing university of information science and technology" with a total of 65 Articles and also "Peking university" published 65 Articles. Also "Nankai University" published 58 Articles. These three research institutions have achieved the most outstanding performance in publication's impact. The top 15 affiliations are presented in figure 5.

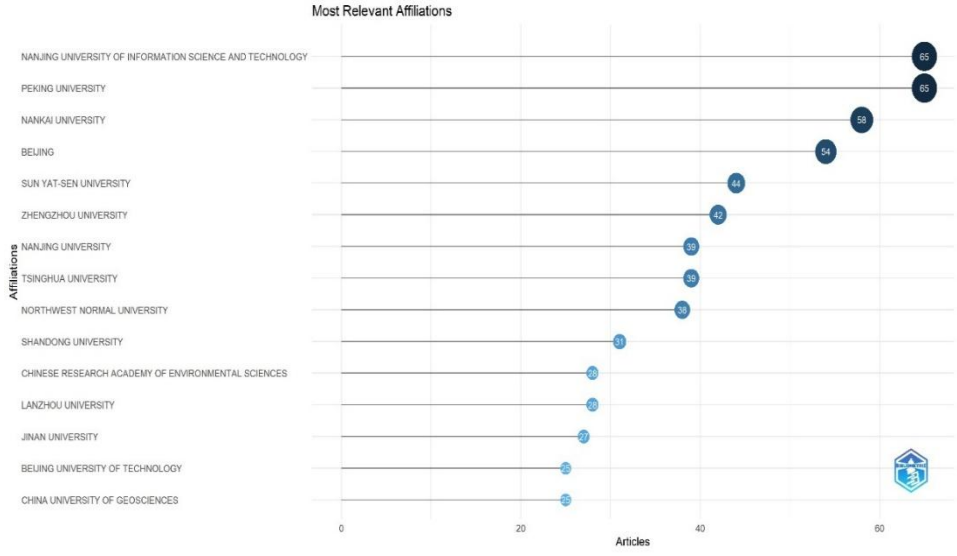

Figure 5: Most relevant affiliations

Figure 6 has been pointed out the overtime production of affiliations which mainly influenced this research field. Nanjing university of information science and technology started slowly in 2017 and reached a maximum of 65 articles by 2024. Peking university has shown a sharp increase from 2 publications in 2022 to 65 articles by 2024. Nankai University's research output will rise sharply from 7 publications in 2022 to 58 Articles by 2024. A rapid growth was observed in its three years. Starting with 5 publications in Beijing, the research output shows an intensive research output of 54 Articles in 2024. Research output will start with 7 publications in 2022 and increase to 44 Articles in 2024,

indicating successful research initiatives from recent efforts. There is a striking pattern of research output peaking in 2024 for most institutions.

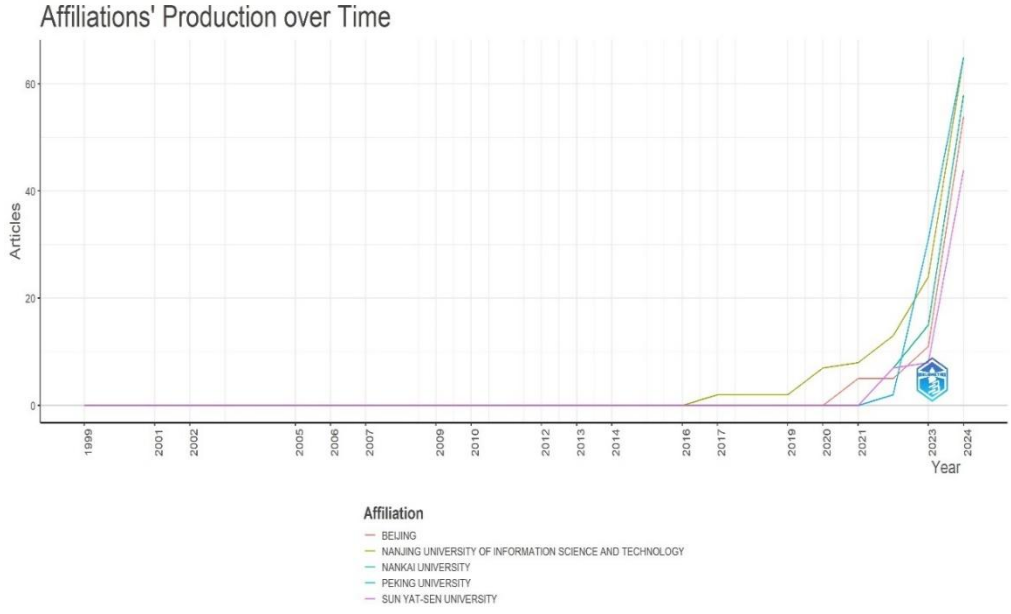

Figure 6: Affiliations' production over time

3.5. Country Performance

Air pollution has attracted the attention of researchers globally.

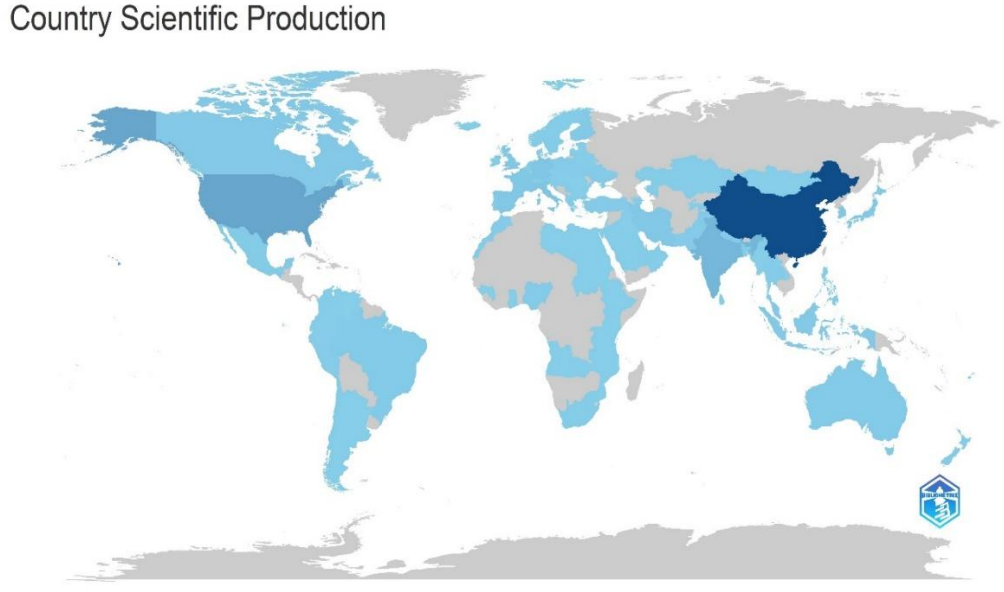

Figure 7: Highest number of publication's countries

Figure 7 above illustrates the countries that have contributed to air pollution publications. According to the analysis of the relevant countries, the three countries with the highest number of papers on Air pollution in the Scopus database are China (2544), USA (749), India (416). China is far ahead of other countries in terms of the number of documents published, which partly reflects the fact that China is more active in the field of air pollution than other countries. Only the top 5 countries are considered in the figure 8. It represents the country's production over time.

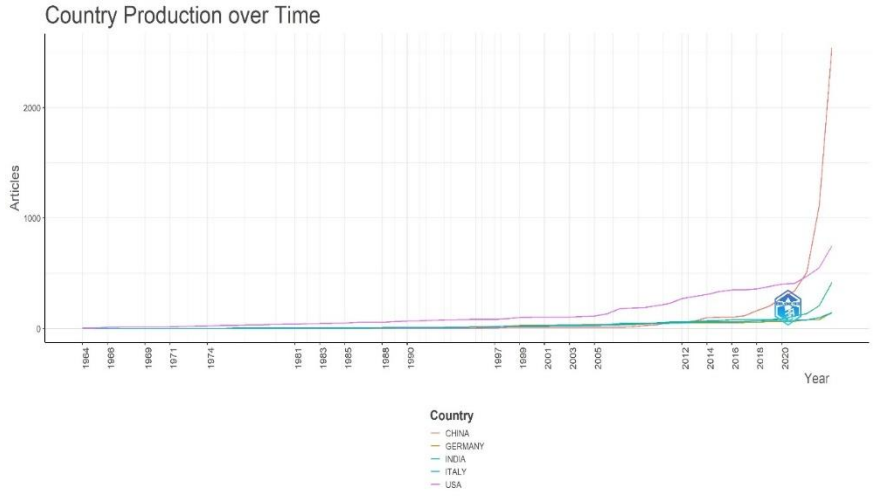

Figure 8: Country production over time

The culmination of 2544 articles highlight China's significant and increasing commitment to air pollution research driven by rapid industrialization and urbanization. In recent years (2022-2024) due to increasing environmental problems, USA has been paying a lot of attention to research on air pollution. Articles production in India has been low for several decades, but there has been a significant increase from the early 2000s to 416 Articles by 2024. Italy (144 Articles) shows a slow but steady increase with Germany (143 Articles).

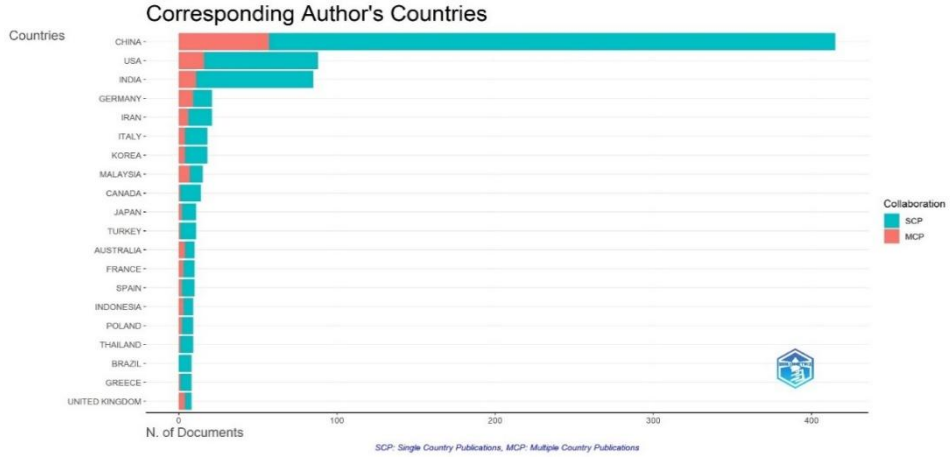

Figure 9. Corresponding Author's countries

Country co-authorship analysis was carried out to determine collaboration among the countries on air pollution. Examining Figure 9, which considers the corresponding authors, if becomes evident that China occupies primary position, followed by USA and India in 2nd and 3rd places. This phenomenon, where authors from the same country collaborate more frequently with each other than authors from other countries, is known as Single Country Publication (SCP), as opposed to Multiple Country Publication (MCP). This observation underscores the importance of intra- Country Collaboration in the context of Evolution and Trends of "Air Pollution Research".

3.6. Contributions by Authors

Several authors have contributed to the publications on evolution and Trends of Air pollution research. In Figure 10, the 10 most prolific Authors within the articles related to the key theme. The blue dots represent the number of publications by each author. Larger circles indicating Greater number of publications. Color density signifies the number of Citations and increased Color intensity corresponds to a higher number of citations.

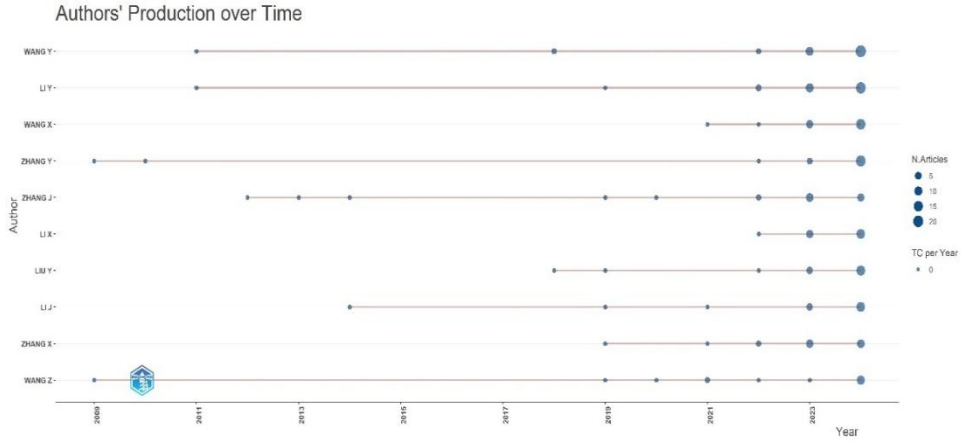

Figure 10. Author's production overtime

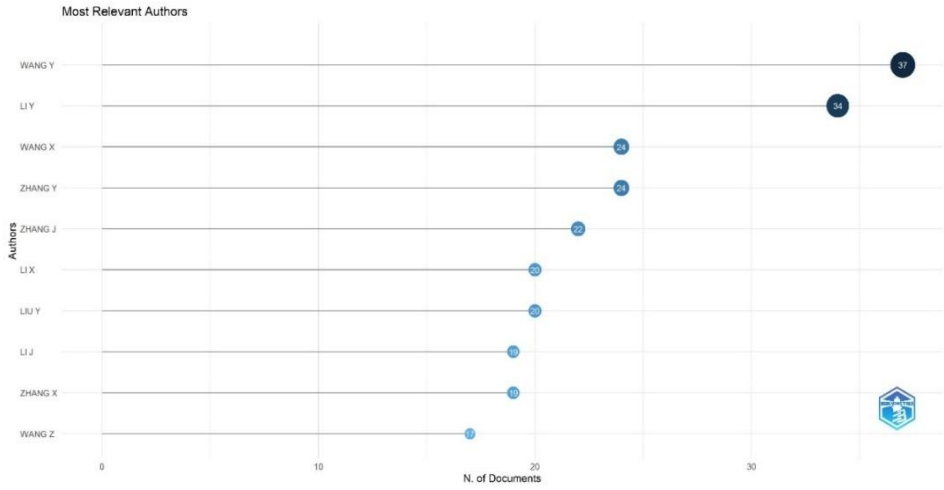

Figure 11. Most relevant authors

In figure 11, Wang Y is the most productive author with 37 Articles, followed by Liy with 34 Articles, Wang X and Zhang Y with 24 Articles.

Thematic map

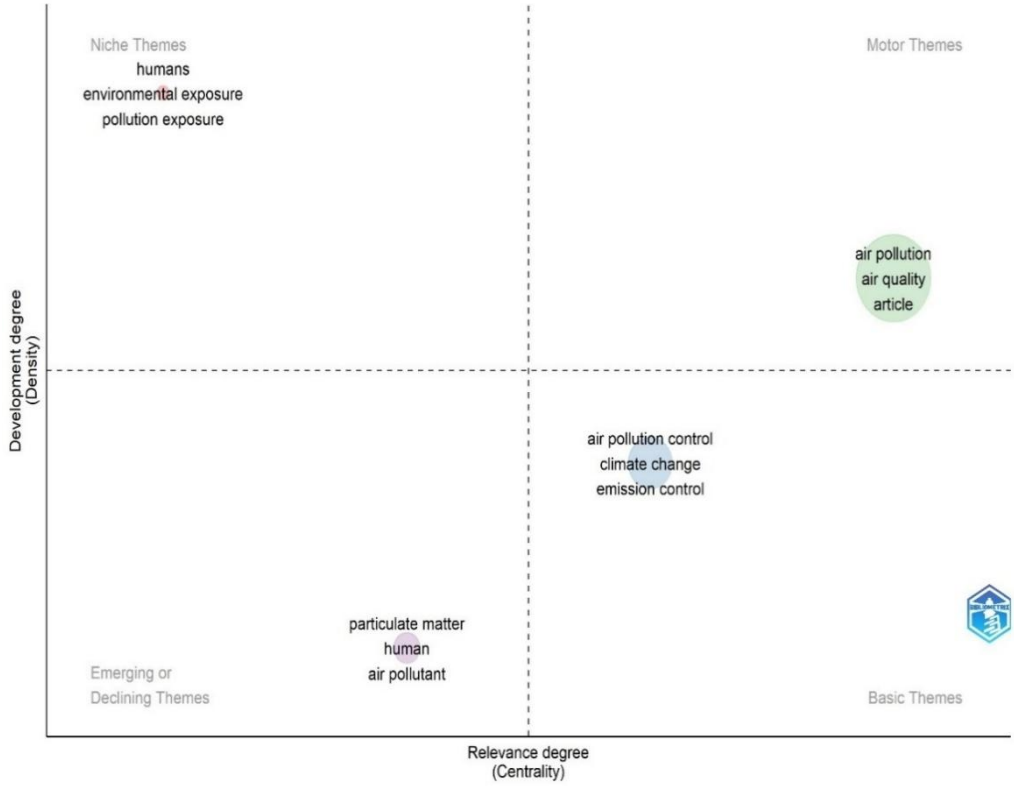

Figure 12. Thematic map

In figure 12, thematic map was also generated based on density and centrality. It divided into four topological regions. This result was obtained from a semi-automatic algorithm. This comprehensive method enabled a more nuanced understanding of thematic variations.

The upper right quadrant shows "motor" or "driving" topics. It indicated by high density and centrality. Topics like Air pollution, Air quality, Article should be developed further given their importance for future research. Moving to the upper left quadrant, themes are specific and less common but display high development potential. These themes indicated by high density and lower centrality - including environmental exposure, pollution exposure, humans. The lower left quadrant contains topics that have been used. It's have experienced a downward trend and indicated by low centrality and density. It including Particulate matter, human, Air pollutant. Lower right quadrant encompasses basic themes. It's marked by high centrality and low density. These topics are important for research as general topics. It included air pollution control, Climate change, emission control. The study provides nuanced understanding of thematic trend by employing this method.

3.7. Keywords analysis

The word cloud in figure 13 presents a visualization of the words that appeared most frequently in the papers on the topic of "Evolution and trends of Air pollution". The largest and most central word was "Air pollution". Second most common word was "Air quality". The word cloud displays words in various sizes according to the number of times they appear.

Figure 13. Word cloud

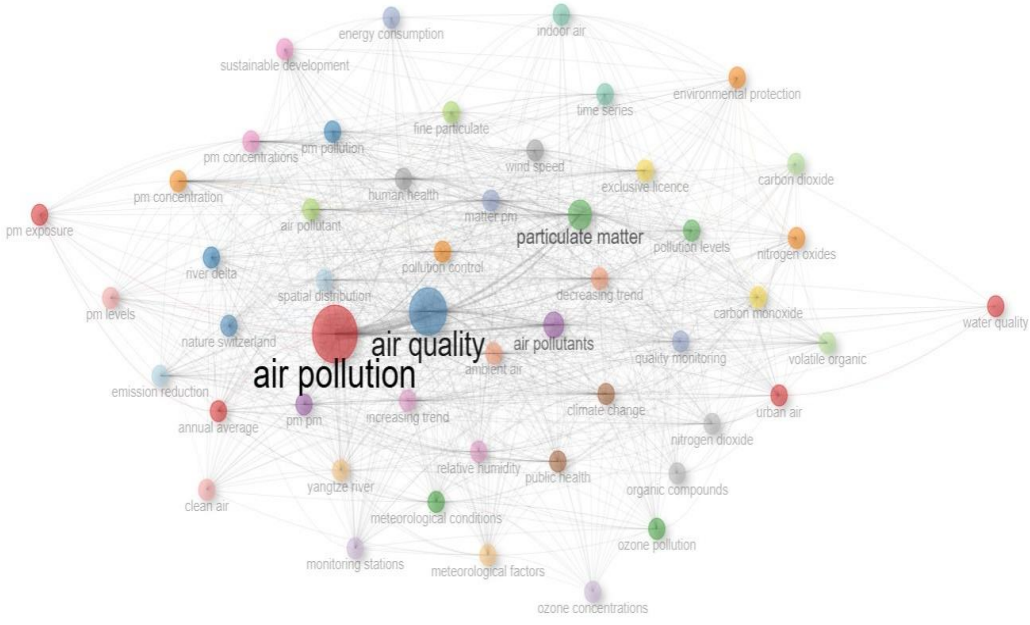

Figure 14. Co-occurrence network

Keywords co-occurrence analysis is shown the figure 14. Keywords were grouped into 25 clusters. Air pollution is the largest and most central node, indicating it is most frequently occurring term and highly connected with other terms. Air quality is another significance node, showing a strong relationship with air pollution and also particulate matter is another central node, indicating its prominence in the research field. Terms like Air pollution, Pollution levels, Quality monitoring, and Human health are closely connected with Air pollution, indicating they are studied together. Terms of Climate change shows a connection between air pollution and Climate change research. Terms like Emission reduction, Monitoring stations, Sapio temporal analysis reflects the methods analyzed in Air pollution studies. These less central terms like sustainable development, Energy Consumption, Indoor air, Exclusive license still show important connections. Overlay, this network provides a detailed map of the interconnection in Air pollution research

4. Conclusion

This bibliometric analysis provides a comprehensive overview of the evolution and emerging trends in air pollution research over the past six decades (1964–2024). The findings reveal a significant and steady increase in scientific publications, particularly after 2019, underscoring the growing global recognition of air pollution as a major environmental, health, and socio-economic concern. The study highlights the strong collaborative nature of air pollution research, reflected in the high rate of international co-

authorship. China, the United States, and India emerged as the leading contributors, with China demonstrating the most substantial research output—indicating its intensive focus and investment in addressing air quality challenges. Among the primary publication sources, *Science of the Total Environment* and *Atmosphere* were identified as the most prolific journals in disseminating key research findings in this domain. In terms of authorship, Wang Y and Li Y stand out as leading contributors, emphasizing the importance of consistent scholarly engagement in advancing this field. Thematic and keyword analyses further identified *air pollution* and *air quality* as the central and driving themes, while related concepts such as *climate change*, *emission control*, and *human health* were recognized as critical complementary areas for future exploration. Overall, this study not only maps the intellectual landscape and knowledge structure of air pollution research but also provides valuable insights into global collaboration patterns, influential contributors, and evolving research foci. The outcomes serve as a foundation for guiding future investigations, fostering interdisciplinary collaboration, and supporting evidence-based policy development aimed at mitigating air pollution and ensuring environmental sustainability.

5. References

Obiefuna, J. N., Inah, E. O., Atsa, J. W. U., & Etim, E. A. (2021). Geospatial Assessment of Ambient Air Quality Footprints in Relation to Urban Landuses in Nigeria. *Environment and Ecology Research*, *9*(6), 426–446. https://doi.org/10.13189/eer.2021.090609

Rahman, R. A., White, B., & Ma, C. (2024). The effect of growth, deforestation, forest fires, and volcanoes on Indonesian regional air quality. *Journal of Cleaner Production*, *457*. https://doi.org/10.1016/j.jclepro.2024.142311

Sierra-Vargas, M. P., & Teran, L. M. (2012). Air pollution: Impact and prevention. In *Respirology* (Vol. 17, Issue 7, pp. 1031–1038). https://doi.org/10.1111/j.1440-1843.2012.02213.x

Suh, H. H., Bahadori, T., Vallarino, J., & Spengler1, J. D. (n.d.). *Criteria Air Pollutants and Toxic Air Pollutants*.

Sun, J., Zhou, Z., Huang, J., & Li, G. (2020). A bibliometric analysis of the impacts of air pollution on children. *International Journal of Environmental Research and Public Health*, *17*(4). https://doi.org/10.3390/ijerph17041277

JOURNAL OF TROPICAL ENVIRONMENT
Vol. 5, Issue i and ii, (December) 2025

Department of Environmental Management
Faculty of Social Sciences & Humanities
Rajarata University of
Sri Lanka

Agricultural Strategies in mitigating the Climate Change impact on tea farming resilience; A narrative review

Madugoda P.M.*[1] and Silva K.N.N.
Department of Agricultural Economics,
Faculty of Agriculture,
University of Ruhuna,
Sri Lanka
*[1]pmmashi93@gmail.com

Abstract

Tea is a significant cash crop in Sri Lanka and serves as a major economic source for local communities. The tea sector plays a key role in foreign exchange and employment. However, climate change poses a serious global problem. Tea plants are very sensitive to temperature fluctuations, irregular rainfall, and droughts. Therefore, Tea Research Institute has introduced the appropriate adaptation strategies for tea sector to cope with ongoing climate change. Current Sri Lankan adaptation strategies such as drought adaptation practices, introduction of drought-tolerant tea varieties, mulching, burying prunings, and shade management are essential to protect healthy tea plantations. The study focuses on providing a comprehensive review of climate adaptation strategies currently applied in Sri Lankan tea industry while identifying the critical gaps that need to be addressed to strengthen the sector against climate change. Study mainly follows several key approaches including adaptation, mitigation, preparedness, capacity building, and ecosystem restoration. This paper will highlight existing gaps and provide relevant recommendations to increase climate resilience in tea sector by examining strategy areas such as drought adaptation measures (ex: shade management, drought tolerant cultivars), mitigation practices (ex: soil carbon enhancement), preparedness practices (ex: early warning systems for extreme weather), capacity-building initiatives (ex: farmer training program) and ecosystem restoration activities (ex: mulching and cover cropping). Eighty-six scientific articles were selected from Google Scholar, JSTOR, emerald insight and government repositories by considering

climate change and climate resilience strategies in tea farming. There were twenty scientific articles that were shortlisted for the review process. After critically reviewing the strategies, more advantages and a few barriers could be realized. To decrease the gaps, needs of a systematic irrigation system by considering water conservation, investigation the ability of tea clones under various climatic conditions in farmland level and testing the soil fertility and root disease are important. The study recommends identified suggestions for farmers to enhance their collaborations such as training workshops, online platforms for learning, and enhanced collaboration between farmers and institutions. It will help to strengthen the resilience strategies to adapt to climate change, ensuring its sustainability and continued economic contribution.

Key words: *Climate change, resilience strategies, Sri Lankan tea sector*

1. Introduction

Tea is one of the most famous beverages worldwide, with global tea production reaching 6.7 million metric tons in 2022, driven by a steady 3.2% annual growth rate over the past decade (Rathnayaka and Poornima, 2024). According to past research papers, tea plants have medicinal usage (Thankappan, 2023). In Sri Lanka, plantation sector plays a major role in country's economic growth. Tea is one of the main cash crops in the plantation sector and it is a key contributor to foreign exchange (Rathnayaka and Poornima, 2024). The origin of the tea plants are tropical and subtropical climates (Tran, 2022), and they can tolerate in proper temperature range 13 ^{0}C to 30 ^{0}C (De Costa *et al.,* 2007). A suitable annual rainfall should be around 2500mm to maintain a healthy life cycle for the plants. Further tea plantation should be in balance temperature and rainfall pattern to gain good profit by protecting taste and quality of the tea leaves (Thankappan, 2023).

Climate change is defined as the long-term shift in Earth's climate and weather conditions. Currently, it is a worldwide problem, and it badly affects environmental sustainability, biodiversity, plantation sector and rural human societies. Further it refers to long-term shifts in temperatures and weather patterns caused by human activities like the burning of fossil fuels that increase greenhouse gases in the atmosphere. Climate change challenges are rising average temperatures, altered precipitation patterns, increased frequency and intensity of extreme weather events, and threatened ecosystems and human societies (Sherwood and Ukkola, 2024).

In Sri Lanka, climate change poses serious threats to both people and natural systems. About half of the country's population lives in low-lying coastal zones vulnerable to sea level rise, coastal erosion, and flooding. Changes in rainfall patterns threaten agriculture and water

resources, while biodiversity faces stress from shifting climate zones and habitat loss. Sri Lanka is ranked as one of the most affected countries globally due to climate change impacts like floods, droughts, and landslides (Adom, 2024). To address these challenges, the country has formulated a National Adaptation Plan (2016–2025) that targets vulnerable sectors including food security, water, health, biodiversity, and coastal zones, involving stakeholder consultations and planning for resilience building and disaster preparedness.

Tea plants are highly vulnerable to climate change. Sri Lankan tea industry has faced formidable challenge to supply high quality sustainable product to the highly competitive market under unpredictable weather conditions (Goswami, 2021). According to past findings, quality and the quantity of the tea change with rising temperature. And Tea yield increases with moderate increment of the temperature. However, when the tea land environment exceeds the optimal temperature range, productivity of tea plantation will be reduced (Zakir, 2018). Furthermore, tea shoot extension rate increases with the temperature and it again decreases with more than 25 ^{0}C. Plant vigor also decreases with the higher temperature conditions (more than optimal range) (Zakir, 2018). For instance, research studies have concluded that the climate change characterized by repeated warm seasons, droughts and uneven rainfall pattern results in formation of gaps in soil cover, pest incidence that compounds the problem of tea farmers (Wijeratne *et al.,* 2007). To mitigate climate change impacts, the government has introduced different strategies for different regions. But there are few scientific articles available on climate resilience strategies in the Sri Lankan tea industry and its implementation process. According to central bank report 2023, climate change is a significant influence on Sri Lankan crop yield reduction. The investigation of current strategies and their common issues should be identified to update them and build up new strategies.

There is a gap of evaluation of current irrigation techniques in Sri Lankan tea industry. If the efficiency of irrigation systems in water usage and tea yield, it will be important to understand best practices to enhance water conservation. Conducting cost effectiveness analysis in farmer level for different irrigation methods will value identifying the most economical viable irrigation option for farmers who are in low rainy regions (Netafim, 2014). Developing rainwater harvesting systems is a beneficial condition for local tea farmers in drought season. Therefore, designing a new strategy relating to it will be a good option. Another hand systematically investigating the ground water recharge sources will help to maintain water availability in dry periods (Bandara, 2011). In Sri Lanka, still policies are not developed regarding climate change and tea cultivation. Researching and proposing it will support to aware farmers about the essential of adaptation of strategies. Mainly it can include financial incentives for effective irrigation systems (Netafim, 2014) and investigation of drought resistant crops (Nguyen, 2022).

2. Methodology

For the study, a narrative review approach was used to identify the adaptation strategies the climate change impact on tea farming resilience. A comprehensive scientific articles search was conducted by using electronic databases including Google Scholar, JSTOR, emerald insight and government repositories. Search terms were used to find scientific articles including the combination of following keywords as "agricultural strategies", "mitigating the climate change", "tea farming resilience". Further Boolean operators (AND, NOT) were used to filter the most reliable papers for the study. It was important to collect a mini dataset of the most relevant findings.

According to inclusion criteria, study mainly focused on adaptation strategies for climate change impact on tea farming. It emphasized Sri Lankan scenario. Study used peer-reviewed journals, and government reports which were published in 2006 to 2024. Most of the articles were excluded because of lacking climate change strategies, and duplicates. Initially, 86 total articles were identified. 69 studies were shortlisted considering the related region of the study. After doing detailed review about the climate change strategies, 37 articles were selected. Finally, 22 most suitable local studies were identified by prioritizing the recent studies and aligned with the research objectives. The shortlisted studies were synthesized the identification of climate resilience strategies, impaction of climate on tea farming and farmers' resilience. The findings were narratively structured to clarify a critical understanding of the topic and strategy implementations.

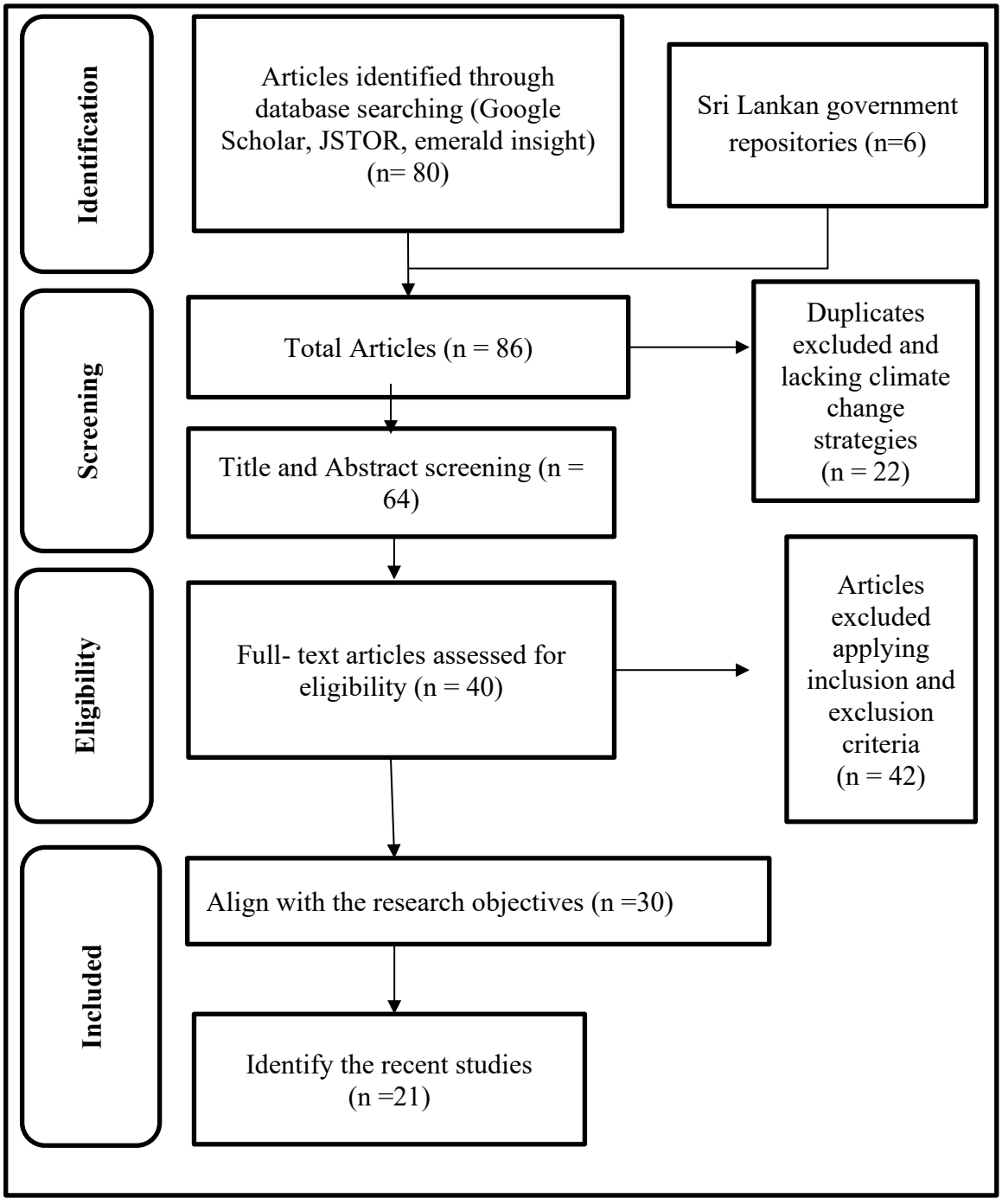

Figure 1: A flow chart of narrative review on Agricultural Strategies in mitigating the Climate Change impact on tea farming resilience/ PRISMA Framework (Popay *et al.,* 2006)

3. Review Findings

3.1 Current climate adaptation strategies in tea cultivation

Tea is a perennial and rain-fed crop in Sri Lanka, and it is significantly contributing to Sri Lankan economy. Tea plants are highly dependent on temperature, rainfall, air saturation deficits, soil water, sunshine hours and evaporation (Bandara, 2011). Most of the tea growing regions in Sri Lanka receive rain from both north – east and south – west monsoons. To maintain proper healthy plantation, tea needs around 2500mm annual rainfall. The annual rainfall pattern of the country has determined the geographical distribution of the tea. Rainfall is a valuable factor for maintaining plant growth, quality of tea shoots and taste of the final tea output. Farmers provide supplementary irrigation systems for tea plantations when annual rainfall is less than 1150mm (Bandara, 2011). Ambient temperature is another valuable climatic factor for tea and is most important to develop tea shoot extension rate and increase good weight of the shoot. The ceiling temperature which has been restricted of shoot growth has not determined. But more than 30 ^{0}C temperature has restricted the tea plant growth. Therefore, drought is a critical environmental problem in Sri Lankan tea plantation sector. Sri Lankan main dry period in most tea growing regions extends from early January to about late March. Some parts of the low and mid country record main dry periods generally late June to about early September (Tea Research Institute, 2011).

Within 13 to 30 ^{0}C temperature range is significantly productive and positively correlates with r tea shoot extension rate and overall plant growth (De Costa *et al.,* 2007). Critical temperatures for tea growth are more than 30 ^{0}C and it can restrict the tea growth rates. If temperature exceeds 35 ^{0}C, tea plant photosynthesis and growth will rapidly decile (Nguyen, 2022). Net photosynthesis decrement significantly increases with temperature, and it adversely affects growth and tea yield. It highlights the need of future research into how tea plants can adapt for it or further resilience needs against rising temperature due to climate change (Nguyen, 2022).

In the adaptation strategy of drought, farmer level practices are available like mulching, weed controlling, spraying of sulphate of potash (SOP), irrigation, green manure crops and pest control mechanisms. All the practices have separate implementation procedures for before, after and following drought periods as well as the different tea growth stages (Tea Research Institute, 2011). The purpose of the practices of mulching is moisture retention, temperature regulation, nutrient enhancement, weed suppression, improved soil structure, and erosion control in the tea land. Tea farmers commonly use grass or plastic materials for mulching purposes. However plastic mulching materials reduce the soil water infiltration in rainy season (Bandara, 2011).

Introducing drought tolerant tea crop varieties for the existing land is another climate adaptation strategy in Sri Lanka (Hettiarachchi, 2023). The Tea Research Institute has released several clones

of the TRI 2000, 3000 and 4000 series. The above series are based on vulnerable to pests, diseases, drought and other hazards. When selecting planting material, 5 – 6 clones can be selected by considering their suitability for the location and extent and clonal suitability can be tested by small – scale planting (at least 200 bushes) (Tea Research Institute, 2011).

Shade in tea is another practicable strategy to protect tea crops from extreme sunlight and maintain healthy microclimate in tea land environment. And it stimulates the forest conditions, improves soil fertility by providing additional organic matter from leaf litter and root biomass. Certain shade plant species can fix nitrogen and supply them to the soil; it helps to promote healthier growth of tea bushes. Tea is shade-loving plant and shaded tea plants have broader leaves. Broader tea leaves under shaded condition contain more amino acids, enhancing the flavor and aroma of the tea (Zuo *et al.,* 2024).

3.2 Climate mitigation practices in tea industry

Burying of prunings to improve carbon content, soil fertility and productivity of tea lands. Relating to the strategy guidelines, it is very important as mitigation practice. Strategy helps capture and store carbon, reducing greenhouse gas emissions while improving soil health. Poor retention of nutrients and water, soil compaction, soil erosion and acidification are the major consequences of lack of soil organic matter in the tea lands. Burying prunings are one of the main in situ sources of organic matter to the lands. Farmers can use branches of pruning tea, additional branches of shade plants and other planting materials as organic matter (Tea Research Institute, 2011). The strategy is valuable implementation rule for protecting soil moisture content and increasing the strongest tea bushes to tolerate extreme weather conditions (Zuo *et al.,* 2024). When considering past studies, different tea clones should be performing analysis under different rainfall patterns, soil types, and climatic conditions to determine their adaptability and resilience in farmer level. There are few studies available regarding the comparison between the yield in traditional crops and drought tolerant crop clones (Huang *et al.,* 2024). Burying and prunings strategy is an important practice to enhance organic content in soil, but the root diseases which are occurring by the strategy and specific preventive measures are not sufficiently available (Tea Research Institute, 2011).

3.3 Preparedness programs in tea industry for climate challenges

Preparedness strategies follow the buildup strengthen the capacity of tea farmers and institutions to anticipate, respond to, and recover from climate-related challenges. Early warning system is very important preparedness practice, and it plays a critical role in reducing the vulnerability of tea cultivation to extreme weather events (Tea Research Institute, 2011).

3.4 Capacity Building program practices among farmers

Sri Lankan tea farming extension officers can conduct monthly training workshops by focusing climate resilience agricultural practices targeting drought tolerant varieties, shade

management and soil fertility enhancement. They can target a specific number of tea farmers to conduct the workshops through demonstrations and interactive sessions (Climate-Resilient Agriculture: Adapting Smallholder Farmers to Changing Weather Patterns – Funds for NGOs - Grants and Resources for Sustainability, 2024). Online courses or mobile applications can be provided for farmers to learn climate resilience practices. It allows flexible learning opportunities for farmers (Tong *et al.,* 2023).

There is a lack of collaboration regarding strategy implementations among farmers and between farmers and institutions. Establishment of farmer cooperative is important to enhance the collaboration. It will be important to share their knowledge, share experiences and adopt the best practices. Further establish the communication channels between farmers and research institutions like the Tea Research Institute, Tea board, Tea extension offices for feedback and updates on strategies (Sustainable Agriculture Network, 2024).

3.5 Ecosystem restoration practices in tea cultivation

Ecosystem restoration activities in the tea industry aim to rehabilitate landscapes, improve biodiversity, and enhance the ecological functioning of tea ecosystems. One effective restoration approach is the introduction of cover cropping systems, where compatible plant species are grown beneath tea bushes to improve soil health, regulate microclimatic conditions, and support long-term sustainability (Sustainable Agriculture Network, 2024).
In Sri Lanka, the use of Mal Ratakaju (*Arachis pintoi*) has become an important cover-cropping practice in tea plantations. Mal Ratakaju is widely recognized for its ecological benefits due to its ability to fix atmospheric nitrogen, produce substantial biomass, and improve soil structure and fertility (Tea Research Institute, 2011).

4. Conclusion

Current major climate change resilience strategies in tea industry are drought mitigation practices such as introducing drought-tolerant tea varieties, mulching and burying prunings, shade management. With the rising temperature, tea plants need specific attention to tolerate it by protecting tea buds and overall tea plant healthy. To improve irrigation techniques by considering water conservations, systematic investigations should be conducted. Most farmers haven't enough water resources capacity for irrigation in drought season. On the other hand, farmers fail to install and maintain their artificial irrigation systems because of their economic problems. Mulching tea lands are very important to protect soil moisture content in drought season. According to findings, most farmers less prefer to mulch because of labor cost and less availability of mulching materials (TRI Annual Report, 2023).

Farmer - centric approaches including regular training workshops, e - learning flatforms, collaboration among farmers and in states are essential to enhance the resilience of tea farming.

Finally, the establishment of policy measures such as financial incentives and promoting climate smart agriculture practices especially considering tea and aligned with farmer level is important. The strategies introduced should be practicable with farmers' economic perspective. Tea farming resilience strategies will enable the tea industry in Sri Lanka to adapt to climate change effectively, ensuring its sustainability and economic contribution in the future. Therefore, more attention to research and development is necessary in tea industry.

5. Reference

Adom, P. K. (2024). The socioeconomic impact of climate change in developing countries over the next decades: A literature survey. Heliyon. https://doi.org/10.1016/j.heliyon.2024.e35134

Bandara, S. N. (2011). Agronomy of irrigated tea in low elevation growing areas of Sri Lanka (Doctoral dissertation, School of Agriculture, Food and Wine, The University of Adelaide).

Climate-Resilient Agriculture: Adapting Smallholder Farmers to Changing Weather Patterns - fundsforNGOs - Grants and Resources for Sustainability. (2024, October 3). FundsforNGOs - Grants and Resources for Sustainability - Grants and Resources for Sustainability. https://www.fundsforngos.org/proposals/climate-resilient-agriculture-adapting-smallholder-farmers-to-changing-weather-patterns/ https://oxfordre.com/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-373.

De Costa W.A.J.M., (2009). Adaptation of agricultural crop production to climate change: A policy framework for Sri Lanka. Journal of the National Science Foundation of Sri Lanka, 38(2), 79–89.

Goswami, R. (2021). Adapting to climate change. Tea Biz. https://tea-biz.com/adapting-toclimate-change/

Hettiarachchi, H. A. I. L., Alwis, L. M. H. R., & Dharmarathna, T. T. D. (2023). Identifying high-performing seedling teas in Passara, Sri Lanka. Tropical Agricultural Research & Extension, 26(3), Article 5669. https://doi.org/10.4038/tare.v26i3.5669

Huang, F., Lei, Y., Duan, J., Kang, Y., Luo, Y., Ding, D., Chen, Y., & Li, S. (2024). Investigation of heat stress responses and adaptation mechanisms by integrative metabolome and transcriptome analysis in tea plants (Camellia sinensis). Scientific Reports, 14, 10023. https://doi.org/10.1038/s41598-024-60411-0

Mukhopadhyay, M., & Mondal, T. (2017, April 26). Cultivation, Improvement, and Environmental Impacts of Tea. Oxford Research Encyclopedia of Environmental

Netafim. (2014, March 5). Tea crop in Tanzania. Irrigazette. Retrieved from https://irrigazette.com/en/news/tea-crop-tanzania

Nguyen, N. (2022, May 12). What are the suitable climatic conditions for growing tea? https://vihaba.global/2022/05/12/growing-tea-what-are-the-suitable-climatic-conditions-for-growing-tea/

Pearce, R., & Hausfather, Z. (2018, September 26). Mapped: How every part of the world has warmed – and could continue to warm. Carbon Brief. https://www.carbonbrief.org/mapped-how-every-part-of-the-world-has-warmed-and-could-continue-to-warm/

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., Britten, N., Roen, K., & Duffy, S. (2006). *Guidance on the conduct of narrative synthesis in systematic reviews: A product from the ESRC Methods Programme*. ESRC Methods Programme. https://www.lancaster.ac.uk/media/lancaster-university/content-assets/documents/fhm/dhr/chir/NSsynthesisguidanceVersion1-April2006.pdf

Sherwood, S., & Ukkola, A. (2024, July 25). Landmark new research shows how global warming is messing with our rainfall. PreventionWeb. https://www.preventionweb.net/news/landmark-new-research-shows-how-global-warming-messing-our-rainfall

Sustainable Agriculture Network. (2024, May 22). Supporting Farmer Cooperatives: Strengthening Collective Action for Sustainability. SAN. https://www.sustainableagriculture.eco/post/supporting-farmer-cooperatives-strengthening-collective-action-for-sustainability

Tea Research Institute. (2023). *Annual report 2023*. TRI, Deniyaya.

Tea Research Institute. (2011, January). Drought mitigation in tea plantation, Guidelines on burying of prunings to improve soil fertility and productivity of tea lands (Circular No. PA 2, Serial No. 2/11 and guideline No. 01/11). Tea Research Institute of Sri Lanka.

Thankappan, N. (2023). Evaluating the effects of climate change on tea and sustainable livelihood: A study of Sri Lankan tea plantation labour. International Journal for Multidisciplinary Research, 5(6). https://www.ijfmr.com

Tong, Q., Ran, S., Liu, X., Zhang, L., & Zhang, J. (2023). Is the internet helping farmers build climate resilience? Evidence from rice production in the Jianghan Plain, China. Emerald Insight. Retrieved from https://www.emerald.com/insight/1756-8692.htm

Tran, H. A. (2022, February 17). What is the ideal climate condition for tea cultivation? Vihaba Trade and Import - Export Company Limited. https://vihaba.global/2022/02/17/what-is-the-ideal-climate-condition-for-tea-cultivation/

Wijeratne, M. A., Anandacoomaraswamy, A., Amarathunga, M. K. S. L. D., Ratnasiri, J., Basnayake, B. R. S. B., & Kalra, N. (2007). Assessment of impact of climate change on productivity of tea (Camellia sinensis L.) plantations in Sri Lanka. Journal of the National Science Foundation of Sri Lanka, 35(2), 119–126.

Zakir, M. (2018). Review on impacts of climate change on tea yield, yield components, and quality. International Journal of Research Studies in Agricultural Sciences (IJRSAS), 4(5), 24–37. https://doi.org/10.20431/2454-6224.0405005

Zuo, H., Chen, J., Lv, Z., Shao, C., Chen, Z., Zhou, Y., & Shen, C. (2024). Tea-derived polyphenols enhance drought resistance of tea plants (Camellia sinensis) by alleviating jasmonate–isoleucine pathway and flavonoid metabolism flow. International Journal of Molecular Sciences, 25(7), Article 3817. https://doi.org/10.3390/ijms25073817

JOURNAL OF TROPICAL ENVIRONMENT
Vol. 5, Issue i and ii, (December) 2025

Department of Environmental Management
Faculty of Social Sciences & Humanities
Rajarata University of
Sri Lanka

Tourist Satisfaction as a Mediator between Key Determinants and Sustainable Eco-Tourism: Insights from Eco-Tourists in Central Province, Sri Lanka

Siromiya S.S.
Department of Tourism Studies,
Faculty of Management,
Uva Wellassa University of Sri Lanka
ies.shiromiya@gmail.com

Abstract

Sustainable ecotourism is significant for protecting the natural environment and supporting local communities. Tourist satisfaction plays a major role in making ecotourism successful. The present study investigates how tourism management policy, the natural environment, infrastructure, and socio-cultural factors impact sustainable ecotourism and whether tourist satisfaction acts as a mediator between these factors and sustainable ecotourism. The research aims to evaluate the mediating role of tourist satisfaction between tourism management policy, the natural environment, infrastructure, culture and society, and sustainable ecotourism. Therefore, the study adopted a quantitative research design, and data were collected through a standardized questionnaire. The questionnaire was completed by a sample group of 385 respondents. To evaluate the quantitative data, descriptive statistics techniques were used by adopting the Statistical Packages for Social Science analysis (SPSS) version 25. Additionally, inferential statistics, including regression analysis, were used to examine the relationship between dependent and independent variables. The results show that there is a positive and significant relationship between dependent and all independent variables such as tourism management policy, the natural environment, infrastructure, and culture and society. Further, tourist satisfaction was found to partially mediates these relationships, indicating that improvements in these factors could increase sustainable ecotourism directly and indirectly via tourist satisfaction. Based on these findings, it is recommended that Sri Lanka's tourism authorities focus on improving infrastructure such as electricity,

roads, and access to destinations, strengthen tourism management policies through better monitoring and legal systems. Promoting the natural environment and encouraging foreign investment can also create unique sustainable ecotourism products for the Central Province, attract more tourists, and enhance overall tourist satisfaction.

Key words:*: Central Province, Culture and Society, Infrastructure, Natural environment, Tourism management policy*

1. Introduction

The tourism industry is considered one of the top-earning industries and the fastest-growing field over a long period of time. It not only contributes to a large share of global income but also generates employment opportunities and increases cultural exchange globally. Recently, global sustainability concerns and growing environmental awareness have influenced travelers. Therefore, ecotourism has become one of the most popular and demanded types of tourism among environmentally oriented travelers, even with many forms of tourism available (Arachchi , 2019).Sustainable ecotourism in Sri Lanka possesses major potential for developing , as it is enriched with natural and social diversity. The country's abundance of natural attractions, cultural heritage sites, and community-based tourism initiatives positions it well to use ecotourism as a tool for economic growth and social development (SLEF, as cited in Arachchi, Yajid, & Khatibi, 2015). Sustainable ecotourism in Sri Lanka not only benefits the national economy but also helps to strengthen environmental conservation and enhance the livelihoods of local communities, thereby motivating the relationship between society and nature. The tourists in the modern context are more knowledgeable and green-oriented compared to those in the past. They are more aware of the negative environmental impact caused by tourism-related activities, including pollution, habitat destruction, and excessive resource usage (Arachchi , 2019) .This leads to the results in a change in tourists' mindsets towards being more responsible about travel behavior, prompting tourism service providers, particularly hoteliers, to adopt sustainable management practices and eco-friendly practices. This circumstance has forced the hospitality industry to emphasize sustainability in its practices, including management policy and facility design, and daily operations to meet the changing expectations of environmentally aware travelers (Lee & Moscardo, 2005).Several studies have been conducted on sustainable ecotourism in various fields. For instance, (McNamara & Prideaux, 2011) noted its roles in creating livelihoods for local communities. Buckley (2011) demonstrated its significance in protecting the natural environment protection. While (Buckley, Castley , Pegas, Mossaz, & Steven, 2012) investigated its contribution to preserving animal species and ecosystems. Additionally, (Vuong & Rajagopal, 2019; Asker, Boronyak, Carrard, & Paddon, 2010), have investigated how tourism development impacts the environment, local lifestyles, and pollution levels, proposing various

approaches to maintain sustainable ecotourism development. Referring to existing literature, several determinants of sustainable ecotourism have been identified, such as tourism management policy (Nangulu, 2018),tourist satisfaction (Oliver.R, 1993; Yao, Huang, & Wang, 2013; Aliman, Hashim, Wahid, & Harudin, 2014),and attractive destinations (Yao, Huang, & Wang, 2013).Moreover, factors impacting tourist satisfaction and the destinations attractiveness include the natural environment (Suanmali, 2014; Stange & Brown, 2012), infrastructure (Bagri & Kala, 2015; Yuksek, Akkoç, , & Bayer, 2016)culture and society (Suanmali, 2014),and management policy (Nangulu, 2018) Altogether, these factors determine the overall sustainability and competitiveness of ecotourism destinations. However, even the some hoteliers adopt genuine eco-friendly practices, a growing number of establishments engage in greenwashing- a deceptive behavior that misleads consumers regarding the environmental advantages of a product, service, or organization (Arachchi , 2019).This leads to confusion among tourists and reduces their trust in sustainability activities .Further, he noted that most of the hotels in the Central Province of Sri Lanka market themselves as "green" on their websites without substantiating their claims through verifiable sustainable practices. Such discrepancies between actual operations and stated policies have increased concerns regarding sustainable tourism practices. This circumstance demonstrates the requirement for deeper scholarly investigation into how tourist satisfaction acts as a mediating factor between perceived sustainability claims and the actual implementation of sustainable practices. This mediating connection is significant to ensure that ecotourism provides genuine environmental, economic, and social benefits. Hence, the mediating impact of tourist satisfaction on sustainable ecotourism requires deeper research to strengthen sustainable tourism techniques and enhance tourists' experiences.

1.2. Problem Statement

Ecotourism is widely recognized as a strategy for sustainable development; however, its practical implementation is inconsistent in developing nations (McNamara & Prideaux, 2011). In the Central Province in Sri Lanka, ecotourism has attracted attention due to its natural and cultural resources (Arachchi , 2019).Without verifiable environmental or community outcomes, many resorts claim to be "eco-friendly," leading to greenwashing .These misleading claims reduce tourist satisfaction and impact behaviors such as revisiting or recommending the destination (Buckley R. C., 2011; Yao, Huang, & Wang, 2013).Prior research studies have investigated tourism management policy, environmental conditions, infrastructure, and socio-cultural factors determinants separately ,but few have explored how these determinants collectively impact sustainable ecotourism via satisfaction of tourists (Nangulu, 2018; Bagri & Kala, 2015; Yuksek, Akkoç, , & Bayer, 2016).Even though the SLTDA strengthens responsible tourism, the effectiveness of these policies in impacting perceptions of tourists remains unclear (Bramwell, 2011; Dao, Tran, Bui, Nguyen, & Nguyen, 2014) .This research study addresses this gap by examining the mediating effect of tourists' satisfaction in connecting key factors, including tourism

management policy, natural environment, infrastructure, and socio-cultural factors, to the impact of sustainable ecotourism in the Central Province in Sri Lanka. This connection is important to ensure ecotourism moves beyond superficial claims toward authentic sustainability that advantages both the environment and the experience of tourists.

1.3. Research Questions

- What is the impact of tourism management policy, the natural environment, infrastructure, culture and society on sustainable eco-tourism?
- How does tourist satisfaction mediate the relationship between tourism management policy, natural environment, infrastructure, culture & society, and sustainable ecotourism?

1.4. Objective of the study

The main objective of this study is to investigate both the direct and mediated effects of key determinants, including the natural environment, infrastructure, culture and society, and management policy, on sustainable ecotourism.

• To investigate the direct impact of the tourism management policy, the natural environment, infrastructure, culture and society, and (independent variable) on sustainable ecotourism (dependent variable)

• To investigate the mediating role of tourist satisfaction in the relationship between key determinants—tourism management policy, the natural environment, infrastructure, culture and society, and sustainable ecotourism

2.Literature review

2.1. Sustainable eco-tourism

Sustainable eco-tourism ensures the preservation of culture and society, history, heritage, and arts of local communities, thereby ensures intellectual and social culture and society protection for sustainable development (Edgell, 2006).Sustainable tourism development provides benefits to local people enabling them to earn income and participate in maintaining a sustainable environment. Furthermore, businesses benefit by offering goods and services at local tourism destinations, investing in the tourism industry, and gaining profits. The tourism industry must enhance revenue, improve service quality, and quantity, and attract investments without harming the natural environment (Middleton & Hawkins, 1998). When tourists are satisfied with sustainable tourism destinations, they recognize the value of tourism resources and contribute to preserving them. Therefore, sustainable tourism development should be implemented efficiently to avoid affecting the needs of

future generations. Community plays an important part in sustainable tourism by preserving ecosystem and reducing human impact on nature (Hall, 2003).The present study adopts Behavioral Theory and the Triple-Bottom Line theory, which explain environmental awareness, institutional environment, and sustainable ecotourism determinants. Behavioral Theory explains human behavior on the surrounding environment (Angell, 2013),while Triple Bottom Line (TBL) emphasizes the social and environmental roles of business beyond profit making (Nguyen , Nguyen , Phong , & Huynh , 2024)This theory can be applied in tourism , demonstrating that companies and people consider regarding social and environmental impact when participating in the field (Faux & Dwyer, 2009). By reviewing theoretical and empirical research, this study partly adopts a research model of (Nguyen , Nguyen , Phong , & Huynh , 2024)) to explain sustainable ecotourism in Central Province ,using determinants of sustainable ecotourism identified in prior studies (Mihalič, Šegota, Cvelbar, & Kuščer, 2016) and (Elshaer, Moustafa, Sobaih, Aliedan, & Azazz, 2021)

2.1.1. Tourism Management Policy impact on Tourist Satisfaction

Tourism management policy refers to a legal system and administrative system designed to effectively manage, monitor, inspect, and expand the tourism industry (Dao, Tran, Bui, Nguyen, & Nguyen, 2014). Local communities can create better conditions for sustainable ecotourism through effective management policies (Bramwell, 2011). Such policies also help promote sustainable ecotourism locally and attract international investments (Crouch & Ritchie, 1999). Effective tourism policies ensure sustainable development by improving services, infrastructure, and the overall appeal of destinations, thereby enhancing tourist satisfaction (Nguyen , Nguyen , Phong , & Huynh , 2024). Moreover, these policies regulate tourist behavior, protect natural resources, and provide a framework for sustainable operations. They help authorities manage visitor flows, prevent overcrowding aswell as preserve the quality of destinations. Moreover, they foster innovation in tourism services and support investment, ensuring that sustainable ecotourism initiatives are both economically as well as environmentally responsible. Therefore, strong management policies enhance attractive destinations and encourage repeat visits.

2.1.2. Natural Environment impact on Tourist Satisfaction

Natural environment impacts tourist satisfaction and plays a vital role in attracting tourists. Attractive destinations consist of pristine natural environments, resources, and other attractions as the primary dimensions of tourist destinations (Vengesayi, Mavondo, & Reisinger, 2009). According to (Lin, Morais, Kerstetter, & Hou, 2007),the natural environment encompasses landscape, environment, atmosphere, and climate at tourist destinations. The natural environment cannot be replaced and must be protected to promote sustainable ecotourism. Furthermore, creating aesthetic appeal, a well-structured natural environment provides opportunities for recreating activities, relaxation, and learning, which empower tourist satisfaction and motivate repeat visits. Destinations with protected and

rich natural landscapes could differentiate themselves in competitive tourism markets and create long-term loyalty among tourists.

2.1.3. Infrastructure impact on Tourist Satisfaction

Infrastructure is significant to promote sustainable tourism industry development (Nguyen , Nguyen , Phong , & Huynh , 2024).Infrastructure includes basic utilities such as electricity, roads, schools, and stations that serve tourism (Lin, Morais, Kerstetter, & Hou, 2007).It also includes accommodation establishments, food services, shops, pubs, agents, and conference offices (Gupta & Bhawe, 2007). Infrastructure is an important dimension that impacts tourist satisfaction, as it covers basic utilities that tourists experience when they reach sustainable ecotourism destinations with the natural environment and landscape (Crouch & Ritchie, 1999). Apart from these basic services, infrastructure also supports safety and communication and immediate responses, which promote the tourism experience. Well-designed infrastructure allows destinations to manage tourist volumes without damaging environmental resources. Adequate and well-maintained infrastructure is significant for comfort, convenience, and satisfaction, making it a cornerstone of sustainable ecotourism.

2.1.4. Culture and Society impact on Tourist Satisfaction

Culture and society include faith systems, customs, cuisine, and handicrafts in one area or country (Nguyen , Nguyen , Phong , & Huynh , 2024). Further, each place has different cultural and social characteristics, and these vary from region to region. Tourists who visit these places can understand social values and distinct cultures and societies, leading to enhanced tourist satisfaction levels (Crouch & Ritchie, 1999).Through engaging local communities in tourism, organizing cultural events, and preserving traditional practices, tourist experiences are empowered while creating economic and social benefits for the community. When tourists are connected to society and local culture, their experiences become more memorable, motivating positive reviews and repeat visitors.

2.1.5. Mediating Role of Tourist Satisfaction

Tourist satisfaction is dependent on the difference between expectations before travel and experiences after travel (Nguyen , Nguyen , Phong , & Huynh , 2024).Tourist satisfaction, which arises from the product and service quality of post-travel perception, reflects what visitors expect from experiencing tourism (Reisinger & Turner, 2003).Satisfaction can lead tourists to revisit sustainable ecotourism destinations, and therefore, tourist satisfaction contributes to sustainable ecotourism performance and development (Le, 2024).When tourism is established sustainably, people receive many opportunities in both tourism business and employment. Determinants of tourist satisfaction include travel services, local heritage sites, local people, adventure, culture and society, nature, journey, beverages and

food, price, safety, communication, experience, and accessibility (Voona & Lee, 2009).In this context, tourist satisfaction act as a mediator between the main determinants—tourism policy, natural environment, infrastructure, and culture/society—and sustainable ecotourism performance. This indicates that satisfied tourists revisit to contribute to both local community development and environmental preservation, explaining that enhancing satisfaction is a main key to achieving sustainable goals of tourism.

2. Methodology

3.1 Research Site

The study was conducted in the Central Province in Sri Lanka. It consists of districts: Nuwara Eliya, Matale, and Kandy. Central Province is identified as one of the attractive regions for ecotourism, known for its rich biodiversity, cultural heritage, and scenic landscape, which make it a popular destination for tourists. The Central Province has the highest number of eco-resorts compared to other provinces, according to Sri Lanka Tourism Development Authority (SLTDA) (Arachchi , 2019). These establishments provide minimum environmental impacts and encourage sustainable tourism practices. Hence, this province ensures an appropriate and relevant context to investigate factors impacting sustainable ecotourism and tourist satisfaction.

3.2 Conceptualization model

Based on the literature review, this study aims to examine the influence of tourism management policy, the natural environment, infrastructure, culture and society on sustainable eco-tourism with the mediating role of tourist satisfaction in Central Province. The study's conceptual framework was adopted from the work of (Nguyen , Nguyen , Phong , & Huynh , 2024). H1–H4 indicate direct effects of independent variables on tourist satisfaction. Moreover, H5 indicates the mediating role of tourist satisfaction between independent variables and sustainable ecotourism.

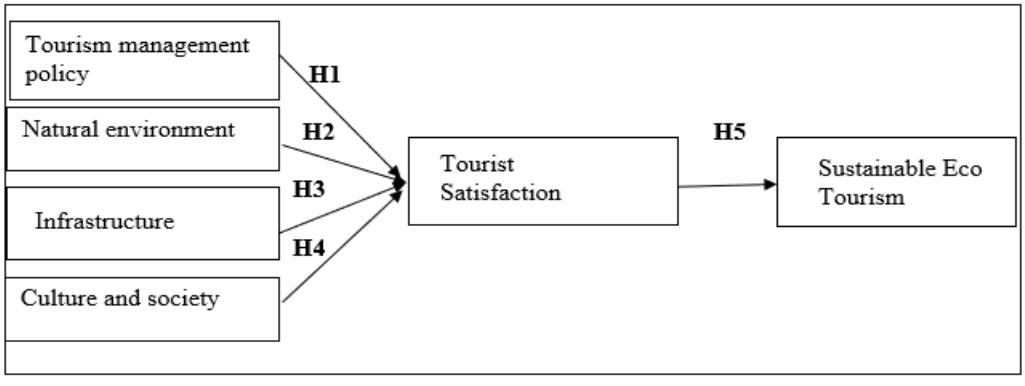

Figure 1:Conceptual framework

Source: Developed using the following resource (Nguyen , Nguyen , Phong , & Huynh , 2024)

3.3. Hypothesis Formulation

H1: There is a relationship between tourism management policy and tourist satisfaction

H2: There is a relationship between natural environment and tourist satisfaction

H3: There is a relationship between infrastructure and tourist satisfaction.

H4: There is a relationship between culture and society and tourist satisfaction

H5: Tourist satisfaction **mediates** the relationships between key determinants including tourism management policy, natural environment, infrastructure, and culture and society and sustainable ecotourism.

3.4. Instrumentation

The questionnaire consisted of 28 items on a 5-point Likert scale, divided as follows: Natural environment (5 items), infrastructure (6 items), culture & society (4 items), management policy (5 items), tourist satisfaction (4 items), and sustainable ecotourism (5 items). The demographic section is separate. The survey questionnaire was utilized from previous research studies indicated in the operationalization table.

Table 1:operationalization table

Variables	Items	Sources
Natural environment	5	(Suanmali, 2014; Stange & Brown, 2012).
Infrastructure	6	(Bagri & Kala, 2015; Yuksek, Akkoç, , & Bayer, 2016; Sukiman, Omar, Muhibudin, Yussof, & Mohamed, 2013)
Culture and society	4	(Suanmali, 2014)
Management policy	5	(Nangulu, 2018; Stange & Brown, 2012)
Tourist satisfaction	4	(Oliver.R, 1993; Yao, Huang, & Wang, 2013; Aliman, Hashim, Wahid, & Harudin, 2014)
Sustainable ecotourism	5	((Elshaer, Moustafa, Sobaih, Aliedan, & Azazz, 2021; Nangulu, 2018).

3.5 Research Design

To investigate the mediating role of tourist satisfaction in the relationship between tourism management policy, natural environment, infrastructure, culture and society, and sustainable ecotourism was the primary objective of the study. The research study adopted quantitative research to achieve this objective. It allows for the collection and numerical data analysis to find out the relationship among variables of the study. The individual eco tourists staying at the sustainable accommodations were considered as the unit of analysis. Moreover, the data were gathered at a single point in time. Due to this, this study adopts a cross-sectional design, which is suitable to identify existing connections and patterns without manipulating variables, providing a snapshot of the current situation on sustainable ecotourism and tourist satisfaction.

3.6. Population

The population of the study consisted of eco-tourists who stayed at sustainable accommodation in the Central Province in Sri Lanka. These accommodations were chosen based on their eco-friendly practices. These accommodations serve as the key tourism venues, demonstrating sustainable and environmentally conscious accommodation options, which makes them relevant objectives of the study.

3.8. Sampling Technique and Sample Size

The population of eco-tourists was unknown in this study, as the exact numbers of eco tourists visiting sustainable accommodations in the Central Province could not be determined. A convenience sampling technique was adopted to gather data from eco tourists who were available and willing to participate during the period of data collection. This method was selected because of time constraints and the respondents' accessibility, but it limits the generalizability of the findings.Hence,the findings indicate associations among the eco-tourists only and may not be generalized to all eco-tourists in the province.

The sample size was calculated using the standard formula for an unknown population, based on a 95% confidence level, a precision rate, and a degree of variability of 5%. Although, the sample size for the study was determined to be 385 respondents, resulting in a response rate of approximately 100%.

The formula used is as follows:

$n_0 = (Z^2 \times p \times (1 - p)) / e^2 = (1.96^2 \times 0.5 \times 0.5) / 0.05^2 = 384.16 =$ **385**.

3.9. Data Collection

Primary data sources were used to achieve the objectives. Structured questionnaires were distributed physically among eco tourists who stayed at sustainable accommodation in the Central Province to gather required information.

3.10. Data Analysis

The gathered data were examined using SPSS version 25. Descriptive and inferential statistical techniques were applied. Descriptive statistics, including mean, standard deviation, percentages, and frequencies, were adopted to summarize the respondents' characteristics and variables. To examine the relationships among variables and investigate the mediating role of tourist satisfaction, correlation and regression analyses were conducted.

4. Results

4.1. Reliability Statistics

Cronbach's alpha coefficient was used to assess the reliability of the six variables of the study. The findings indicated that natural environment, infrastructure, culture and society, tourism management, tourist satisfaction, and sustainable ecotourism indicated a high level of reliability, above the commonly accepted threshold of 0.70.

Table 2:Reliability Statistics

Reliability Statistics		
Variables	Cronbach's Alpha	N of Items
Natural environment	.873	5
Infrastructure	.883	6
Culture and Society	.782	4
Management policy	.888	5
Tourist Satisfaction	.714	4
Sustainable eco-tourism	.825	5

Source: SPSS,2024

4.3. Demographic Data Analysis

The first part of the questionnaire covered questions to collect basic details about the respondents from the tourists in Central Province. The data that were collected were

analyzed using frequency statistics. The age category of the respondents indicates that 35.9% were from the age group of 20-30 years age group, 25.7% were from the age group of 41-50 years age group, and the remaining 38.3% were from the 31-40 years age group (Table 2). Most of the respondents were female, according to Table 3, with females accounting for 79%, while 21 % were male respondents.

Table 3:age

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-30	138	35.9	35.9	35.9
	31-40	99	25.7	25.7	61.7
	41-50	148	38.3	38.3	100.0
	Total	385	100.0	100.0	

Source: SPSS,2024

Table 4:Gender

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	81	21.0	21.0	21.0
	Female	304	79.0	79.0	100.0
	Total	385	100.0	100.0	

Source: SPSS,2024

4.4. Descriptive Statistics

Table 5:Descriptive Statistics

Descriptive Statistics			
	N	Mean	Std. Deviation
Natural environment	385	4.0997	.50065
Infrastructure	385	3.7900	.49870
Culture and Society	385	3.9357	.51815
Management policy	385	4.1938	.53479
Tourist Satisfaction	385	4.0123	.37631
Sustainable eco-tourism	385	4.0442	.37890
Valid N (listwise)	385		

Source: SPSS,2024

Descriptive statistics techniques are used to summarize the attributes of the including the mean, mode, median, standard deviation, etc. They also help the evaluate the current situation of the selected dimensions. The questions of the study were examined using the following rule. A 5-point Likert scale can be divided into 5 equal ranges, each equal to 0.8. This means items with scores falling within the following ranges were considered as

4.21–5.00: Very important
3.41–4.20: Important
2.61–3.40: Neutral
1.81–2.60: Not important
1.00–1.80: As not important at all (Ganganandа, Wijesundara, Bandara, Pattiyagedara, & Ranatunga, 2022).

According to the study's findings, the natural environment, culture and society, tourism management policy, and infrastructure are considered important factors impacting sustainable eco-tourism. Furthermore, the mediator variable, tourist satisfaction, is also categorized as important. Similarly, the dependent variable, sustainable eco-tourism and tourist satisfaction is also recognized as important.

4.5. Correlations Analysis

Table 6:Correlations

Correlations						
		Natural environment	Infrastructure	Culture and Society	Management Policy	Tourist Satisfaction
Natural environment	Pearson Correlation	1	.056	-.065	-.063	.333**
	Sig. (2-tailed)		.274	.203	.214	.000
	N	385	385	385	385	385
Infrastructure	Pearson Correlation	.056	1	-.034	.034	.262**
	Sig. (2-tailed)	.274		.507	.508	.000
	N	385	385	385	385	385
Culture and Society	Pearson Correlation	-.065	-.034	1	.107*	.256**
	Sig. (2-tailed)	.203	.507		.036	.000
	N	385	385	385	385	385
Management Policy	Pearson Correlation	-.063	.034	.107*	1	.425**
	Sig. (2-tailed)	.214	.508	.036		.000

	N	385	385	385	385	385
Tourist Satisfaction	Pearson Correlation	.333**	.262**	.256**	.425**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	385	385	385	385	385
**. Correlation is significant at the 0.01 level (2-tailed).						
*. Correlation is significant at the 0.05 level (2-tailed).						

Source: SPSS,2024

The correlation analysis was conducted to investigate the relationship among natural environment, infrastructure, culture and society, and management policy on tourist satisfaction. The results of the Pearson correlation coefficients are presented in the table above. These findings demonstrate that all four variables are positively correlated with tourist satisfaction. The natural environment indicates a moderate positive correlation with tourist satisfaction ($r = .333$, $p < .01$), demonstrating that destinations with well-preserved natural environments tend to have tourist satisfaction. Infrastructure shows a weak but positive correlation with tourist satisfaction ($r = .262$, $p < .01$), representing that infrastructure contributes to tourist satisfaction. The culture and society also represent a weak to moderate positive relationship with tourist satisfaction ($r = .256$, $p < .01$), highlighting that cultural richness and social friendliness create positive tourist satisfaction. Furthermore, management policy presents a significant positive correlation with tourist satisfaction ($r = .425$, $p < .01$), indicating that effective management policy plays a significant role in empowering tourist experiences and tourist satisfaction. Overall, these results highlight that sustainable ecotourism's success in the central province depends on environmental preservation, governance, cultural engagement, and infrastructure.

4.6. Mediation Analysis

To investigate both the direct and mediated effects of key determinants, including the natural environment, infrastructure, culture and society, and management policy, on sustainable ecotourism. The findings are presented in the tables below.

4.7. Model Summary

Table 7:Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.648[a]	.420	.414	.28996

2	.689[b]	.475	.468	.27642
a. Predictors: (Constant), natural environment, infrastructure, culture and society, and management policy				
b. Predictors: (Constant), natural environment, infrastructure, culture and society, and management policy				

Source: SPSS,2024

Natural environment, infrastructure, culture and society, and management policy were included as predictors in the Model 1. The R value is 0.648, indicating a strong positive relationship between the dependent and independent variables. The R-squared value of 0.420 highlights that 42% of the variation in sustainable ecotourism can be explained by these four determinants. Additionally, the adjusted R-squared (0.414) shows that the model still explains 41.4% of the variance, highlighting a very good model fit. In the context of Model 2, tourist satisfaction was added as further predictor variable. The R value slightly increased to 0.689, which indicates a stronger connection. Additionally, the R-squared value increased to 0.475, indicating that the extended model explains 47.5% of the variance in sustainable ecotourism. Compared to Model 1, the Adjusted R Square (0.468) increased, demonstrating that the inclusion of tourist satisfaction increased the overall predictive power of the model. Overall, the results present that tourist satisfaction contributes positively to explaining sustainable outcomes of ecotourism. This highlights that while environmental, infrastructural, socio-cultural, and policy factors are main determinants, tourists' satisfaction plays an important role in empowering sustainable ecotourism in the Central Province.

4.8 Anova Analysis

Table 8:ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.181	4	5.795	68.930	.000[b]
	Residual	31.948	380	.084		
	Total	55.129	384			
2	Regression	26.170	5	5.234	68.499	.000[c]
	Residual	28.959	379	.076		
	Total	55.129	384			
a. Dependent Variable: sustainable eco-tourism						
b. Predictors: (Constant), natural environment, infrastructure, culture and society, and management policy						
c. Predictors: (Constant), natural environment, infrastructure, culture and society, and management policy						

Source: SPSS,2024

The Analysis of Variance (ANOVA) test was investigated to determine the overall significance of the regression models as well as to examine whether the independent variables collectively have a statistically significant influence on sustainable ecotourism. In Model 1, which includes natural environment, infrastructure, culture and society, and management policy as predictors, the F-value is 68.930 with a significance level (Sig.) of 0.000. This demonstrates that the regression model is significant at the 1% level ($p < 0.01$) , confirming that these determinants significantly explain a variance in sustainable ecotourism. In Model 2, which includes tourist satisfaction as a further predictor, the F-value is 68.499 with a significance level (Sig.) of 0.000, indicating that the extended model is also statistically significant. Although the F-value is lower compared to Model 1, the inclusion of tourist satisfaction enhanced the explanatory power of the model due to the increased R^2 value from 0.420 to 0.475. This demonstrates that tourist satisfaction serves as a significant determinant, increasing the whole model fit and contributing to explaining additional variance in sustainable ecotourism.

4.9 Coefficients

Table 9:Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.313	.230		1.358	.175
	Natural environment	.274	.030	.361	9.207	.000
	Infrastructure	.179	.030	.236	6.023	.000
	Culture and Society	.178	.029	.243	6.173	.000
	Management Policy	.294	.028	.414	10.524	.000
2	(Constant)	.337	.220		1.536	.125
	Natural environment	.177	.032	.234	5.494	.000
	Infrastructure	.100	.031	.132	3.220	.001
	Culture and Society	.097	.030	.132	3.181	.002
	Management Policy	.216	.029	.305	7.351	.000
	Tourist satisfaction	.328	.052	.326	6.254	.000
a. Dependent Variable: sustainable eco-tourism						

Source: SPSS,2024

The findings demonstrate that the natural environment, infrastructure, culture and society, and management policy significantly impact sustainable ecotourism. In Model 1, which investigated direct effects, management policy (β = .414) and the natural environment (β = .361) were the strongest predictors. Both culture and society (β = .243) and infrastructure (β = .236) had significant and moderate effects. This indicates that effective policies and quality of environment are main factors contributing to sustainability. Tourist satisfaction was added as a mediator in Model 2, and the results indicated that it partially mediates the connection between all independent variables and sustainable ecotourism (β = .326, $p < .001$). All determinants remained significant, which indicates partial mediation with tourist satisfaction empowering their effects. The explanatory power of the model increased from $R^2 = 0.420$ to 0.475 after adding tourist satisfaction, indicating its important role in connecting destination attributes to sustainable outcomes. Overall, these findings represent sustainable ecotourism in the Central Province.

5. Discussion

This finding indicates that the impact of key determinants of sustainable ecotourism is made through the partially mediating effect of tourist satisfaction. The natural environment strongly impacts tourist satisfaction, indicating that tourists in the sampled eco-resorts in Central Province value clean, scenic, and well-preserved surroundings. This aligns with, (Buckley R. C., 2011) who noted that the quality of the environment directly shapes visitor experiences and satisfaction. Moreover, the relationship between infrastructure and tourist satisfaction is weak but positive, indicating that well-planned facilities empower accessibility; however, excessive growth could damage the ecological charms of destinations (Bagri & Kala, 2015). Therefore, infrastructure must balance comfort with conservation in eco-destinations in Sri Lanka (Fernando et al., 2018). Additionally, culture and society indicate correlations with tourist satisfaction, representing that authentic cultural experiences and local hospitality contexts create emotional connections with visitors. Similar findings were noted by López-Sánchez and Pulido-Fernández (2016), who emphasized that cultural authenticity is a key factor in tourist loyalty. Management policy indicates a strong positive impact, showing that effective policies ensure genuine environmental practices, increasing trust and satisfaction among tourists (Lee & Moscardo, 2005; Nangulu, 2018). This is important for Sri Lanka, where "greenwashing" can reduce credibility. In the context of mediating effect, tourist satisfaction acts as a partial mediator, strengthening the connection between these factors and sustainable ecotourism. This supports the study of (Hoang, Nguyen, & Le, 2023)who noted that satisfaction links destination attributes with sustainable outcomes.

6. Recommendation of the study

According to this study, natural environment, tourism management policy, infrastructure,

and culture and society positively impact tourist satisfaction in the Central Province, as indicated by the correlation analysis. Therefore, the relevant tourism authority in Sri Lanka has to enhance these four factors to improve tourist satisfaction. Among these, culture and society have the impact on tourist satisfaction. The natural environment must be preserved and maintained via ecofriendly practices, including cleaning landscapes and biodiversity protection, to provide tourists with enjoyable and authentic experiences. In the context of infrastructure, tourism authorities should ensure destinations are well-equipped with basic utilities such as electricity, roads, and access to those destinations. Culture and society must be actively empowered by involving local communities in tourism activities. Initiatives such as organizing cultural events, showcasing local traditions, and engaging residents in tourism programs will strengthen the tourist experience. Under the management policy, a robust and sufficient legal system is significant. Local authorities must practice techniques to expand, monitor, and manage sustainable ecotourism development. Since tourism is a high-earning industry, authorities must adopt open policies to attract investment and create sustainable tourism product brands for the Central Province. The foreign investment in ecotourism will enhance the natural environment and landscapes at destinations. By motivating unique sustainable tourism products and services, authorities attract more tourists, enhance satisfaction, and empower the long period of sustainability of the ecotourism industry. Focusing on these areas will empower tourist satisfaction and promote the sustainable development of tourism in the Central Province.

7. Conclusion

This research study found that the natural environment, infrastructure, culture and society, and tourism management policy have a positive impact on tourist satisfaction in Central Province in Sri Lanka. Further, tourist satisfaction mediates the relationship between key determinants and sustainable ecotourism. This research study confirms that tourist satisfaction partially mediates the relationship between key determinants and sustainable ecotourism, indicating that enhancing tourist satisfaction empowers and strengthens the impact of environmental, infrastructural, cultural, and policy factors on sustainable ecotourism. These findings indicate that improving tourist satisfaction could strengthen the effectiveness of sustainable ecotourism activities. But there are some limitations of the study. The data were gathered by utilizing convenience sampling, which limits the generalizability of the findings to all eco-tourists in the Central Province.

3. References

Arachchi , R. (2019). The Effect of Green Practices on Tourists' Behavioral Intention:A Study of Hoteliers in Central Province of Sri Lanka. Peradeniya Management Review Vol. I, No.02.

Aliman, N., Hashim, S., Wahid, S., & Harudin, S. (2014). Tourist expectations, perceived Tourist expectations, perceived Effects on perceived value and satisfaction of tourists visiting Langkawi Island, Malaysia. Asian Journal of Business and Management,2(3). Retrieved from https://www.ajouronline.com/index.php/AJBM/article/view/1397

Angell, B. (2013). Behavioral theory. In Encyclopedia of social work.

Asker, S., Boronyak, L., Carrard, N., & Paddon, M. (2010). Effective community based tourism. A best practice manual for Peru. .

Bagri, S., & Kala, D. (2015). Toursim m satisfaction at Trijuginaraan . An emerging spiritual and adventure tourist destination in Garhwal Himalaya India. Turizam 19(4).

Bramwell, B. (2011). Governance,the state and sustainable tourism:A political economy approach. Journal of Sustainable Tourism,19(4/5).

Buckley, R. C. (2011). Tourism and Environment. doi:https://doi.org/10.1146/annurev-environ-041210-132637

Buckley, R., Castley , J., Pegas, F., Mossaz, A., & Steven, R. (2012). A population accounting approach to assess tourism contributions to conservation of IUCNRedlisted mammal species.

Crouch, G., & Ritchie, J. (1999). Tourism, competitiveness and societal prosperity. Journal of Business Research, 44(3).

Dao, K., Tran, T., Bui, T., Nguyen, D., & Nguyen, L. (2014). . The impact of local attributes on the satisfaction of investment enterprises: Evidence from Hai Duong. Journal of Economics and Development, 210(1).

Edgell, D. (2006). Managing sustainable tourism. A legacy for the future (3rd ed.). New York:Haworth Press. .

Elshaer, I., Moustafa, M., Sobaih, A., Aliedan, M., & Azazz, A. (2021). The impact of women's empowerment on sustainable tourism development: Mediating role of tourism involvement. Tourism Management Perspective, 38,Article 100815.

Gangananda, A., Wijesundara, W., Bandara, W., Pattiyagedara, P., & Ranatunga, R. (2022). The Impact of Corporate Social Responsibility (CSR) Dimensions on Brand Image of Hotels (Prospect of Local Community Established Around Hotels in Galle and Kandy Districts). Wayamba Journal of Management, Vol.13, Issue 2.

Gupta, V., & Bhawe, N. (2007). The influence of proactive personality and stereotype threat on women's entrepreneuria intentions. . Journal of Leadership & Organizational Studies, 13(4),.

Hall, D. (2003). Tourism and sustainable community development .

Hoang, T., Nguyen, N., & Le, T. (2023). Sustainability. 15(4).

Le, T. (2024). Influences of the ecotourism industry in Mekong Delta–Vietnam: The mediating role of tourist satisfaction. Cogent Business & Management, 11(1), .

Lee, W., & Moscardo, G. (2005). Understanding the impact of eco-tourism resort experiences on tourists'environmental attitudes and behavioral intentions. . Journal of Sustainable Tourism.

Lin, C., Morais, D., Kerstetter, D., & Hou, J. (2007). Examining the role of cognitive and affective image in predicting choice across natural, developed, and theme-park destinations. . Journal of Travel Research,46(2).

Mihalič, T., Šegota, T., Cvelbar, L., & Kuščer, K. (2016). The influence of the political environment and destination governance on sustainable tourism development:A study of Bled, Slovenia. Journal of Sustainable Tourism, 24(11).

McNamara, K., & Prideaux, B. (2011). Experiencing 'natural'heritage. .

Nangulu, H. (2018). Effect of stakeholders initiatives on sustainable tourism development in MT Elgon Region, Kenya(Master's Thesis). University ofEldoret. Retrieved from http://erepository.uoeld.ac.ke/handle/123456789/966

Nguyen , p., Nguyen , V., Phong , T., & Huynh , N. (2024). "Factors affecting sustainable ecotourism in Vietnam: Mediating role of tourist satisfaction and attractive destination". Environmental Economics,15(2).

Oliver.R. (1993). Cognitive, affective, and attribute bases of the satisfaction response. Journal of Consumer Research, 20(3.

Reisinger, Y., & Turner, L. (2003). Cross-cultural behaviour in tourism (1st ed.). New York, NY Routledge.

Stange, J., & Brown, D. (2012). Tourism destination management.Achieving sustainable and competitive results. USAID, The GeorgeWashington University, GSTA,and THEMIS. .

Suanmali, S. (2014). Factors affect ing tourist satisfaction: An empirical study in the northern part of Thailand. doi: https://doi.org/10.1051/shsconf/20141201027

Suherlan , H., & Hidayah , N. (2021). Destination image dimension: A descriptive analysis of foreign visitors at Borobudur, Indonesia. Journal of Indonesian Tourism and Development Studies, 9(2.

Suherlan, H., & Hidayah, N. (2021). Destination image dimension: A descriptive analysis of foreign visitors atBorobudur, Indonesia. Journal of Indonesian Tourism and Development Studies, 9(2).

Sukiman, M., Omar, S., Muhibudin, M., Yussof, I., & Mohamed, B. (2013). Tourist satisfaction as the key to destination survival in Pahang. . ProcediaSocial and Behavioral Sciences, 91.

Vengesayi, S., Mavondo, F., & Reisinger, Y. (2009). Tourism destination attractiveness: Attractions facilities, and people as predictors. Tourism Analysis, 14(5).

Voona, B., & Lee, N. (2009). Identifying dimensions of tourist satisfaction for a cultural destination Sarawak (Borneo). . International Journal of Business & Society,10(2).

Vuong, T., & Rajagopal, P. (2019). Analyzing factors affecting tourism Sustainable toursim sustainable development towards vietnam in the new era.

Yao, G., Huang, W., & Wang, X. (2013). Research on the development of tourism information inSingapore. . Journal of Nanjing University of Posts and Telecommunications (Social Sciences Edition),15(9).

Yuksek, G., Akkoç, i., , & Bayer, R. (2016). The effects of public transport performance on destination satisfaction. African Journal of Hospitality, Tourism and Leisure, 5(4).

JOURNAL OF TROPICAL ENVIRONMENT
Vol. 5, Issue i and ii, (December) 2025

Department of Environmental Management
Faculty of Social Sciences & Humanities
Rajarata University of
Sri Lanka

Analyzing the Present Status, Challenges, and Future Directions of Extension and Advisory Services in Ceylon Cinnamon Industry : A Systematic Review

Jayamini D.M.C.*[1] and Silva K.N.N.*[2]
[1]Faculty of Graduate Studies,
University of Ruhuna, Sri Lanka
[2]Department of Agriculture Economics and Agribusiness,
Faculty of Agriculture,
University of Ruhuna , Sri Lanka
*Jayaminidissanayaka2@gmail.com

Abstract

The economy of Sri Lanka is heavily dependent on the cinnamon industry and Ceylon cinnamon bring in foreign currency into the country. This study used 17 of methodical literature review using PRISMA method to identify the current status of extension services in the cinnamon industry, examine the challenges faced by extension and advisory services within the cinnamon industry, assess the existing policies and regulations governing these services, and suggest improvements to enhance the extension services in Sri Lanka's cinnamon industry. Moreover, there are few research articles emphasized the current situation, challenges and suggestions of extension services in Sri Lanka's cinnamon industry. Hence, this study offers significant insight for future researchers regarding the current status, challenges and suggestions to improve the extension and advisory services in the cinnamon industry. The research indicates that although public sector entities have effectively executed diverse extension initiatives, notable obstacles continue to exist. Financial limitations, poor infrastructure, poor communication, and a lack of workers are a few of these, and taken together they limit the sector's potential for growth and impair the best possible delivery of extension services. Moreover, to overcome these issues, policy support of government is determined to be vital, emphasizing the importance of more funding, the development of infrastructures of rural areas, and improved cooperation between the public agencies, academic

institutions, and private sector.it is important to address these challenges using technological evaluation and government policy intervention. By effectively responding these ongoing challenges, the Sri Lankan cinnamon industry can promote its long-term sustainability and future development.

Key words – *Cinnamon Industry, Digital Platforms, Extension Services, Policy Support, Public-Private Partnerships*

1. Introduction

Being an agricultural nation, Sri Lanka mainly depends on agricultural sector for its foreign exchange. Nevertheless, export crops have become more significant in Sri Lanka‘s agricultural export in recent years. Especially, Ceylon cinnamon acts an important role among the export crops and helps to generate more foreign exchange than other export crops (Hewavitharana *et al*., 2022).

After black pepper, cinnamon is considered as the second most important spice in European and North American trade (Jayaprakasha *et al*. 2007). Two kinds of cinnamon mainly exist in the world market. The first type is obtained from the inner bark of *Cinnamomum verum* (also called *Cinnamomum zeylanicum* Blume Berchthold & Presl) is more specifically known as Ceylon cinnamon, Sri Lankan cinnamon, or even true cinnamon. This variant is native to Sri Lanka and as well grows in Madagascar, and the Seychelles (Pathirana and Senaratne., 2020). Globally famous true cinnamon mainly originates from the genus *Cinnamomum* Schaeffer, a member of the family *Lauraceae*. The family *Lauraceae* is made up essentially of woody evergreen trees and shrubs, with the exception of the herbaceous *hemiparasite Cassytha*. There are approximately 53 genera and 2,500-3,000 species in the *Lauraceae* family, many of which are found in tropical and subtropical areas in Sri Lanka (Pathirana and Senaratne., 2020). Moreover, Cinnamon played an important role in the Sri Lankan economy from the 13th to the 19th century. It was a vital product in the expanding trade across the Indian Ocean (Dewasiri *et al*., 2020). Currently, cinnamon is the fourth key export crop in Sri Lanka and the top ranking spice contributing to foreign exchange earnings. Known as "True cinnamon" or "Pure cinnamon," it is the only product where Sri Lanka maintains a monopoly in the global market (De Silva and Esham., 2020)

In terms of both primary and value- added forms of Ceylon cinnamon, such as chopped pieces, powder, oil, tablets, and crushed form (Spice Council of Sri Lanka, 2014). Export Development Board, (2014);. Sachitra, and Chong., (2016) reportedly stated that Sri Lanka exports cinnamon worth USD11, 860 million on average annually. Threfore, Ceylon cinnamon is very important crop for agriculture based countries such as Sri Lanka. Although this sector constitutes an important segment of the rural economy, efficient disbursement of knowledge and support through extension services has not obtained adequate research interest. Previous research is mainly concerned with crop issues and

marketing opportunities.

Furthermore, the cultivation of the true cinnamon is generally grown in the intermediate and wet zones of Sri Lanka, including Galle, Matara, Ratnapura, Hambantota and Kalutara districts. According to the Central Bank of Sri Lanka (2019a); De Silva and Esham (2020), the total area under Ceylon cinnamon cultivation was nearly 33,000 hectares which produced an average annual production of 24,000 Mt. The cinnamon cultivation was generally located in Galle district (35%), Matara district (27%), Ratnapura district (12%), Kalutara district (6%), and Hambantota district (6%). The Southern Province alone contributed nearly 70% of the total cinnamon production (Samaraweera *et al*., 2020).Moreover, Sri Lanka produces around 17,000 tons of cinnamon bark per annum. Almost 90% of this is exported mainly as quills with very minimal value addition. A handful of countries in South and North America are the principal importers, with Mexico alone taking up 70% of the exports (Pathirana and Senaratne., 2020).

1.2. Problem Statement and Objectives of the study

The Export Development Board (EDB) was engaged in branding and promotional activities to improve the export potential of true cinnamon, while the Department of Export Agriculture (DEA) was actively involved in promoting its cultivation. Nevertheless, the previous government decided to segregate the cinnamon section from the DEA and created a separate department as the Department of Cinnamon Development for the development and promotion of the cinnamon industry under the Cabinet Paper No. 23/1501/601/050. When considering the present situation of the cinnamon industry in Sri Lanka, the Department of Cinnamon Development is working as an independent body from the Department of Export Agriculture (IFC report., 2024).There is a need to develop extensive research, which can not only reveal the current state of extension and advisory services or untangle the factors that the existing policies for such services are going to meet, but also assess those policies. This research closes this gap by affording a comprehensive account of the situation and proposing measures to improve the efficiency and viability of extension services in the cinnamon value chain. This study aimed,

- To identify the current status of extension services in the cinnamon sector
- To examine the challenges faced by extension and advisory services within the cinnamon industry, assess the existing policies and regulations governing these services

To suggest improvements to enhance extension and advisory services in the cinnamon industry.

Furthermore, a less number of research work has been published regarding extension and advisory services for cinnamon industry. This underlines the relevance of this study that fills a significant gap in the existing understanding and helps to design appropriate infrastructure for supporting the sector.

2. Methodology

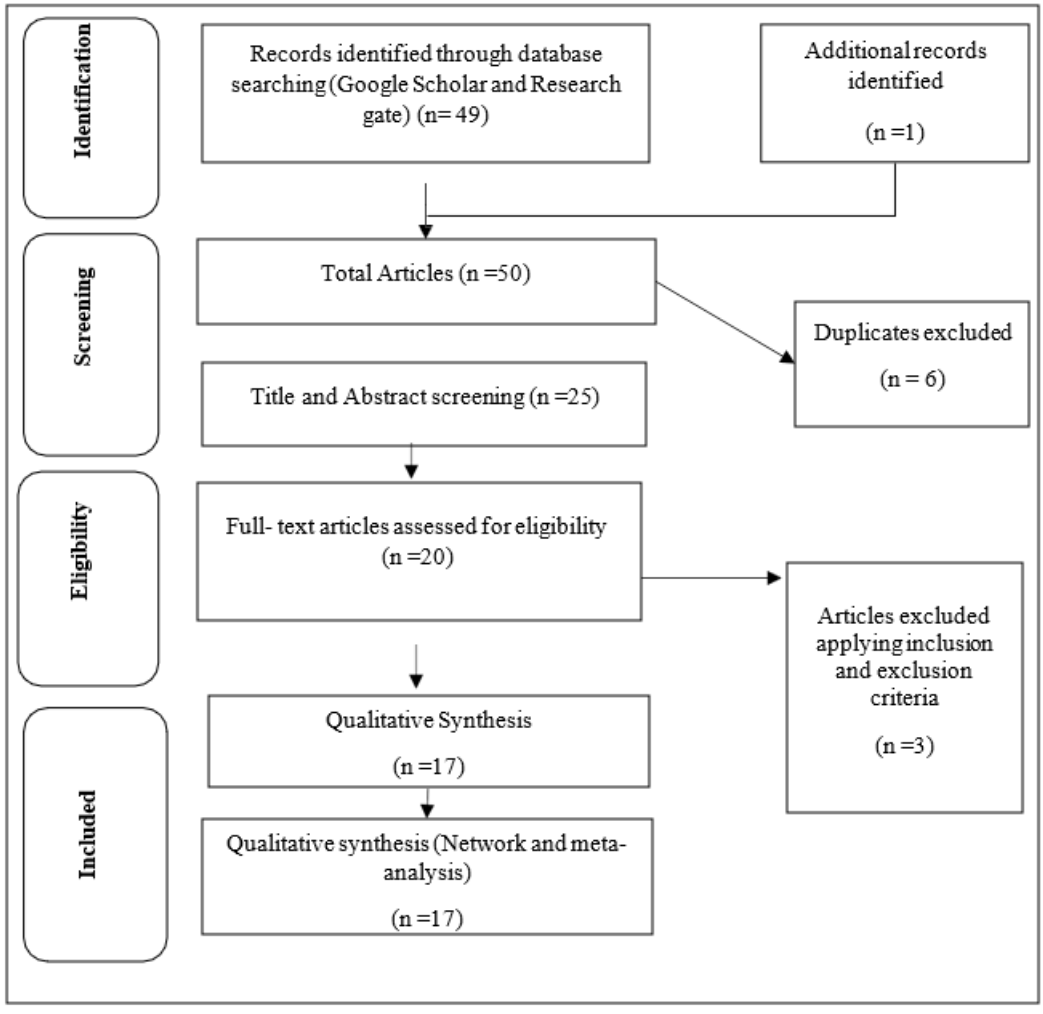

Figure 1 – PRISMA flow chart of the systematic review

The systematic literature review approach was used to this review article in order to evaluate Sri Lankan cinnamon industry and its extension and advisory services. This systematic literature review was conducted using recommended PRISMA guideline (Liberati et al., 2009). The selected approach is useful for enhancing the reliability and decreasing the possibility of mistakes in calculations (Abigail et al., 2015; Patel, 2021). The review followed

five main steps, as shown in Figure 1: There are five key steps they suggested including (i) defining research objectives, (ii) database selection, (iii) identification of relevant keywords, (iv) identification of appropriate journal articles and (v) information extraction (Sina and Nazemi, 2022).

According to the figure 1, the research objective was to identify the current status of extension services in the cinnamon sector by focusing on several areas including, 1) examine the challenges faced by extension and advisory services within the cinnamon industry, 2) assess the existing policies and regulations governing these services, and 3) suggest improvements to enhance extension and advisory services in the cinnamon sector. To achieve these objectives, Google Scholar and Research Gate were used as the databases for collecting studies related to the research objectives. Moreover, Google Scholar and Research Gate were used as the primary data bases due to their wide and free accessibility and direct coverage. Articles were searched using the search string / Boolean operation of "cinnamon" AND "minor export spices crops" AND "contribution of extension services" AND "role of extension services" AND "challenges" AND "barriers AND in Sri Lanka NOT Other South Asian countries". It resulted 49 articles. Finally, selected 17 articles with a focus on relevance and English language papers were used for this systematic literature review, focusing on the key areas. Moreover, this systematic literature review is based on articles published between 2005 to 2024 years.

3. Review Findings

3.1. Extension Services in Agriculture

Extension programs primarily involve advice, practical training, and the dissemination of research-based technical knowledge. The extension explains that it is intended to provide rural men, women, and youth with the necessary and demand-based knowledge and skills in formal, non-formal, and collaborative settings in order to enhance farming capacity and raise living standards and productivity (Kazbekov & Qureshi, 2011; Waddington et al., 2014). Moreover, A non-formal educational approach known as "Agricultural Extension" is used gradually to raise farmers' and their families' standard of living by boosting the output and profitability of their farms. Farmers are expected to refine their agricultural technology, farming techniques, and agricultural marketing knowledge, skills, and attitudes in order to meet the objectives outlined above (Herath et al., 2021; Mahaliyanaarachchi & Bandara, 2010).

Over the past few decades, national governments and international development organizations have funded and implemented a wide range of extension models, strategies, and programs. A large number of these initiatives have proven successful and have improved livelihood options and agricultural productivity for Sri Lanka's farming community, thereby elevating their standard of living and contributing to sustainable development (Madan & Maredia, 2021). While many research institutes concentrate on creating technologies that will help increase production, technology dissemination programs, or "extension," concentrate on introducing

technologies that will be accepted by relevant stakeholders. Strong extension services are essential for the work in field-focused methods, and strong applied agricultural research institutions are necessary for the extension services to continue serving the agricultural communities (Qamar, 2005).

Another area (village) with a coconut grove is Magananakarika. Magananakarika is probably the same as Ptolomy's Margana, placed south of Moduttou, probably Mahatittha (Manthei – Mannar). The name takes the form of Mangana in Pali. In the Sihalavatthuppakarana, it is said to have been five yojanas from Anuradhapura (SVP, 1959: 168). The name is also found in King Vasaba's inscription of Sinna – Andiyagala. Nicholas thinks that the remains at Mullikulam at the mouth of Modaragam Aru are these of Magana (Paranavitana, 1983:31- 34).

In addition to these two locations, coconut groves were present at Napakiliya, Punaka, Karabadara, and Aganagama, as named in the inscription. This allows us to decide that Sri Lanka had separate coconut groves at the beginning of the first century AD. The story in the Samantapasadika also mentioned that coconut was very plentiful in Antarasamudda, and coconut would have been introduced to Sri Lanka a long time ago, before the first century AD. Another physical archaeological evidence at Mihintale proves coconut had been used for religious and other purposes before the first century A.D., i.e., stone bas – relief sculpture of the eastern frontispiece of the Kantaka Cetiya stupa. Neither the builder nor the date of the building of stupa is known definitely. The Mahavamsa mentions that King Devanampiyatissa (250 – 210 B.C.) prepared sixty-eight caves as dwellings for monks in the place of Kantaka Cetiya and its periphery (MV, 16, 12) while King Lanjitissa (119 – 109 B.C.) enlarged the stupa by a stone cover (Kanncuka-blouse) (MV, 33, 25). Accordingly, the stupa would have been built in between the reign of these two kings. The powerful and devoted kings in the period were Devanampiyatissa (250 – 210 B.C.), Uttiya (210 – 200 B.C.), Dutthagamini (161 – 137 B.C.), Saddhatissa (137 – 119 B.C.), and Lanjitissa (119-109 B.C.). King Lanjitissa succeeded King Saddhatissa. If Saddhatissa built the stupa, there was no need to repair or enlarge it immediately after it was built. All religious activities done by Dutthagamini were ascribed in detail in the Mahavamsa without mentioning this stupa which implicitly reflects that the stupa may not built by the same king. Two brothers of kings, i.e., Devanampiyatissa and Uttiya, kept a closer relation with Mihintale than any other ruler, and they have built several buildings, including stupas, according to the chronicles and archaeological evidence.
The above factors allow to conclude that the kings, either Devanampiyatissa or his successor Uththiya, built Kantaka Cetiya and four frontispieces in the third century B.C. Otherwise, the frontispieces would have been built by King Lanjitissa, who enlarged the stupa in the second century B.C. The above-mentioned frieze of the stone bas relief is sculptured at the upper part of the eastern frontispiece of the Kantaka Chethiya which was also belongs to the same period of the king.

There is a seated figure of God Ganesha (lyar-lyyanayaka), i.e., God of the wisdom of the Hindu pantheon of gods, in the center of the frieze. This is the oldest figure of God Ganesha in Sri Lanka, and it is the only Buddhist monument ever found with the figure of Ganesha (Lagamuwa, 2009: 104-106). Either side of him has two queues of male devotees coming towards the Ganesha with meritorious goods in their hands. Those are a stick of sugar cane (*Saccharum officinarum),* a fruit of mango (*Mangifera indica*), a bunch of plantain (*Musa sapientum*), a pot of water, and a fruit of the coconut, which he likes to eat and drink. He prefers coconut over other edibles. Coconut is also closely related to the cult of God Ganesha. Therefore, nothing is offered to him without coconut, even with no other meritorious goods.

3.2. Previous and Current Status of Extension Service in the Cinnamon Industry

In Sri Lanka, public sector organizations such as the Department of Export Agriculture (DEA) and the Sri Lanka Export Development Board (EDB) were primarily responsible for providing extension services to the cinnamon industry, although there is also some private sector involvement. Important export commodities for the nation, such as cardamom, cloves, cinnamon, and pepper, are the main focus of these services. Moreover, Department of Export Agriculture (DEA): The DEA was a major source of technical knowledge for the cultivation of cinnamon. Advice on best agricultural practices, managing pests and diseases, post-harvest procedures, and sustainable production methods were given by their extension officers. In order to encourage the use of cutting-edge technologies and better spice varieties, they also hold field trips, training sessions, and demonstrations. In order to assist growers and processors, the Spices and Allied Products Producers' Association (SAPPTA) collaborates closely with the EDB and other stakeholders. In order to provide better market access, SAPPTA works to close the gap between growers and exporters and promote higher quality standards (EDB report, 2023).

Under the Cabinet Paper No. 23/1501/601/050 , The Department of Cinnamon Development was separated from Department of Export Agriculture by previous government to give more attention for the cinnamon industry and currently, Department of Cinnamon Development is working as an independent government body (IFC report .,2024).

3.3. Role of Extension Officers in the Cinnamon Industry

Extension and advisory officers are important to the cinnamon sector, they serve as a bridge between farmers and other stakeholders in the cinnamon industry. By facilitating the sharing of best practices and knowledge, their main objective is to enhance agricultural productivity and quality in the cinnamon industry. Sharing current and pertinent information with farmers about pest control, irrigation methods, market trends, and enhanced agricultural practices is one of their main duties. Through better decision-making enabled by this knowledge, farmers are able to increase the quantity and quality of their Cinnamon production. (Wanigasundera & Atapattu, 2019).

3.4. Challenges in Extension and Advisory Services within the Spice Industry

Financial constraints and inadequate infrastructure, present major challenges for extension services in the spice industry, especially in the cinnamon industry. (EDB report, 2023). Furthermore, farmers are frequently difficult to be reached through extension services when it comes to pertinent agricultural practices and market information (Wanigasundera & Atapattu, 2019). Marambe *et al*., (2020) and Senaratne & Pathirana., (2021) noted that staffing shortages (inadequate extension officers and shortage of trained officers) are a major issue facing advisory and extension services in the cinnamon industry. This staffing shortfall makes it more difficult to provide services to farmers in an efficient manner, which in turn hinders productivity and sectoral development. Farmers are unable to receive the necessary support, training, and direction.

Moreover, Samarawickrema (2015) noted that there's some information on the cinnamon supply chain but due to a lack of a consolidated database this is a real challenge especially when trying to get comprehensive information that will allow for an efficient sectoral analysis of the cinnamon supply chain. EOs frequently visited the cinnamon field where the office was often on the roadside as compared to the interior part. Hence, it is one of the significant causes for the poor extension and advisory services in the sector of cinnamon in Sri Lanka (Mohomad *et al*, 2019). Raw quill remains the main source of earnings for Cinnamon, despite advances made in the sector, value addition is at a low level because of inadequate market information, quality standards, skills, equipment, and capital. Lack of adequate extension and advisory services is worse in enhancing these challenges hence making it hard to come up with barriers to value addition (Senaratne & Pathirana., 2021). A key barrier is the shortage of both skilled and unskilled labor in cinnamon industry, further aggravated by inadequate training opportunities and extension services (Gunasekare *et al*., 2020).

3.5. Policy Support for Extension Services in the Cinnamon Sector

The creation and execution of policies that improve extension services' ability to satisfy farmers' changing needs ought to be a top priority for policymakers. Moreover, this entails setting aside enough funds for educational initiatives, enhancing facilities, and making contemporary technology more accessible. In order to guarantee that extension services are well-coordinated and responsive to market demands, policies should also encourage cooperation between government agencies, research institutes, and agricultural organizations. Policy support has the potential to greatly improve the efficacy of extension services by creating an enabling environment, which will ultimately raise productivity and quality in the cinnamon sector (Senaratne & Pathirana., 2021).

3.6 Future Trends and Recommendations for Enhancing Extension Services

Enhancing extension services in Sri Lanka's cinnamon industry is expected to be greatly aided by the integration of digital platforms and mobile applications. These technologies will make it easier for farmers to quickly make informed decisions by facilitating the dissemination of real-time information on market prices, weather forecasts, pest management techniques, and best agricultural practices (Mohomad *et al*, 2019). It is crucial to create thorough training programs that integrate contemporary agricultural methods, business acumen, and sustainable farming methods in order to improve extension services (Senaratne & Pathirana., 2021). Furthermore, advised is the promotion of farmer cooperatives, which increase farmers' negotiating power by giving them group access to markets, resources, and training. In order to evaluate the success of extension services and incorporate farmer feedback for ongoing program improvement, it is also essential to put monitoring and evaluation systems in place (Wanigasundera & Atapattu, 2019). Additionally, expanding the mapping of cultivated areas and improving the reach of extension services require strengthening public-private partnerships, especially with groups like the Spice Council. These kinds of partnerships can facilitate the creation of focused training programs that cater to the particular requirements of regional farmers and enhance the distribution of resources (EDB report, 2023).

Moreover, a promising suggestion is to educate and train cinnamon peelers to improve their knowledge in producing higher-grade quills. To supplement this, the Sri Lankan government could further strengthen the certification system for peelers, in collaboration with the Vocational Training Institute of Sri Lanka, the Spice Council of Sri Lanka, and the University of Ruhuna, in order to transform the traditional cottage industry into a more market-oriented approach (Weerasinghe and Pushpitha,., 2020). At the same time, it will be relevant to explore cooperation possibilities with foreign firms ready to invest in local farmers' training and help them obtain certification for the cinnamon industry (Gunasekare *et al*., 2020). Establishment of centers of excellence and training facilities to encourage technology transfer, create awareness, and ensure quality assurance, establishment of village-level quality testing centers would help in building local capacity for maintaining standards (Weerasinghe and Pushpitha,., 2020).

Table 01: Role, Challenges, Policies and future trends of extension and advisory services in cinnamon industry

Description	Main Findings	References
Extension Services in Agriculture	Extension programs primarily involve advice, practical training, and the dissemination of research- based technical knowledge.	Kazbekov & Qureshi, 2011 Waddington et al., 2014
	Agricultural Extension" is used gradually to raise farmers' and their families' standard of living by boosting the output and profitability of their farms	Herath et al., 2021 Mahaliyanaarachchi & Bandara, 2010 Madan & Maredia, 2021
	National governments and international development organizations have funded and implemented a wide range of extension models, strategies, and programs to improve farmers' livelihood pattern.	Qamar, 2005
	Strong extension services are essential for the work in field-focused methods, and strong applied agricultural research institutions are necessary for the extension services to continue serving the agricultural communities.	
Previous & current situation of extension services in cinnamon industry	DEA and EDB were primarily responsible for providing extension services to the spices industry Currently, Department of cinnamon Development was established to promote the cinnamon industry and currently DCD acts as independent government body.	EDB report ,2023 IFC reports , 2024
Role of Extension Officers in the cinnamon industry	Extension officers are essential to the spice industry because they serve as a bridge between farmers and other stakeholders such as politicians, researchers, and market associations	Wanigasundera & Atapattu , 2019
Challenges in extension and advisory services within the cinnamon industry	Financial constraints and inadequate infrastructure for extension and advisory Services in spice industry	EDB report ,2023
	Difficult to reach agricultural practices and market information.	Wanigasundera & Atapattu , 2019

	Lack of staff of extension and advisory service in cinnamon industry	Senaratne & Pathirana., 2021 Marambe *et al*., 2020) Mohomad *et al*,2019
	Lack of databases for cinnamon industry	Samarawickrema .,2015
	Lack of extension services for value added production.	Senaratne & Pathirana ., 2021 Gunasekare *et al*., 2020
Policy Support for Extension Services in the Spice Sector	Policy support has the potential to greatly improve the efficacy of extension services in cinnamon industry	Senaratne & Pathirana ., 2021
Future Trends and Recommendations for Enhancing Extension Services	Digital platforms and mobile applications for extension services in cinnamon industry.	Mohomad *et al*,2019
	create thorough training programs that integrate contemporary agricultural methods, business acumen, and sustainable farming methods in order to improve extension services	Senaratne & Pathirana ., 2021
	promotion of farmer cooperatives and increase farmers' negotiating power by giving them group access to markets, resources, and training	Wanigasundera & Atapattu , 2019 EDB report ,2023
	Strengthening public-private partnerships	Weerasinghe and Pushpitha, ., 2020
	Educate and train cinnamon peelers to improve their knowledge in producing higher-grade quills	Gunasekare *et al*., 2020
	Explore cooperation possibilities with foreign firms ready to invest in local farmers' training	

4. Limitation of the Systematic Review

One of the major limitations of this systematic review is the Shortage of published research articles, specifically related to the extension and advisory services in the cinnamon industry. Since the separation of the cinnamon sector from the Department of Export Agriculture (DEA), there is a noticeable gap in the literature, with limited evidence of focused academic investigation in this field. Furthermore, there are common scarcity of the research on the extension services even within the broader domain of export crops. Hence, this systematic review was constrained by the lack of empirical data, evidence and peer-reviewed literature articles. Nevertheless, this gap emphasizes the need for future investigation and highlights the potential and value of this review to offer critical insights and direction for future researchers in this overlooked field.

5. Conclusion

In Sri Lanka's cinnamon industry, extension services are essential in raising agricultural productivity and boosting farmers' income. Previously, the extension and advisory services of the cinnamon industry was done by the Department of Export Agriculture (DEA) and the Sri Lanka Export Development Board (EDB). Presently, the Department of Cinnamon development acts as an independent government body. However, the cinnamon industry faces a number of difficulties despite the important contributions made by extension officers in bridging the gap between farmers and stakeholders by providing vital information.

Notably, the efficient provision of these services is hampered by budgetary limitations, inadequate infrastructure, and a lack of personnel. These restrictions make it more difficult for farmers to get the instruction, advice, and technical assistance they need to raise the caliber and yield of their spice crops. The gap between extension services and farmers is made worse by ineffective communication, which also limits the sector's ability to grow and respond to changing market demands. The support of policy is essential to addressing these problems. The development of infrastructure, the provision of sufficient funding, and the availability of contemporary technologies must be given top priority by policymakers, who should also encourage partnerships between public agencies, academic institutions, and private businesses. Additionally, a promising path toward enhancing the distribution of real-time information and helping farmers make more informed decisions is the integration of digital platforms and mobile applications. Enhancing the efficacy of extension services will also require the development of monitoring and assessment mechanisms as well as the encouragement of farmer cooperatives. Enhancing public-private collaborations, especially with groups such as the Spice Council, can additionally enable focused instruction and distribution of resources adapted to regional requirements.

Conclusively, although there have been significant advancements in the extension services within Sri Lanka's cinnamon industry, it will be imperative to tackle the issues of insufficient workforce, restricted resources, and communication deficiencies to guarantee continued expansion in the agricultural sector. Extension services can continue to improve the productivity, quality, and sustainability of the cinnamon industry with the right policy support and the adoption of cutting-edge technologies.

07. References

Abigail, M.E.A., Samuel, S.M. and Ramalingam, C., (2015). Addressing the environmental impacts of butachlor and the available remediation strategies: a systematic review. International journal of environmental science and technology, 12, pp.4025- 4036.

Chavasit, V. and Photi, J., (2018). Condiments and sauces. In Food fortification in a globalized world (pp. 153-158). Academic Press.

Dewasiri, N.R., Wagenaar, L.J. and Uyangoda, J., (2020). Historical, ethno-botanical and social aspects of cinnamon cultivation in Sri Lanka. Cinnamon: Botany, Agronomy, Chemistry and Industrial Applications, pp.39-61.

Export Development Board (2023) National Export Strategy of Sri Lanka: Spices and Concentrates Strategy. Colombo: Export Development Board. https://www.srilankabusiness.com/pdf/nes/sri-lanka-spices-and-concentrates-4-2- web.pdf

Gunasekare, K., de Silva, S. and Runage, R., (2020). Public-Private Partnership in Growth and Development of Cinnamon Industry in Sri Lanka. Cinnamon: Botany, Agronomy, Chemistry and Industrial Applications, pp.349-361.

Herath, M.M., Ahmad, N., Hassan, M.M. and Jaafar, W.M.W., (2021). Agricultural Extension among the Farming Community in Sri Lanka. International Journal of Academic Research in Business and Social Sciences, 11(11), pp.1819-1835. http://dx.doi.org/10.6007/IJARBSS/v11-i11/11663

Hewavitharana, S. D., Kuruppu, I. V., & Priyankara, E. A. C., (2022). Assessment of Sri Lankan Cinnamon Export Competitiveness in the Global Market. Sri Lankan Journal of Agricultural Economics, 23(1).https://doi.org/10.4038/sjae.v23i1.4658

International Finance Corporation (IFC) - World Bank Group., (2024). Baseline Export Assessment Report Sri Lanka Ceylon Cinnamon:A custom report compiled. https://www.ifc.org/en/pressroom/2024/ifc-partnership-drives-ceylon-

cinnamon- exports-to-reach-high-val

Jayaprakasha, G.K., Negi, P.S., Jena, B.S. and Rao, L.J.M., (2007). Antioxidant and antimutagenic activities of Cinnamomum zeylanicum fruit extracts. Journal of food composition and analysis, 20(3-4), pp.330-336.

Kazbekov, J. and Qureshi, A.S., (2011). Agricultural extension in Central Asia: Existing strategies and future needs (Vol. 145). IWMI.

Lankage J (2017) How to identify Ceylon cinnamon and why cinnamon should be consumed instead of cassia. Sri Lanka ExporterChavasit, V. and Photi, J., 2018. Condiments and sauces. In Food fortification in a globalized world (pp. 153-158). Academic Press.

Madan, S., & Maredia, K., (2021). Global Experiences in Agricultural Extension , Community Outreach & Advisory Services. Case Studies of Global Experiences in Agricultural Extension Training & Visit Model of Extension in Developing Counties. In innovations in agricultural extension (pp. 1–16). Michigan State University.

Mahaliyanaarachchi, R. P., & Bandara, R. (2010). Commercialization of Agriculture and Role of Agricultural Extension. Sabaragamuwa University Journal, 6(1), 13–22. https://doi.org/10.4038/suslj.v6i1.1686

Marambe, B., Weerahewa, J. and Disna, A.P.P., (2020). Planning and Strategic Policy Interventions for Building a Globally Competitive Cinnamon Industry in Sri Lanka. *Cinnamon: Botany, Agronomy, Chemistry and Industrial Applications*, pp.407- 434.

Mohamed, M.A., Indika, W.A., Sugathadasa, L. and Senaratne, R., (2019). Minimizing issues and information gaps in value chain of cinnamon industry in Sri Lanka through ICT based intervention: A case study. *Journal of the University of Ruhuna*, *7*(2), pp.63-75..

Patel, H., (2022). Comparison of batch and fixed bed column adsorption: a critical review. *International Journal of Environmental Science and Technology*, *19*(10), pp.10409-10426.

Qamar, K. . (2005). Modernizing National Agricultural Extension Systems: A practical guide for policy- makers of developing countries. Research, Extension and Training Division Sustainable Development Department, Food and Agriculture Organization of the United Nations.

Sachitra, K.M.V. and Chong, S.C., (2016). Enhancing competitive advantage of Sri Lankan minor export crops.

Senaratne, R. and Pathirana, R. eds., (2021). *Cinnamon: Botany, Agronomy, Chemistry and Industrial Applications*. Springer Nature..

Sina, L.B. and Nazemi, K., (2022), July. Visual analytics for systematic reviews according to prisma. In *2022 26th International Conference Information Visualisation (IV)* (pp. 307- 313). IEEE.

Waddington, H., Snilstveit, B., Hombrados, J., Vojtkova, M., Phillips, D., Davies, P., & White, H. (2014). Farmer Field Schools for Improving Farming Practices and Farmer Outcomes: A Systematic Review. Campbell Systematic Reviews, 10(1), 217–336. https://doi.org/10.4073/csr.2014.6

Waddington, H., Snilstveit, B., Hombrados, J., Vojtkova, M., Phillips, D., Davies, P., & White, H. (2014). Farmer Field Schools for Improving Farming Practices and Farmer Outcomes: A Systematic Review. Campbell Systematic Reviews, 10(1), 217–336. https://doi.org/10.4073/csr.2014.6

Wanigasundera, W.A.D.P. and Atapattu, N., (2019). Extension reforms in Sri Lanka: lessons and policy options. In *Agricultural extension reforms in South Asia* (pp. 79-98). Academic Press.https://doi.org/10.1016/B978-0-12-818752-4.00005-9

Weerahewa, J. And Punyawardena, B.V.R., A REVIEW OF RESEARCH ON Homegardens IN SRI Lanka: The Status, Importance And Future Perspective.

Weerasinghe, K.D.N. and Pushpitha, N.P.G., (2020). Cinnamon process technology. *Cinnamon: Botany, Agronomy, Chemistry and Industrial Applications*, pp.233-250

JOURNAL OF TROPICAL ENVIRONMENT
Vol. 5, Issue i and ii, (December) 2025

Department of Environmental Management
Faculty of Social Sciences & Humanities
Rajarata University of
Sri Lanka

Impact of Social Networks on Agricultural Technology Adoption: A Case Study of Ongoing Extension Programs for Paddy Cultivation in Matara District

Seram P.S.S.N.[1*]
Silva K.N.N.
Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Sri Lanka
* seram4827@ags.ruh.ac.lk

Abstract

This study investigates the influence of social networks on the agricultural technology adoption of new sustainable agricultural extension programs among paddy farmers in Matara District. The study's specific objectives are to assess technological acceptance in existing extension programs among three areas in Matara district, measure the impact of social network density and centrality on adoption, investigate factors influencing the relationship between Agricultural Instructors (AI) and farmers and give suggestions to improve agricultural technology adoption among paddy farmers in Matara district. Purposive sampling was used to select three AI divisions from Matara North, Matara Central, and Matara South, simple random sampling was used to choose 25 farmers from each area, and data was obtained via pre-structured interviews. Social network analysis (SNA) was analyzed with UCINET 6.773 software to analyze the network, and Chi squared test and Spearman Correlation Coefficient test was used for inferential analysis. Chi squared results revealed that the technology adoption among three areas in Matara district ($\chi^2 = 8.948$, $p = 0.011$) is varied and *Matara North* has the highest adoption rate (82%). Social network density has a significant impact ($\rho = 1.00$, $p=0.00$) on agricultural technology adoption of paddy farmers. However, the centrality of AI officers did not show a relationship with technology adoption ($\rho=-0.500$, $p=0.667$), suggesting that trustworthiness may limit their relationship. The study finds that introducing training programs are critical to improve agricultural technology dissemination

in the district. These findings make meaningful recommendations for future extension services and policy interventions focused on improving sustainable paddy farming methods in the Matara District.

Key Words: *Social Network, Agricultural Extension, technology adoption, paddy farming*

1. Introduction

Sri Lanka is a developing country, and most people are involved in subsistence farming and commercial agriculture, which is very rare. The major aim of developing countries should be to increase productivity in farming activities due to fewer inputs. Applying modern and sustainable agricultural technologies is the best solution to increase agricultural productivity in developing countries (Boahene, Snijders and Folmer, 1999; Doss and Morris, 2000; Todo, Matous and Mojo, 2014). Extension is an informal educational role that pertains to any organization that shares knowledge and makes recommendations to encourage learning. It is typically linked to rural development, agriculture, fisheries, and aquaculture (Maulu et al., 2021). And also, normally new agricultural technologies are introduced to farmers as packages (Afranaa Kwapong & Ankrah, 2023).

Agricultural extension officers' responsibilities include educating farmers, enhancing their abilities using a range of communication techniques, and assisting them in making some important decisions. Offering information on sustainable agriculture education can be greatly aided by the extension services (AL-Sharafat, Altarawneh and Altahat, 2012). Extension services support farmers, their organizations, and other market participants in gaining access to knowledge, information, and technologies; support their collaboration with partners in agribusiness, education, research, and other establishments, and help them establish their own technological, organizational, and management techniques and abilities (Umeta, 2013). One of the key elements in helping farmers raise their output and productivity is extension contact, which serves a variety of purposes, including keeping farmers' knowledge and skills up to date and connecting them with marketing organizations and input suppliers (Umeta, 2013).

Rice is the staple food in Sri Lanka, and paddy cultivation is the main income source of most farmers. In 2024, the average rice yield in Sri Lanka is 3,893 kg per net hectare and the total production is 1,976,496 metric tons for Yala season (Department of Census and Statistics, 2024). For Maha Season, the average rice yield is 3,712 kg per net hectare and the total production is 2,721,958 metric tons (Department of Census and Statistics, 2024).
In the Southern Province, paddy is mainly cultivated as the main economic crop (Silva and Gunasekara, 2022). However, paddy production is deficient in the Matara district because some paddy lands are not well functioning in the Matara district, and farmers face a lot of problems while doing their paddy farming practices to reach sustainable levels. Reasons for

that are a lack of irrigation facilities, acid sulfate accumulation in the lowlands, iron toxicities in the highlands, weedy rice problems, and high costs for inputs and operations. Soil is mainly composed of shallow and bog soil, and therefore, water drainage problems affect the paddy cultivation in the Matara district (Silva and Gunasekara, 2022).

Some paddy lands near the coastal area are lower than the sea level, so water cannot flow from the paddy lands to the sea. Due to that, acid sulfates accumulate in paddy lands. Due to soil erosion in hilly areas, iron accumulates at the bottom of the slopes, and then iron toxicity occurs in hilly areas. Other than that, water is the primary input that limits rice production. Irrigation systems in Sri Lanka range in size from modest village-based systems to extremely large reservoirs. Low-rainfall areas that cannot receive water from the main irrigation systems are largely dependent on the village irrigation systems (VIS) (Gedara et al., 2012).

There are some extension programs for the agricultural sector in Sri Lanka, and some of them were introduced in the Matara District to improve profitability in the paddy farming sector by providing solutions to the above problems. They are the Certified Seed Production Program, *Yaya* Development Program, Self-seed Paddy Production Program, Weedy Rice Program, and Good Agricultural Practices (GAP) Program (Ministry of Agriculture Sri Lanka, 2024). Currently, the *Yaya* Development Program, Weedy Rice Program, and GAP Program are actively conducted in many areas of the Matara District.

However, dissemination of information is very poor in these programs among farmers, and not every farmer has a clear image of these programs. According to Besley & Case, 1993 and Conley & Udry, 2010 farmers learn from their own experimentation and from Agricultural extension services, and also, externalities play an important role in disseminating agricultural technologies among farmers. Formal institutions have a significant impact on technology dissemination, but peer farmers and their social network have a great impact on agricultural technology adoption among them (Zhang et al., 2020). Therefore, in this research study, the social network of paddy farmers in the Matara district which are included in these three programs was analyzed to find the impact of social networks on agricultural technology adoption of paddy farming programs in *Matara* district and the results of this study will be helpful for future decision making in extension services.

If the network members are closer, their effect is greater than that of distant members, and due to that, having more close friends is highly productive for agricultural technology dissemination (Ward and Pede, 2015). Centola (2010) investigated that social network impacts are greater in the last adoption stage than in the information diffusion stage. Farmers depend more on peers than extension officers to get information because farmers tend to trust their peers. The reason for this is that peers frequently interact with farmers, and extension officers rarely come to visit farmers. Regarding extension officers, the most important thing is trustworthiness, and frequency has less influence (Ward and Pede, 2015; Todo, Matous and Mojo, 2014).

A social network is an effective abstraction of the structure and dynamics of various types of interpersonal connection and interaction (Marcin and Niewiadomska, 2016). Social network analysis (SNA) is a significant and helpful approach for extracting knowledge from large amounts of unstructured data of a social network. Graph theory is the main concept that provides a mathematical background for the SNA. Social networks and peer effects are key determinants of human behavior in a range of circumstances in both developing and developed countries (Bandiera and Rasul, 2006).

There are some special terms and measurements used in Social Network Analysis, and some of them are nodes, ties, centrality, density, etc. In a social network, individuals, organizations, and enterprises are viewed as nodes, with centrality indicating their power, activity, and communication convenience (Zhang and Luo, 2017). Ties are the linkages between nodes of the Social Network (Wasserman and Faust, 1994). The term "network density" refers to the percentage of interactions in a network compared to the maximum number of interactions (Silva, 2022).

Social networks can be used as the main source of information and knowledge dissemination relating to agricultural technologies. Thus, social networks play a significant role and influence technology adoption in the farming community. The adoption rate of farmers on technological programs will depend on the actors in the network, the strength of the social network, and network properties (Ten Kate et al., 2010). Commonly used social network properties are social network density, centrality and tie strength. Network density means the connectedness level of the social network, and it can be calculated by dividing the number of lines in graph by the maximum number of lines. Dense networks have close relationships, and sparse networks, or non-dense networks have loose relationships among actors (Gibbs, Sequeira and White, 2007). In a dense network, actors know each other well, and in a sparse network, actors do not know each other well.

An actor's centrality increases with proximity to the network's center, which represents more power, influence, and convenience that comes with joining that network (Zhang and Luo, 2017). If any actor in the social network has many connections with other members, that actor is a very prominent actor, and he or she has a lot of power to influence others in the social network. Based on According to Granovetter (1983), tie strength is a combination of duration emotional depth, closeness, and mutual services that define the relationship. Strong ties and weak ties are two types of ties, and both are very important for the dissemination of information in social networks.

There are many literatures describes the positive and negative impacts of social networks on the agricultural technology adoption of farmers in different countries (Wang et al., 2020; Maertans and Barret, 2013; Ramirez, 2013; Ward and Pede, 2015 and Mazur and Onzere, 2012). In Sri Lanka, Dissanayake et al. (2022), Silva and Broekel (2016), and Dias et al. (2020) explained the factors that impact the agricultural technology adoption of Sri Lankan

farmers. Walisinghe et at (2017) and Silva (2020) explained the impact of extension services on agricultural technology adoption by farmers in Sri Lanka. And also, there are very few studies that focused on the social network impact on the agricultural technology adoption in Sri Lanka, like Silva (2022), Abeysinghe (2021) and Silva and Broekel (2016). Therefore, this research fills the literature gap of finding the social network impact on the agricultural technology adoption, especially in small-scale farmers in Sri Lanka.

1.1. Problem Statement

Despite the implementation of several extension programs aimed at increasing paddy productivity in the Matara District, such as the Yaya Development Program, Weedy Rice Program, and Good Agricultural Practices (GAP) Program, agricultural extension officers complain that there is no significant impact of those programs. Poor information transmission and limited interaction between farmers and extension agents are major reasons to the low adoption rate (Silva and Broekel, 2015; Wang et al, 2020 and Ramirez; 2013). Furthermore, while social networks play an important role in changing farmers' behavior and decision-making processes, particularly in rural areas, the extent to which these networks impact technology adoption in Sri Lanka has not been thoroughly studied.

The impact of social networks and extension services on agricultural technology in Matara District has not been explored, nor has the structure, strength, and influence of these social networks on technology adoption been deeply investigated. Understanding how network features like density, centrality, and tie strength influence or hinder the adoption of contemporary agricultural technologies is critical for developing more effective extension techniques. Furthermore, the relationship dynamics between agricultural instructors (AI officers) and farmers may have a substantial impact on technology diffusion, although there has been little empirical research in Sri Lanka on this

As a result, there is a critical requirement to investigate the impact of social networks on agricultural technology adoption within extension programs in the Matara District. This research initiative aims to fill this knowledge gap by examining how network characteristics and AI officer-farmer interactions influence technology uptake, ultimately guiding strategies for strengthening extension services and increasing agricultural output.

1.2 Objectives

To analyze the impact of social networks on the agricultural technology adoption of the existing extension programs in the Matara District.

Specific objectives are:

- To identify the technology adoption of existing extension programs across three areas in the Matara district.
- To analyze the impact of social network density and centrality on the agricultural technology adoption of farmers.
- To identify the impact of factors that can affect the relationship between AI officers and farmers.
- To give suggestions and recommendations to enhance the technology adoption of farmers in the Matara district.

2. Methodology

This study was conducted in the Matara District, focusing on three distinct areas: *Kamburupitiya*, *Malimbada*, and *Wilpita*. Wilpita is situated in Matara North, Kamburutpitiya is situated in Matara Central, and Malimbada is situated in Matara South. Figure 2.1 gives a clear idea of the situation of these three areas in the Matara district.

Figure 2.1: Map of Wilpita, Kamburupitiya and Malimbada
Source: Scribd

The Sample size was seventy-five paddy farmers who were involved in Existing Extension programs, and they were selected from Matara-North, Matara-Central, and Matara- South using purposive sampling techniques. Three AI divisions (Wilpita from Matara North, Kamburupitiya from Matara Central and Malimbada from Matara South) in Matara District which enrolled for paddy farming programs were selected using purposive sampling technique and then got lists of farmers who participate to at least on paddy farming program and after that twenty-five farmers from each area were selected using simple random sampling technique. Pre-structured interviews were used to gather data from the sample, and the questionnaire included both quantitative and qualitative questions. Data on technology adoption rates were gathered through surveys administered to farmers in the three areas, categorizing their responses into adopted, maybe adopted, and not adopted. The Chi-squared test (significance level 0.05) was applied to determine if there were statistically significant differences in adoption rates across the regions. For the analysis of social network density and centrality, data were collected and processed using UCINET 6.773 software, which provided the density scores and centrality measures for each area (Silva, 2023; Zhang et al., 2020). The centrality of AI officers was assessed by selecting two AI officers from each area and calculating their degree centrality to understand their influence within their social networks. The Spearman Correlation Coefficient test under 0.05 significance level was used to analyze the relationships between social network density and technology adoption rates, as well as between AI officers' centrality and technology adoption. Additionally, factors affecting the relationship between AI officers' centrality and technology adoption were investigated, including trustworthiness, communication issues, distance to agrarian service centers, and communication barriers. These factors were analyzed using the Spearman Correlation Coefficient under 0.05 significant level. To gather suggestions for improving technology dissemination, the survey included some suggestions to rate, such as increasing the number of AI officers, contact farmers, training programs, and establishing social media platforms. Mean scores and standard deviations were calculated to assess the level of agreement with each suggestion. Ethical considerations included obtaining informed consent from all participants and ensuring the confidentiality of the collected data, which was used solely for research purposes.

3. Results and Discussion

3.1. Demographic analysis

The sample of this study includes 81.3% of male farmers and 18.7% of female farmers, and all of them are married. Farmers in the 45-60 years age group and the 60-75 years age group have the same percentage of paddy farmers, and it is 36%. The 30-45 years age group has 16% of paddy farmers, and the more than 75 years age group has 12% of paddy farmers. The paddy farmers in this sample did not get higher education, and 24% of them studied up to the

Advanced Level examination and 42.7% of them studied up to the Ordinary Level examination and the rest (33.3%) did not study up to at least the Ordinary Level examination. From this sample 25.7% of farmers have more than 40 years of experience, 16.2% of farmers have 30-40 years of experience, 12.2% of paddy farmers have 20-30 years of experience, 21.6% of farmers have 10-20 years and the rest 24.3% of paddy farmers have less than 10 years of experience in paddy farming.

3.1.1. Comparative Analysis of Agricultural Technology Adoption of Existing Extension Programs Across Three Areas in the Matara District

The Chi-squared test was used to compare agricultural technology adoption rates among farmers in three Matara District communities: *Kamburupitiya, Malimbada*, and *Wilpita*. The study found a statistically significant difference in technology adoption between these areas ($\chi^2 = 8.948$, df = 2, p = 0.011). This shows that technology adoption varies between regions.

Figure 3.1 shows that *Wilpita* (84%) has more farmers who have adopted agricultural technologies than *Malimbada* (44%) and *Kamburupitiya* (68%). *Malimbada* (56%) has a higher prevalence of the "Maybe" category, which represents doubt or partial acceptance of technology, than *Kamburupitiya* (32%) or *Wilpita* (16%). Extension officers in the Matara District believe that implementing new agricultural technologies is easiest in Matara-North, moderately tough in Matara-Central, and most difficult in Matara-South. Therefore, the above findings provide statistical evidence for that statement. In this study, the overall agricultural technology adoption percentage is 53%, and it is approximately similar to the findings of Silva and Broekel (2016). According to Silva and Broekel, (2016) the technology adoption rate of paddy farmers in Hambantota district is 40-60 percent and Hambantota district situated in Southern Province near to Matara District.

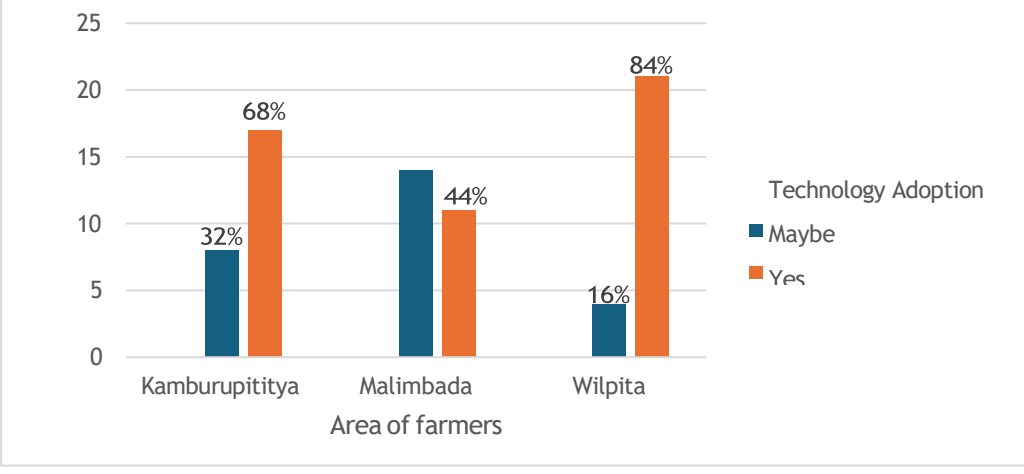

Figure 3.1: Comparison of Agricultural technology adoption among paddy farmers in Wilpita, Kamburupitiya and Malimbada

3.2. Impact of Social Network Density for Agricultural Technology Adoption of Existing Extension Programs across three areas in Matara District

According to the results of UCINET software, the Wilpita area has the highest social network density, and it is 0.201; Kamburupitiya area has a moderate social network density, and it is 0.168; and Malimbada area has the lowest social network density, and it is 0.144. Figure 3.2, Figure 3.3, and Figure 3.4 show the social networks of paddy farmers and extension officers in Wilpita.

Kamburupitiya, and *Malimbada* areas. The social network density is not high in Matara District according to these results, and Silva, (2023) shows provincial social network density for paddy farmers in Hambantota district is 0.846 and interprovincial social network density is 0.882. Several reasons can be attributed to this, like in the Matara district, the extension programs for technology dissemination are in their introductory stages, and farmers are not well organized for the agricultural technology adoption in the Matara district.

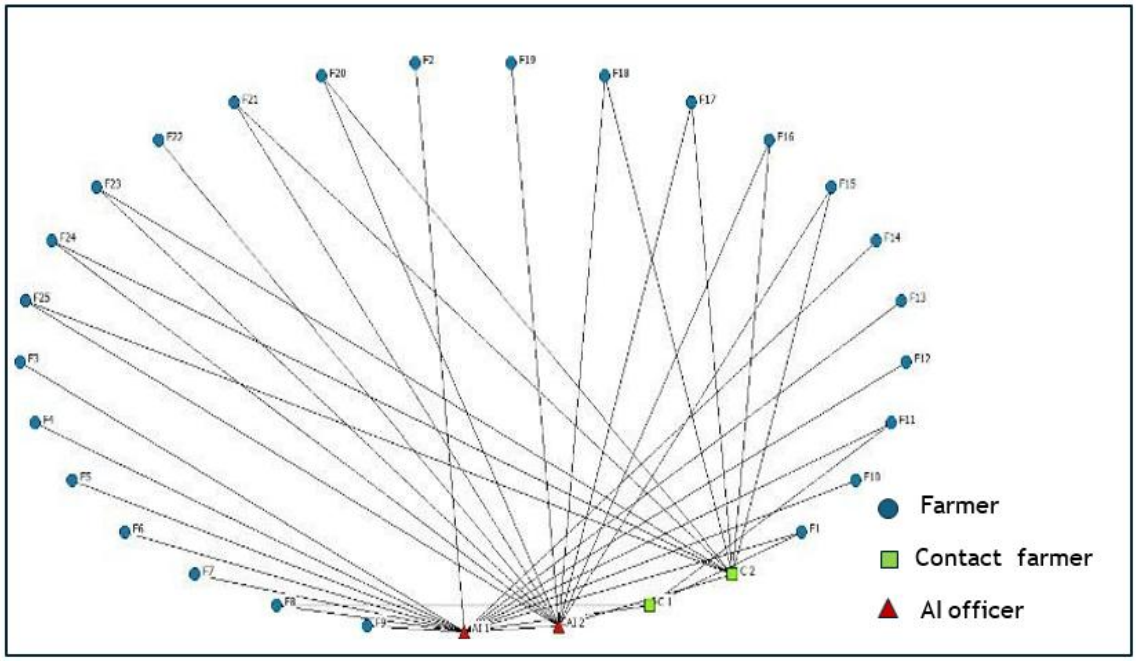

Figure 3.2: Social network of existing extension program information dissemination in Wilpita area

Source: Survey (2023)

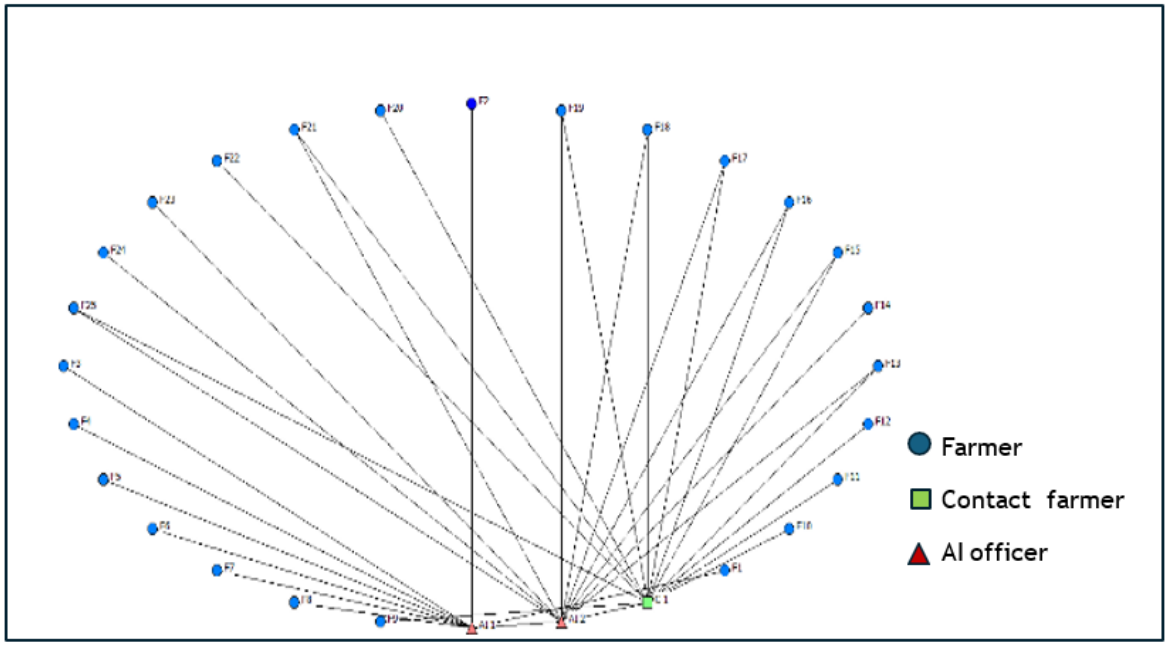

Figure 3.3: Social network of existing extension program information dissemination in Kamburupitiya area

Source: Survey data, 2023

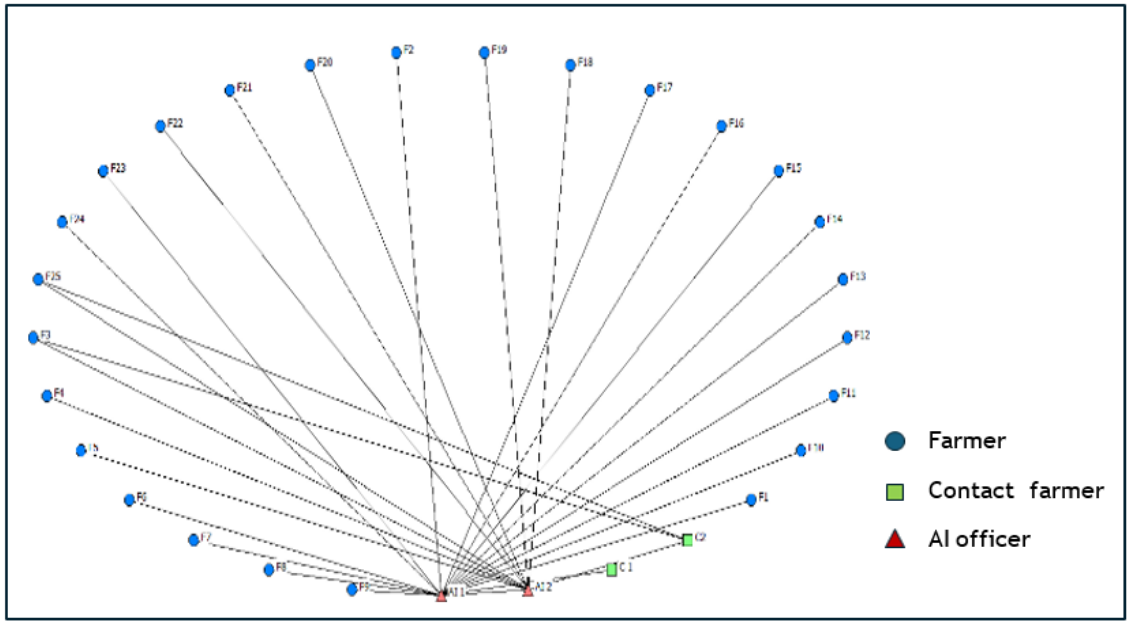

Figure 3.4: Social network of existing extension program information dissemination in Malimbada area
Source: Survey data, 2023

The Spearman Correlation Coefficient test was used to analyze the relationship between the social network density of farming communities that are involved in existing extension programs and the Agricultural technology adoption of those farmers. Results revealed that there is a significant relationship (p-value=0.00) and it is a perfect positive relationship (ρ = 1.00). Therefore, the agricultural technology adoption of paddy farmers in the Matara district can be increased using their social network density. In order to increase social network density, agricultural institutions can increase the number of farmers who join agricultural extension programs in the Matara district. Previous research based on the impact of social network analysis on agricultural technology adoption is very rare, and therefore, the research findings related to density and centrality measures are rare for farming communities in Sri Lanka.

3.3. Impact of Social network centrality of main influences on the Agricultural Technology Adoption

Agricultural technologies of existing extension programs for paddy cultivation in Matara District are disseminated mainly through agricultural instructors and contact farmers' support. Therefore,

Agricultural extension officers believe that the contribution of Agricultural instructors is huge to conduct existing extension programs in the Matara district and, the extension officers were identified as the key node of extension programs in Hambantota district (Silva, 2023) and in Central province key farmers (contact farmers) were identified as the main characters of the social network in spice farming community (Abeysinghe et al., 2021). In this study, two AI officers from each area were selected and then the Centrality of those two AI officers was considered. The degree of Centrality of AI officers in the *Wilpita* area is 0.5175, *Kamburupitiya* is 0.407 and *Malimbada* is 0.518. Actors with a high degree of centrality can influence others' opinions. An informal leader who tends to have an impact on those around them is known as an opinion leader. Therefore, those actors can be used to disseminate knowledge effectively (Ten Kate et al., 2010).

The Spearman Correlation Coefficient test was used to analyze the relationship between the social network centrality of AI officers who were involved in existing extension programs and the Agricultural technology adoption of paddy farmers who got information from those two AI officers. Results revealed that there is not a significant relationship (p-value=0.667) and it is a moderately negative (ρ = (-)0.500) relationship. Therefore, increasing the number of AI officers in Matara district may not effectively increase the agricultural technology adoption. This result is in contrast to the finding of Abeysinghe et al. (2021), because it shows that central figures are important for agricultural technology dissemination among farming communities

3.4. Identification of the impact of factors that can affect the relationship between AI officers and Farmers on agricultural technology adoption.

Factors that can be affected by that negative relationship were evaluated and the factors were the Trustworthiness of AI officers, problems of contacting AI officers, distance to the agrarian service center, and communication barriers of AI officers

Table 3.1: Relationship between factors that can affect the relationship between AI officers and farmers and agricultural technology adoption, Source: Survey (2023).

Factors	Significance level	Correlation
Trustworthiness of AI officers	Significant p-value = 0.00	0.425 (Low positive)
Problems with contacting AI officers	Not significant p-value = 0.244	-0.136 (Negligible correlation)
Distance to Agrarian Service Centers	Not significant p-value = 0.246	-0.136 (Negligible correlation)
Communication barriers of AI officers	Not significant p-value = 0.083	-0.202 (Negligible correlation)

The results of the Spearman Correlation Coefficient test are included in Table 3.1 and according to those results, the Trustworthiness of AI officers have a significant impact (p=0) on agricultural technology adoption among farmers in existing extension programs under 0.05 significant level and it has a low positive (ρ=0.425) relationship with the Agricultural technology adoption of paddy farmers. Problems with contacting AI officers (p=0.244), distance to Agrarian Service Centers (p=0.246), and communication barriers (p=0.083) have not had a significant impact on the agricultural technology adoption of paddy farmers in Matara district. Therefore, farmers rely on peer farmers for agricultural knowledge mainly due to a lack of trust in AI officers.

3.5. Suggestions to develop a technology dissemination network of existing extension programs for paddy cultivation in Matara District.

Table 3.2 shows the mean scores and standard deviations for various suggestions targeted at increasing agricultural technology adoption among paddy farmers.

Table 3.2 Suggestions to improve the social network in the Matara District, Source: Survey (2023).

Suggestion	Mean	Standard Deviation
Increase the number of AI officers	+1.56	.89
Increase the number of Contact farmers	+1.33	.91
Increase the number of training programs	+1.61	.80
Introducing social media platforms to paddy farmers	+0.45	1.52

The answers show the highest agreement with the increased number of training programs (Mean = +1.61 and SD =0.804), while the suggestion to establish social media platforms (Mean = +0.45 and SD = 1.518) appears to be the least agreed. Increase the number of AI officers (Mean=+1.56 and SD=0.89) and increase the number of contact farmers (Mean=+1.61 and SD=0.89) can get as suggestions but there are some issues regarding increasing the number of AI officers without increasing the effectiveness of current AI officers, and therefore, it can generate extra cost to the government. Using social media platforms is not effective for these farmers because they have low literacy levels, and 33.3% of them at least did not study up to the Ordinary Level examination, and their digital literacy also remains at a very low level.

4. Conclusion

This study investigated the impacts of social networks in the adoption of agricultural technology among paddy farmers participating in existing extension programs in the Matara District, with a particular emphasis on Wilpita, Kamburupitiya, and Malimbada. The data found that technology adoption rates differ significantly across these three localities, with Wilpita having the highest level and Malimbada having the lowest. This variation is statistically significant and consistent with the perceptions of local extension staff in the Matara district.Social network density is positively related to the adoption of technology, and this implies that improved technology transmission can be greatly aided by closer ties between farmers and extension agents. However, there was no obvious positive correlation between technology adoption and the centrality of AI officers, who are frequently regarded as important influencers in extension efforts. This suggests that simply adding more AI officers would not be enough unless their effectiveness and connectivity within the network are enhanced.

Further investigation into the factors affecting the interaction between AI officers and farmers revealed that, although communication hurdles and service center distance had little to no effect, trustworthiness significantly positively correlated with technology adoption. These results highlight how crucial it is to increase confidence and enhance channels of communication between farmers and AI authorities to promote more efficient knowledge sharing. The study's overall findings emphasize the importance of increasing social network

density, fostering trust, and supporting more efficient extension initiatives to boost technology adoption in the Matara District. Achieving this objective may be significantly aided by strategic initiatives to boost farmer involvement, enhance interpersonal communication, and encourage peer learning. In the future, comprehensive studies can be done to find the effectiveness of ongoing extension programs separately, and it can be helpful to decide the most suitable extension programs to the Matara district.

5. Suggestions and Recommendations

According to the results of this study, some recommendations can be introduced to improve the adoption of paddy farmers in existing extension programs in the Matara district. The first recommendation is that instead of increasing the number of AI officers, training can be provided to current AI officers to increase their efficiency. And also, an incentive system or rewarding method should be introduced to AI officers who have high performance.

Contact farmers who have high knowledge about paddy farming and who have good organizing skills should be selected for each yaya, and they should be encouraged to identify farmers' problems and to give solutions after discussing them with extension officers and contact farmers should be encouraged to monitor other farmers of their yaya to manage the whole yaya equally.

On behalf of the top-down approach to technology dissemination, a bottom-up approach should be introduced to the Matara district to overcome the gap between farmers' real issues and extension advice. Farmers like it if they can make a noise, and they do not like to always obey the guidelines, which are not practical solutions for their problems. Regular meetings should be conducted to inform farmers about new technologies and discuss farmers' problems. Extension officers should be careful while selecting a date, time, and venue for meetings by avoiding busy dates for farmers.

Some technologies are not compatible with some areas of the Matara district, and some adjustments should be made to adjust technologies for different areas. For example, the line establishment is not suitable for the muddy lands, and therefore, another technique, like the parachute technique, should be introduced for muddy areas in the Matara district.

AI officers should go to the field, and they have to observe the farmers there. They have to be more practical than theoretical because AI officers do not have enough practical knowledge to answer the real problems of farmers, and it is hard to implement all theoretical answers in practical scenarios. And also, they have to work closely with farmers to win their trust. Some agricultural technologies are new, and they are complicated for farmers, and they may use them in the wrong way. Therefore, training programs for paddy farmers should be organized when extension officers introduce new extension methods.

The application of social media for social networking is very effective and efficient because information can be disseminated to farmers within a few minutes using social media platforms like Whatsapp groups, Youtube channels, and Facebook groups. Other than that, mobile apps can also be used to disseminate information, and extension officers can be aware of farmers' problems. These methods are very attractive, but not all farmers have devices to connect to those platforms, and they do not have enough technical knowledge to use them properly. Therefore, farmers can be motivated and trained to test new technologies, and farmers who have access to these technologies can give updates to other farmers.

Other than the suggestions for farmers, future researchers can focus more on the social network improvement among farming communities in Sri Lanka, and it can be helpful to develop a good social network among farmers in Sri Lanka. It will definitely improve the farmers' productivity because new technologies and methods have a big impact on developing the agriculture sector, and that can keep farmers motivated.

2. References

Abeysinghe, B. N., Amarawansha, S., Ito, T., & Kaneko, S. (2021). Information Diffusion and the Role of Central Figures: Experimental Evidence of Network-based Agricultural Extension in Sri Lanka. *IDEC DP2 Series*, *10*(9), 1-38.

Afranaa Kwapong, N., & Ankrah, D. A. (2023). Understanding innovation process within an interactive social network: Empirical insights from maize innovations in southern Ghana. Cogent Social Sciences, 9(1), https://doi.org/10.1080/23311886.2023.2167390 .

Altahat, E., Al-Sharafat, A., & Altarawneh, M. (2012). Factors affecting profitability of layer hens enterprises. American Journal of Agricultural and Biological Sciences, 7(1), 106-113.

Bandiera, O., & Rasul, I. (2006). Social networks and technology adoption in northern Mozambique. The economic journal, 116(514), 869-902. https://doi.org/10.1111/j.1468-0297.2006.01115.x

Besley, T., & Case, A. (1993). Modeling technology adoption in developing countries. The American economic review, 83(2), 396-402.

Boahene, K., Snijders, T. A., & Folmer, H. (1999). An integrated socioeconomic analysis of innovation adoption: the case of hybrid cocoa in Ghana. Journal of Policy Modeling, 21(2), 167-184. https://doi.org/10.1016/S0161-8938(97)00070-7

Centola, D. (2010). The spread of behavior in an online social network experiment. science, 329(5996), 1194- 1197. DOI: 10.1126/science.1185231

Conley, T. G., & Udry, C. R. (2010). Learning about a new technology: Pineapple in Ghana. American economic review, 100(1), 35-69. 10.1257/aer.100.1.35

Department of Census and Statistics. (2024). Paddy Statistics 2023/2024 Maha Season. Retrieved from https://www.statistics.gov.lk/Agriculture/StaticalInformation/PaddyStatistics/PaddyStatistics/2023_20 24_MahaSeaso

Department of Census and Statistics. (2024). Paddy Statistics 2024 Yala Season. Retrieved from https://www.statistics.gov.lk/Agriculture/StaticalInformation/PaddyStatistics/PaddyStatistics/2024Yal a Season

Dias, N., Munaweera, T., & Bandara, S. (2020). Factors influencing farmers' adoption of protected agriculture: A case of vegetable farmers in dry zone Sri Lanka. technology, 13(14), 16-20.

Dissanayake, C. A. K., Jayathilake, W., Wickramasuriya, H. V. A., Dissanayake, U., & Wasala, W. M. C. B. (2022). A review on factors affecting technology adoption in agricultural sector. Journal of Agricultural Sciences–Sri Lanka, 17(2). 10.4038/jas.v17i2.9743

Doss, C. R., & Morris, M. L. (2000). How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Agricultural economics, 25(1), 27-39. https://doi.org/10.1111/j.1574-0862.2001.tb00233.x

Gedara, K. M., Wilson, C., Pascoe, S., & Robinson, T. (2012). Factors affecting technical efficiency of rice farmers in village reservoir irrigation systems of Sri Lanka. Journal of Agricultural Economics, 63(3), 627-638. https://doi.org/10.1111/j.1477-9552.2012.00343.x

Gibbs, S., Sequeira, J., & White, M. M. (2007). Social networks and technology adoption in small business. International Journal of Globalisation and Small Business, 2(1), 66-87. https://doi.org/10.1504/IJGSB.2007.014188

Granovetter, M. (1983). The strength of weak ties: A network theory revisited. Sociological theory, 201-233. https://doi.org/10.2307/202051

Maertens, A., & Barrett, C. B. (2013). Measuring social networks' effects on agricultural

technology adoption.

American Journal of Agricultural Economics, 95(2), 353-359. https://doi.org/10.1093/ajae/aas049

Maulu, S., Hasimuna, O. J., Mutale, B., Mphande, J., & Siankwilimba, E. (2021). Enhancing the role of rural agricultural extension programs in poverty alleviation: A review. Cogent Food & Agriculture, 7(1), https://doi.org/10.1080/23311932.2021.1886663

Mazur, R., & Onzere, S. (2012). Social networks and status in adopting agricultural technologies and practices among small-scale farmers in Uganda. In Innovation Africa (pp. 146-160).

Mincer, M., & Niewiadomska-Szynkiewicz, E. (2012). Application of social network analysis to the investigation of interpersonal connections. Journal of Telecommunications and information technology, (2), 83-91.

Ministry of Agriculture of Sri Lanka. 2024. Progress Report Budget Debate Committee Stage 2023/24. https://www.agrimin.gov.lk/web/images/11.12.2023-1/3.%20Progress%20Report%20for%20Budget%20-%20English.pdf.

Ramirez, A. (2013). The influence of social networks on agricultural technology adoption. Procedia-Social and Behavioral Sciences, 79, 101-116. https://doi.org/10.1016/j.sbspro.2013.05.059

Silva, K. N. N. (2020). The roles of absorptive capacity, technology adoption, and extension services in a local agricultural innovation system in Sri Lanka. https://doi.org/10.15488/10200

Silva, K. N. (2022). Social network to accelerate agricultural technology adoption: evidence from Hambanthota district, Sri Lanka. Indian Journal of Extension Education, 59(1), 1-6.
10.48165/IJEE.2023.59101

Silva, K. N. N, & Broekel, T. (2015, December). Agriculture knowledge and information network in sri lanka: Perceptual aspects of agriculture instructors (ais). In 12th International Conference on Business Management (ICBM).

Silva, K.N.N., & Broekel, T. (2016, December). Factors constraining farmers' adoption of new agricultural technology programme in Hambantota district in Sri Lanka: Perceptions of agriculture extension officers. In University of Sri Jayewardenepura,

Sri Lanka, 13th International Conference on Business Management (ICBM).

Silva, K. N. N., & Gunasekara, S. D. W. (2022). Analysis of the paddy cultivation pattern in Galle and Matara districts in the Southern province of Sri Lanka. Journal of Agro-Technology and Rural Sciences, 1(2). 10.4038/atrsj.v1i2.30

Ten Kate, S., Haverkamp, S., Mahmood, F., & Feldberg, F. (2010). Social network influences on technology acceptance: A matter of tie strength, centrality and density.

Todo, Y., Matous, P., & Mojo, D. (2014). Effects of social network structure on the diffusion and adoption of agricultural technology: Evidence from rural Ethiopia. Available at SSRN 2447208.

Umeta, G. (2013). Analysis of female headed households' participation in agricultural extension package program in East Showa Zone, Ethiopia. American Journal of Research Communication, 1(8), 227-245.

Walisinghe, B. R., Ratnasiri, S., Rohde, N., & Guest, R. (2017). Does agricultural extension promote technology adoption in Sri Lanka. International Journal of Social Economics, 44(12), 2173-2186.

Wang, G., Lu, Q., & Capareda, S. C. (2020). Social network and extension service in farmers' agricultural technology adoption efficiency, 15(7) https://doi.org/10.1371/journal.pone.0235927

Ward, P. S., & Pede, V. O. (2015). Capturing social network effects in technology adoption: the spatial diffusion of hybrid rice in Bangladesh. Australian Journal of Agricultural and Resource Economics, 59(2), 225-https://doi.org/10.1111/1467-8489.12058

Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications

JOURNAL OF TROPICAL ENVIRONMENT

ISSN 2950-6808