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CONFERENCE PROCEEDINGS

of the Annual Research Conference of the Sri Lanka Students' Association in Japan

Sustainability Beyond Boundaries: Collaborative Research for a Shared Future

ORGANIZED BY

Students' Association in Japan (SLSAJ) in Collaboration with the Regional Center for Strategic Studies (RCSS) Sri Lanka

12th Research Conference
of
Sri Lanka Students' Association
in Japan

SLSAJ ARC 2025/2026

Sustainability Beyond Borders
Collaborative Research for a Shared Future

31st January 2026

Organised by

Sri Lanka Students' Association in Japan
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Message from the Chief Guest

Prof. Pivithuru Janak Kumarasinghe
H.E. the Ambassador of Sri Lanka to Japan

On behalf of the Embassy of Sri Lanka in Japan, I am pleased to extend my warm greetings and congratulations to the Sri Lanka Students' Association in Japan for successfully organizing the 12th Annual Research Conference under the theme, "*Sustainability Beyond Boundaries: Collaborative Research for a Shared Future.*"

In an era of interconnectivity and complex challenges, this conference is both timely and significant. Its theme reflects the spirit of contemporary scholarship, promoting innovative and sustainable solutions that transcend boundaries.

The United Nations Sustainable Development Goals remind us that no nation can thrive in isolation. Sri Lanka, committed to resilience and global partnerships, can leverage this platform to address pressing issues like climate change and social equity through collaboration.

I commend SLSAJ for its dedication to academic excellence and cultural ties between Sri Lanka and Japan. Your efforts exemplify the best of our youth, shaping a future defined by cooperation and creativity.

I hope this conference inspires impactful ideas and lasting partnerships. Wishing all participants, a productive and enriching experience as we work together for a sustainable future.

Message from the Conference Chair

Prof. N. S. Cooray
Professor
International University of Japan

It is with great pleasure that I write this message for the Book of Abstracts of the 12th Research Conference of the Sri Lanka Students' Association in Japan (SLSAJ ARC 2025), "Sustainability Beyond Boundaries: Collaborative Research for a Shared Future," which was held online on Saturday, January 31, 2026. The conference was organized by the SLSAJ in collaboration with the Regional Centre for Strategic Studies (RCSS). As the conference chair, I welcome the speakers, participants, and readers of the Book of Abstracts.

This year's conference theme captures one of the most pressing imperatives of our time, as sustainability challenges extend beyond subject disciplines, geography, or sector. We live in an interdependent and interconnected world. Sustainability issues such as poverty and inequality, natural capital management, energy insecurity, governance of artificial intelligence, global health and pandemics, digital disruption, and financial stability transcend national and disciplinary boundaries. Sustainability beyond boundaries underscores the need to move beyond fragmentation across disciplines, societies, nations, the public and private sectors, and even between theory and practice.

Collaborative research underscores the need for comprehensive solutions to global problems through committed partnerships that advance a shared future, collective responsibility, and intergenerational equity. Addressing these challenges requires collaborative, cross-disciplinary, and cross-border research. This conference, therefore, served as a platform for global knowledge exchange, partnership building, and the promotion of inclusive and impactful research that contributes to long-term environmental sustainability, social well-being, and economic resilience.

I would like to extend my sincere appreciation to the Chief Guest, His Excellency Prof. Pivithuru Janak Kumarasinghe, Ambassador of Sri Lanka; the Guest of Honor, Ravinatha Aryasinghe, Retired Ambassador and Executive Director of the Regional Centre for Strategic Studies (RCSS); and our Keynote Speaker, Prof. Kelum Jayasinghe, Chair Professor of Accounts, University of Sheffield, UK. I would also like to extend special thanks to our distinguished panelists, Prof. Saj Mendis, Prof. Jay Rajasekara, Prof. Srikantha Herath, and Prof. Richard Wickramaratne. I would like to warmly acknowledge the scholarly contributions of the session keynote speakers and chairs, as well as the paper reviewers, who are central to the success of this conference. I would

also like to extend sincere gratitude to all paper presenters, whose contributions formed the intellectual backbone of this conference.

The conference is organized around four thematic tracks. Of the 30 submissions received, 21 papers were selected through a rigorous peer-review process, reflecting both the quality of the contributions and the scientific committee's commitment to academic excellence. Session One was honoured to feature Professor Saliya De Silva, Professor in the Faculty of Economics at Saga University, Japan, who served as both Session Chair and Keynote Speaker. He was joined by Dr. Premakumara Jagath, Principal Researcher and Director of the IGES Centre at the Institute for Global Environmental Strategies (IGES), Japan, who also served as Session Chair. Session Two was chaired by Dr. N. G. P. B. Neluwala, Senior Lecturer at the University of Peradeniya, who additionally delivered the Session Keynote Address. He was joined by Dr. Asanga Nagalla, Researcher at the RIKEN, Tokyo, Japan, who served as Co-Chair. Session Three was chaired by Professor Piyadasa Rathnayake, Professor Emeritus at the Faculty of Economics, Saga University, Japan. I had the privilege of serving as Co-Chair alongside him for this session. Session Four was chaired by Ms. Chamika Indeewari Wijesuriya, Research and Programme Officer at the Regional Centre for Strategic Studies (RCSS), who also delivered the Session Keynote Address. I commend all of your efforts to advance knowledge across management, economics, science and engineering, information technology, and the social sciences.

Before concluding this message, I would like to express my sincere appreciation to the Organizing Committee, whose dedication, hard work, and professionalism made this conference possible. I also thank all volunteers and support staff for their invaluable behind-the-scenes contributions. Finally, I very much look forward to another productive, engaging, and intellectually rewarding conference next year.

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Message from the Guest of Honor

Ravinatha Aryasinha
Former Ambassador
Executive Director
Regional Center for Strategic Studies (RCSS)

I am honored to share some thoughts at the 12th Research Conference under the timely theme: “Sustainability Beyond Boundaries; Global Cooperation for a Shared Future.” The decision by the Regional Centre for Strategic Studies (RCSS) to co-host this event is reflective of the importance it placed both - in supporting climate change related initiatives concerning the region, and also as a means of remaining engaged with the Sri Lankan student diaspora at the intellectual level. To this end the RCSS has invested its expertise and resources on climate change as a key focal area and utilized its ‘Track 1.5’ engagement framework to bridge social and policy gaps.

We have to recognize that the challenges of the 21st century, be it geopolitical tensions, economic instability, climate change or technological shifts, do not respect national borders. Our response must be equally borderless. Disaster losses are currently outpacing adaptation and mitigation investments in South Asia, and to achieve sustainability, we must seek to operationalize a ‘continuum of resilience’ - overcoming governance challenges, facilitating disaster risk reduction, enabling climate change adaptation, and ensuring diplomatic synergy.

Collaboration among countries and regions in the ‘Global South’ is crucial to create sustainable, replicable models of assistance that move beyond traditional bilateral aid. Japan as a middle power has collaborated with countries and regions in the ‘Global South’ in doing so. We must also draw inspiration from historical frameworks like the G15 of Developing Countries which proved effective in the 1990s in seeking to address current structural gaps in global policy and enable South - South Cooperation. The RCSS is committed to support students in Sri Lanka and the diaspora, as they endeavor to ensure their intellectual contributions translate into real-world solutions for the region.

To this end, I urge young scholars to seek to bridge the gap between research and policy. First, design research projects with impact pathways from data to policy to practice. Second, engage donors and practitioners early, not merely as funders, but as partners in problem-solving. Third, anchor innovation in equity, ensuring that adaptation and resilience-building reach the most vulnerable communities.

Message from the President

Mr. Tharindra Koralegedara
President, Sri Lanka Students' Association in Japan

It is with great pleasure and honor that I welcome you to the 12th Research Conference of the Sri Lanka Students' Association in Japan (SLSAJARC 2025) and present this volume of conference proceedings, which captures the intellectual contributions and collaborative spirit of this year's event.

The theme of this year's conference, "Sustainability Beyond Boundaries: Global Cooperation for the Shared Future," reflects the urgent need for unified global action in addressing the multifaceted challenges of our time. In an era marked by rapid environmental change, technological advancement, and evolving socio-economic dynamics, it is increasingly evident that sustainable development cannot be achieved in isolation. Rather, it requires cross-disciplinary innovation, international collaboration, and a shared commitment to building resilient and inclusive systems for the future.

SLSAJARC has continuously served as a dynamic platform that brings together scholars, researchers, and professionals from diverse academic and professional backgrounds. This year's conference is no exception, encompassing a broad range of fields including Management, Economics and Environmental Studies, Science and Engineering, Information Technology, and Social Sciences. Through these diverse tracks, we aim to foster meaningful dialogue that bridges theoretical insights with practical applications, ultimately contributing to solutions that address both local and global challenges.

We are deeply honored to host Prof. Kelum Jayasinghe as our keynote speaker, whose globally recognized expertise in corporate governance and sustainable development provides valuable perspectives on navigating complex sustainability transitions. We are also privileged to welcome H.E. Prof. Pivithuru Janak Kumarasinghe, Ambassador of Sri Lanka to Japan, as our Chief Guest, and Mr. Ravinatha Aryasinha, a distinguished diplomat and policy expert, as our Guest of Honor. Their presence enriches the conference by connecting academic discourse with real-world policy and international cooperation.

The success of SLSAJARC 2025 would not have been possible without the dedication and collective effort of many individuals and institutions. I would like to extend my sincere appreciation to Prof. N. S. Cooray, Conference Chair, for his invaluable leadership and guidance throughout

the organization of this event. My heartfelt thanks also go to the panelists, session chairs, reviewers, and the organizing committee, whose commitment and professionalism have ensured the high quality and integrity of this conference.

We are also grateful to our collaborators and supporting organizations for their continued partnership, and to all authors who have contributed their research to this proceedings volume. The papers presented here demonstrate not only academic rigor but also a deep commitment to addressing pressing global issues through innovative and sustainable approaches.

As we compile and share these proceedings, it is my sincere hope that the knowledge and ideas presented will inspire further research, foster interdisciplinary collaboration, and contribute to impactful actions beyond the scope of this conference. Let this be a stepping stone toward strengthening global cooperation and advancing sustainable development for the benefit of future generations.

I thank you all for your participation and valuable contributions, and I wish you continued success in your academic and professional endeavors.

Message from the Conference Secretaries


Ms. Sanduni Nipunika
Assistant Secretary, Sri Lanka Students' Association in Japan
Ms. Wasana Abeysinghe
Secretary, Sri Lanka Students' Association in Japan

Dear Participants, Presenters, and Esteemed Guests,

It is with great pleasure and honor that we welcome you to the 12th Annual Research Conference 2025/2026 of the Sri Lanka Students' Association in Japan (SLSAJ), held under the theme "Sustainability Beyond Boundaries: Collaborative Research for a Shared Future." This conference, successfully conducted on 31 January 2026 via Zoom, reflects our continued commitment to promoting meaningful academic dialogue and fostering collaborative research across borders.

Organized under the able guidance of our Conference Chair, Prof. N. S. Cooray, this year's conference brought together nearly 40 scholars, professors, and researchers from Sri Lanka, Japan, Pakistan, and India. Their active participation and valuable contributions created a vibrant platform for intellectual exchange and strengthened international academic networks.

We are deeply honored to have received inspiring messages from H.E. the Ambassador of Japan to Sri Lanka, Prof. Pivithuru Janak Kumara, and Ambassador (Ret.) Ravinatha Ariyasinghe, Executive Director of the Regional Centre for Strategic Studies (RCSS), our esteemed collaborative partner. Their encouragement and support reaffirmed the importance of regional and global cooperation in advancing sustainable development.

We were privileged to host Prof. Kelum Jayasinghe of the University of Sheffield, UK, as our keynote speaker. His insightful address on green transition, ecosystem management, environmental governance, and global cooperation provided valuable perspectives and set a strong foundation for the conference deliberations. The engaging panel discussion, moderated by Prof. N. S. Cooray, and featuring distinguished academics and diplomats, further enriched the discourse by offering diverse viewpoints on contemporary sustainability challenges.

The conference also featured research presentations across four thematic tracks. Out of 30 submissions, 21 high-quality papers were selected through a rigorous peer-review process. We

extend our sincere appreciation to the reviewers and session chairs for their dedication and professionalism in maintaining academic excellence. The Best Paper Awards presented in each session recognized outstanding research and encouraged scholarly innovation among participants.

This conference stands as a testament to the power of collaboration and collective effort. We gratefully acknowledge the unwavering support of RCSS, our advisors, reviewers, panelists, and all contributors. Our heartfelt appreciation also goes to the SLSAJ committee members and volunteers whose tireless efforts ensured the smooth organization and success of this event.

We sincerely hope that the discussions, ideas, and partnerships formed during this conference will inspire continued research and meaningful action toward building a sustainable and shared global future. May this platform serve as a catalyst for interdisciplinary collaboration and long-lasting academic engagement.

We thank all participants for their enthusiastic involvement and valuable contributions. We look forward to your continued support and participation in future SLSAJ initiatives.

Keynote Speaker

Prof. Kelum Jayasinghe
Chair in Accounting Management School,
The University of Sherfield,
United Kingdom.

Panelists

Prof. Srikantha Herath
Visiting Professor at Toyama University's Global Research Centre for Advanced Sustainability Science (GRASS),
Director of Enviforecasting.

Prof. Jay Rajasekara
Professor,
Vice President,
Tokyo International University,
Japan.

Panelists

Prof. A. Saj U. Mendis
Former Ambassador of Sri Lanka to Vietnam, Bahrain and South Korea,
Former Chargé d'Affaires Embassy of Sri Lanka in Japan.

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Session 1: Management, Economics and Environmental

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Dr. Premakumara Jagath Dikella Gamaralalage
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Session 2: Science, Engineering Studies, Information Technology and Innovations

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Dr. Asanga Nagalla
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Session 3: Development economics and public policy

Prof. N. S. Cooray
Professor in Economics,
Graduate School of International Relations,
International University of Japan.

Prof. Piyadasa Ratnayake
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Emeritus at the Faculty of Economics,
Saga University in Japan.

Session 4: Governance and Institutions, Social Sciences

Ms. Chamini Indeevari
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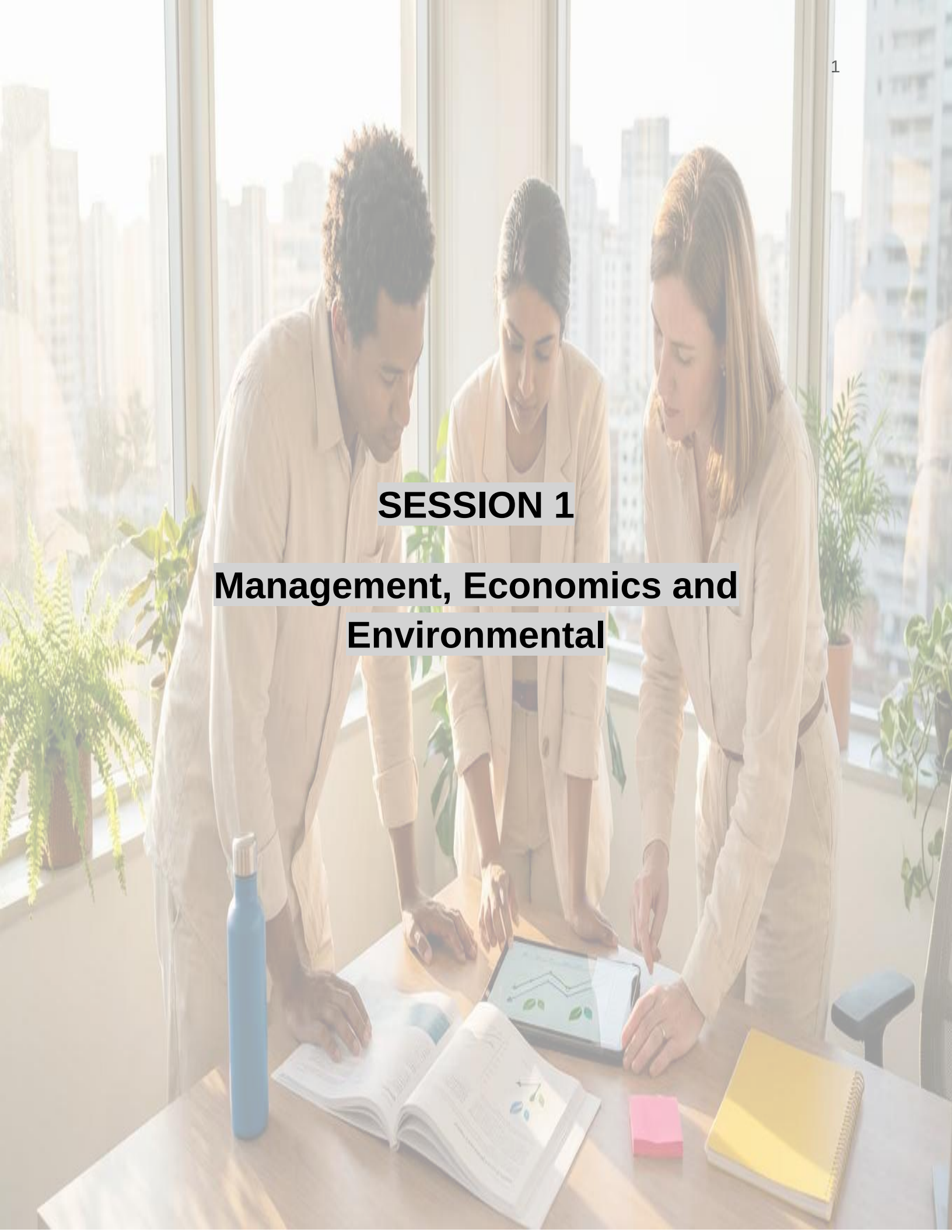

SESSION 1

Management, Economics and Environmental

Optimizing Sentinel-2 Vegetation Indices for Monitoring Urban Green Spaces in the Hilly Landscapes of Kandy District, Sri Lanka

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Keywords: Urban green spaces (UGS), Sentinel-2, Vegetation indices, Normalized Difference Vegetation Index (NDVI), Green Ratio (GR)

Introduction

Urban green spaces (UGS) play a crucial role in maintaining ecological balance, regulating microclimates, and enhancing human well-being, particularly in rapidly expanding urban areas. In hilly urban regions like the Kandy District of Sri Lanka, tracking vegetation changes is difficult due to steep slopes, varied land use, complex lighting, and strong soil background effects. These challenges often reduce the effectiveness of standard vegetation indices, particularly in densely built-up and shadowed terrain. Satellite remote sensing, particularly Sentinel-2 images with high resolution, provides a valuable means of monitoring vegetation across complex landscapes. However, common indices like Normalized Difference Vegetation Index (NDVI) often experience saturation and lower sensitivity in mixed urban pixels. Newer soil-adjusted and transformed indices may perform better under these conditions. This research examines six Sentinel-2-based vegetation indices—NDVI, EVI, SAVI, MSAVI, Green Ratio (GR), and Transformed Vegetation Index (TVI)—to find the most reliable indicators for tracking urban green spaces in Kandy's hilly terrain. The goals are to (i) explore how each index's spatial patterns vary, and (ii) evaluate their radiometric quality using Peak Signal-to-Noise Ratio (PSNR), Root Mean Square Error (RMSE), Standard Deviation (SD), and Correlation Coefficient (CC).

Methodology

The study was conducted in the Kandy District, Sri Lanka, characterized by rugged topography, steep slopes, dense urban development, and mixed vegetation cover. Sentinel-2 Level-2A surface reflectance imagery for 2024 was accessed and processed using Google Earth Engine (GEE), enabling efficient large-scale data handling and cloud-based computation. To minimize atmospheric and illumination-related distortions, images with cloud cover less than 20% were

selected. Scene Classification Layer (SCL)-based masking was applied to remove clouds and cloud shadows. A median composite was generated at 10 m spatial resolution to reduce residual noise and temporal anomalies.

Table 1: Table of Different Vegetation Indices

Vegetation Indices	Formulas	References
NDVI	$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$	Rouse et al., (1974)
EVI	$EVI = 2.5 \times \frac{(NIR - R)}{(NIR + 6 \times R - 7.5 \times B + 1)}$	Huete et al., (2002), Zahir et al., (2024)
SAVI	$SAVI = \frac{((NIR - R) \times (1 + L))}{(NIR + R + L)} (L = 0.5)$	Huete (1988)
MSAVI	$MSAVI = \frac{\left(2 \times NIR + 1 - \sqrt{(2 \times NIR + 1)^2 - 8 \times (NIR - R)}\right)}{2}$	Qi et al., (1994), Zahir et al., (2024)
GR	$GR = \frac{NIR}{G}$	Gitelson et al., (1996)
TVI	$TVI = 0.5 \times \frac{[120 \times (NIR - R) - 200 \times (B - R)]}{(NIR + R + 0.59)}$	Deering et al., (1975)

Six vegetation indices—NDVI, EVI, SAVI, MSAVI, GR, and TVI—were computed using standard band combinations involving near-infrared, red, green, and blue bands. These indices were selected to represent conventional, soil-adjusted, and transformed approaches to vegetation detection. The radiometric performance of each index was quantitatively evaluated using four image quality metrics: PSNR, RMSE, SD, and CC. These metrics are widely used in remote sensing image quality assessment to measure information preservation, error magnitude, contrast variability, and structural similarity between images. Higher PSNR and CC values, along with lower RMSE values, indicate superior radiometric stability and reliability. All processing and analyses were executed within the GEE environment.

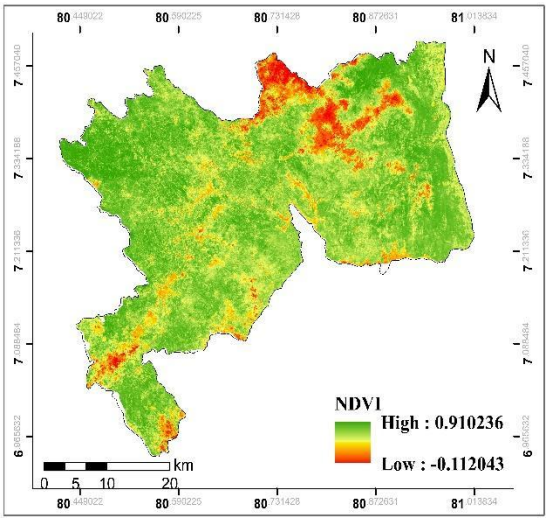
Table 2: Image quality parameters for vegetation indices

Image Quality Parameters	Formulas	Description	References
RMSE	$RMSE = \sqrt{\frac{1}{N}\Sigma \frac{(Iref - Itest)^2}{n}}$	Iref – the pixel value in the reference image, Itest – the pixel value in the test image, N – the total number of pixels in the image. RMSE measures the average difference between the reference and processed images. A lower RMSE indicates higher similarity and less error.	Gonzalez & Woods (2018); Wald et al. (1997)
PSNR	$PSNR = 10 \times log10\left(\frac{(MAX_I)^2}{MSE}\right)$	MAX_i – the highest pixel value in the image, MSE – the mean squared error between the reference and test images. PSNR evaluates the ratio between the maximum possible pixel intensity and the reconstruction error. A higher PSNR indicates better image quality and closer similarity to the reference image.	Gonzalez & Woods (2018); Wald et al. (1997)
SD	$SD = \sqrt{\frac{1}{N}\Sigma (X - \bar{X})^2}$	x – the pixel value in the image, $\bar{x}$ – the mean pixel value, N – the total pixel count within the image. SD measures the variability or contrast of the pixel values. A larger SD usually reflects more detail or contrast in the image.	Pohl & Van Genderen (1998); Wald (2000)

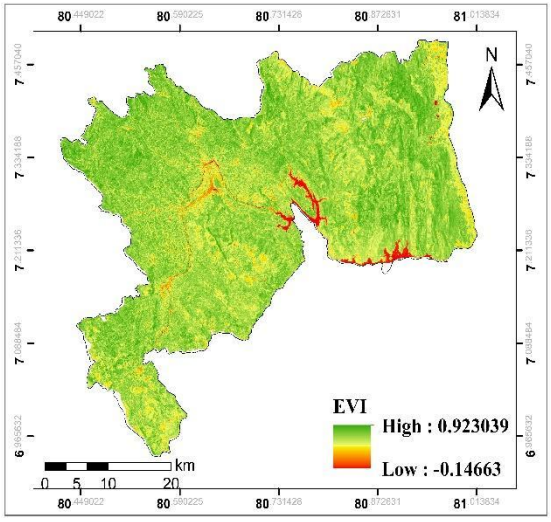
CC	$CC = \frac{\Sigma(Xi - \bar{X})(Yi - \bar{Y})}{\sqrt{[\Sigma(Xi - \bar{X})^2 \Sigma(Yi - \bar{Y})^2]}}$	Xi and Yi – pixel values in the reference and test images, respectively, $\bar{X}$ and $\bar{Y}$ – their mean pixel values. CC measures the degree of linear correlation between reference and processed images.	Chavez et al., (1991); Wald et al. (1997)

Results / Findings

The spatial distribution of the six vegetation indices clearly distinguished vegetated areas—such as forest reserves, tea plantations, and riparian corridors—from densely built-up urban zones. NDVI, EVI, and SAVI effectively captured general vegetation patterns but exhibited reduced sensitivity in shadowed and high-density urban areas. Quantitative image quality assessment revealed that MSAVI and TVI consistently outperformed other indices. MSAVI recorded the lowest RMSE (0.018) and a high PSNR value (46.2 dB), indicating strong radiometric stability and reduced soil background influence. TVI achieved the highest PSNR (46.8 dB) and a high correlation coefficient (0.962), demonstrating its sensitivity to subtle vegetation variations. In contrast, the GR index showed the weakest performance, with the highest RMSE (0.220) and lowest correlation coefficient (0.840), highlighting its vulnerability to illumination and terrain-induced variability. These findings align with previous studies emphasizing the superiority of soil-adjusted and transformed indices in complex and mountainous urban landscapes.



(a)



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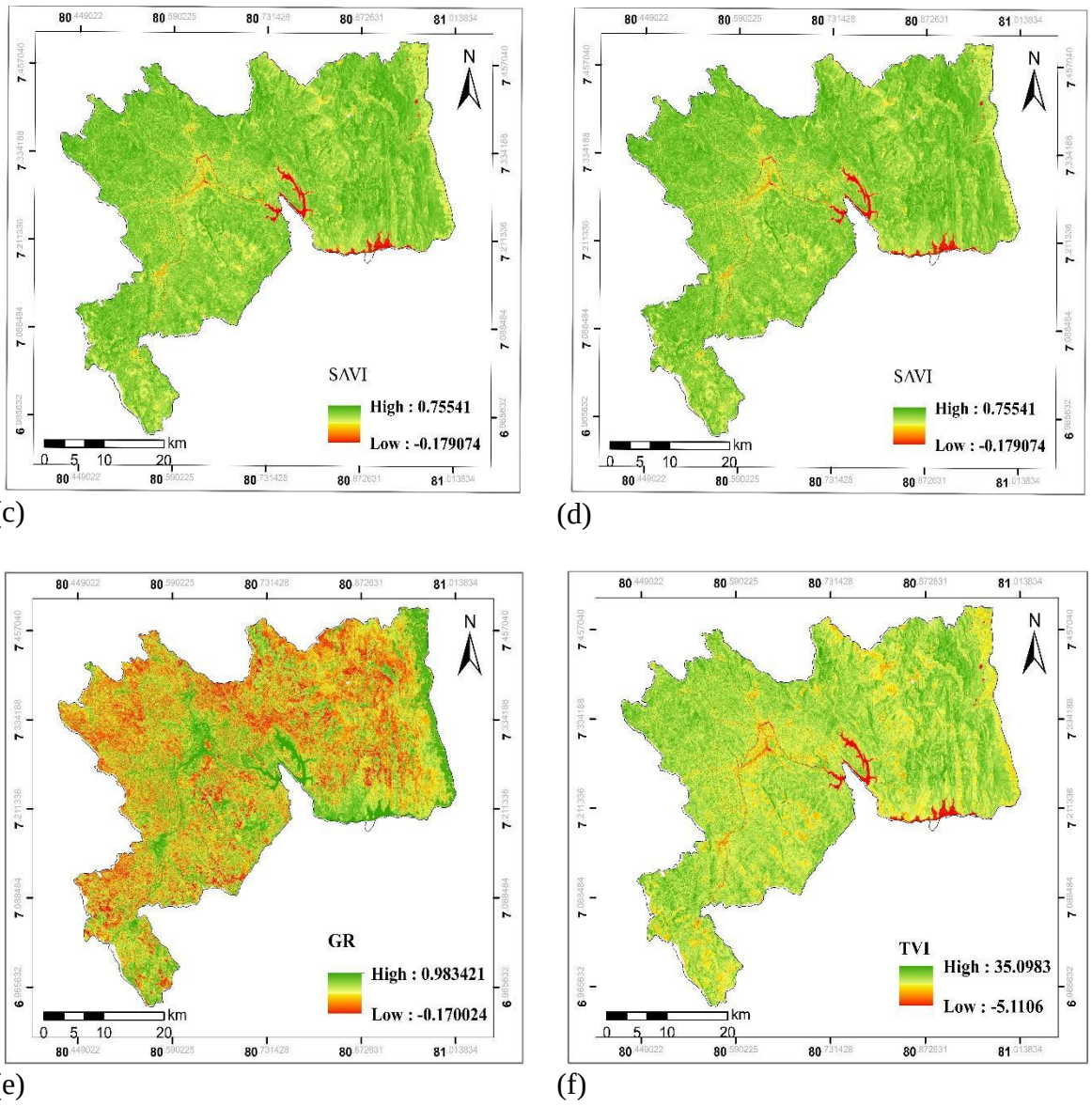

Figure 1: (a) NDVI; (b) EVI; (c) SAVI; (d) MSAVI; (e) GR; (f) TVI

Discussion

The findings of this study demonstrate that terrain-adjusted vegetation indices are superior to traditional indices in mountainous urban areas. Specifically, the Modified Soil-Adjusted Vegetation Index (MSAVI) was found to be very effective in the Kandy District since it is developed in a way that reduces the impact of soil background and improves vegetation detection even on steep slopes and on land-cover heterogeneous types. The Transformed Vegetation Index (TVI), with a wider range of numbers, was more responsive to minor changes in vegetation density,

which confirms its utility as a useful additional index in complex urban environments. Even though NDVI and SAVI continue to be useful in the overall monitoring of vegetation, their work in terrain-induced shading and high-density built-in structures was limited. Conversely, the Green Ratio (GR) index was relatively low, indicating its great sensitivity to illumination variability, which is common in hilly terrain. In general, these findings are not new, but they are in line with earlier research that revealed the excellence of soil-adjusted and transformed indexes in complex topography and the significance of using the vegetation index, which is better adapted to the terrain and land-use properties of the study region.

Table 3: Image quality of different vegetation indices

Vegetation Index	Peak Signal to Noise Ratio (PSNR)	Root Mean Square Error (RMSE)	Standard Deviation (SD)	Correlation Coefficient (CC)
NDVI	38.5	0.070	0.120	0.959
EVI	44.0	0.021	0.010	0.963
SAVI	39.8	0.050	0.170	0.962
MSAVI	46.2	0.018	0.065	0.967
GR	31.5	0.220	0.360	0.840
TVI	46.8	0.028	0.095	0.962

Conclusion

This study demonstrates that the Modified Soil-Adjusted Vegetation Index (MSAVI) is the most reliable indicator for monitoring urban green spaces in the hilly landscapes of the Kandy District, owing to its high radiometric stability and reduced sensitivity to soil and terrain effects. The Transformed Vegetation Index (TVI) further complements MSAVI by enhancing the detection of subtle vegetation variations in heterogeneous urban environments. The combined application of MSAVI and TVI provides a robust methodological framework for urban green space assessment, urban planning, and climate-resilient landscape management. This approach is transferable to other rapidly urbanizing regions in Sri Lanka and similar mountainous settings worldwide.

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Non-Linear Modeling of Ocean-Atmosphere Heat and Energy Fluxes in the Western Indian Ocean: A Machine Learning Approach,

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Keywords: Heat flux, Machine learning, MERRA-2, Random Forest, Western Indian Ocean

Introduction

Ocean-atmosphere heat flux exchanges are fundamental drivers of regional climate dynamics and marine ecosystem functioning in the tropical Indian Ocean. These energy transfers regulate sea surface temperature, mixed layer depth, and upper ocean heat content, influencing monsoon systems that affect billions of people (Schott et al., 2009). The Western Indian Ocean, particularly waters surrounding Sri Lanka, exhibits complex oceanographic dynamics influenced by the South Asian monsoon system, making it critical for understanding climate variability (Shankar et al., 2002).

Traditional linear statistical approaches often fail to capture inherently non-linear relationships between atmospheric variables, limiting our ability to characterize complex air-sea interactions. Recent advances in machine learning provide powerful tools for modeling such environmental systems (Breiman, 2001), yet their application to tropical ocean-atmosphere flux dynamics remains underexplored, particularly for the data-limited Western Indian Ocean region. This study addresses this knowledge gap by applying advanced non-linear machine learning techniques to 23 years of MERRA-2 reanalysis data. The research makes three novel contributions: (1) it provides the first comprehensive characterization of long-term heat and energy flux variability specific to Sri Lankan waters using contemporary reanalysis products, (2) it systematically compares multiple machine learning algorithms for atmospheric flux modeling at monthly timescales, revealing critical insights about algorithm performance and sample size requirements, and (3) it establishes a predictive framework that quantifies the relative importance of different flux components and temporal patterns, advancing our mechanistic understanding of air-sea coupling in this monsoon-dominated region.

Methodology

Monthly gridded data from NASA's MERRA-2 reanalysis system (Gelaro et al., 2017) were obtained for the Western Indian Ocean region (78.75°E-80.5°E, 5.5°N-10°N) spanning August 2002 to May 2025 (n=274 observations). Three atmospheric flux variables were analyzed: latent heat flux (EFLUX, W/m²), sensible heat flux (HFLUX, W/m²), and eastward atmospheric kinetic energy flux (UFLXKE, kg/m·s³).

Data preprocessing included temporal feature engineering with cyclical encoding of monthly patterns using sine-cosine transformations to preserve seasonal periodicity. Time series decomposition was performed using additive models to separate trend, seasonal, and residual components. Statistical analysis included Pearson correlation, linear trend analysis, and seasonal climatology computation.

Three non-linear machine learning algorithms were implemented to model the relationships between concurrent atmospheric flux variables: (1) Random Forest Regression with 200 trees and maximum depth of 15; (2) Gradient Boosting Regression with 200 estimators and learning rate of 0.05; and (3) Multi-Layer Perceptron Neural Network with hidden layers of 100-50-25 neurons. The modeling framework used concurrent values of HFLUX, UFLXKE, time index, and cyclical month encodings to estimate EFLUX. This represents diagnostic modeling of contemporaneous relationships rather than temporal forecasting, enabling characterization of the underlying physical coupling between flux components within the same time period. The dataset was partitioned into training (80%, n=219) and testing (20%, n=55) sets using temporal ordering. Model performance was evaluated using coefficient of determination (R^2), root mean squared error (RMSE), and mean absolute error (MAE).

Results/Findings

Over the 23-year period, mean latent heat flux was 125.51±16.85 W/m² (range: 83.47-186.03 W/m²), sensible heat flux averaged 14.51±5.27 W/m² (range: 5.49-33.43 W/m²), and eastward kinetic energy flux exhibited high variability (mean: $-9.57\times10^6\pm8.99\times10^6$ kg/m·s³). Linear trend analysis revealed a statistically significant declining trend in HFLUX (-0.151 W/m²/year, $p=0.002$, $R^2=0.036$), while EFLUX showed no significant trend ($p=0.446$).

Strong seasonal patterns characterized all variables (Table 1). Latent heat flux peaked during boreal winter (DJF: 141.56 W/m²) corresponding to northeast monsoon conditions, while lowest values occurred during pre-monsoon transition (MAM: 118.24 W/m²). Kinetic energy flux showed pronounced seasonal amplitude, with southwest monsoon (JJA) values seven times larger in magnitude than winter values, reflecting strong seasonal wind reversals.

Table 1: Seasonal Mean Values of Atmospheric Flux Variables

Variable	**DJF**	**MAM**	**JJA**
EFLUX (W/m²)	141.56	118.24	123.45
HFLUX (W/m²)	18.32	13.45	11.28
UFLXKE (10^6 kg/m·s³)	-3.21	-8.45	-22.67

Note. DJF=December-February; MAM=March-May; JJA=June-August.

Correlation analysis revealed moderate negative coupling between EFLUX and HFLUX ($r=-0.401$, $p<0.001$), indicating compensatory mechanisms in surface heat budget partitioning. Random Forest regression achieved superior performance ($R^2=0.557$, RMSE=10.71 W/m², MAE=8.73 W/m²), substantially outperforming Gradient Boosting ($R^2=0.495$, RMSE=11.44 W/m²) and Neural Network ($R^2=-3.71$, RMSE=34.91 W/m²) approaches. The Neural Network's negative R^2 coefficient represents a significant finding in itself: with the relatively modest sample size (n=274) typical of monthly reanalysis datasets, deep learning architectures proved unsuitable for this application. This outcome demonstrates that ensemble tree-based methods exhibit greater robustness than neural networks when working with moderate-scale monthly atmospheric datasets, an important methodological consideration for similar oceanographic studies.

Feature importance analysis revealed cyclical temporal patterns dominated predictive power, with cosine component (40.6%) and sine component (23.9%) collectively explaining 64.5% of model capability. HFLUX contributed 15.5%, reflecting the inverse EFLUX-HFLUX coupling, while UFLXKE provided 11.3% importance and linear time trend only 8.7%.

Discussion

The pronounced seasonal variability reflects dominant monsoonal forcing on air-sea interactions in the Western Indian Ocean. Winter maximum in latent heat flux corresponds to the northeast monsoon period when dry continental air masses enhance evaporation over warmer waters. The dramatic amplification of kinetic energy flux during JJA directly reflects the strong cross-

equatorial Findlater Jet (Findlater, 1969), capturing substantial momentum transport during the southwest monsoon.

The significant declining trend in sensible heat flux (-0.151 W/m²/year) may indicate changing air-sea temperature gradients, potentially reflecting differential warming rates between atmosphere and ocean. This has implications for upper ocean thermal structure and mixed layer depth evolution. The compensatory relationship between EFLUX and HFLUX (r=-0.401) likely represents energy partitioning within the surface boundary layer, where increased sensible heating reduces the energy available for latent heat transfer.

Random Forest's superior performance demonstrates the effectiveness of ensemble tree-based methods for capturing non-linear atmospheric dynamics in diagnostic modeling applications. The dominance of cyclical seasonal features (64.5% combined importance) validates the cyclical encoding approach and confirms that seasonal patterns are the primary driver of flux variability in this monsoonal region. While the model achieves R^2=0.557 and successfully captures the dominant seasonal and inter-flux relationships, approximately 44% of variance remains unexplained. This residual variance likely reflects additional dynamic processes not captured by the current variable set, including sea surface temperature gradients, boundary layer humidity profiles, cloud radiative effects, and mesoscale atmospheric phenomena. Incorporation of these variables in future studies could further improve model performance and provide deeper insights into air-sea coupling mechanisms.

Conclusion

This study demonstrates that Random Forest regression effectively models diagnostic relationships between concurrent ocean-atmosphere heat flux components in the Western Indian Ocean, achieving R^2=0.557 and capturing 55.7% of variance in latent heat flux. Strong seasonal variability driven by monsoonal forcing dominates flux patterns, with cyclical temporal features accounting for 64.5% of predictive importance. The significant declining trend in sensible heat flux warrants attention as an indicator of changing air-sea thermal gradients with potential implications for regional ocean thermal structure. A key methodological finding is that neural networks are unsuitable for monthly-scale atmospheric flux modeling with sample sizes typical of reanalysis

datasets, while ensemble tree-based approaches prove robust. These findings advance understanding of air-sea energy exchanges in this climatically sensitive region and demonstrate machine learning utility for diagnostic atmospheric flux modeling. The predictive framework could be extended by incorporating additional oceanic and atmospheric variables to explain the remaining variance, supporting improved understanding of monsoon-ocean interactions and marine resource management in the Western Indian Ocean.

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Assessing the Role of Facilities Management in Enhancing Building Resilience to Climate-Induced Disasters in Sri Lanka

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Introduction

Sri Lanka is facing climate-related consequences that affect areas including agriculture, water and marine sector, health, human settlement and infrastructure, biodiversity, energy and transportation (Senevirathna, 2016). The built environment sector is also impacted by climate change in different ways (Lacasse et al., 2020). Barrelas et al. (2021) declared that the severity of wind, precipitation, and other phenomena, such as landslides, will increase building maintenance costs. Extreme catastrophes induced by climate change have harmed infrastructure, including transportation, water, sanitation, and energy (Calvin et al., 2023). Regional climate change significantly affects vegetation and landscape (Chen et al., 2020). Developing countries, including Sri Lanka, have limited adaptive capacity to face these impacts (Cevik & Jalles, 2022).

Sri Lankan built environment sector encounters regional challenges in disaster management including environmental, social, political and inter-organizational challenges (Abdeen et al., 2021). Facilities managers (FMs) in Sri Lanka need to prioritize competencies to prepare for disasters, as this area requires urgent attention in the region (Peiris et al., 2025). According to Warren (2010), FMs need to conduct risk assessments for climate change and prepare disaster management strategies. Educational institutions in Ghana face challenges in managing disasters, highlighting the requirement of FMs' involvement (Mohammed et al., 2025). However, their involvement in disaster preparedness is not sufficient, due to other priorities they have and the lack of personnel to address these issues (Hardy et al., 2009). In terms of identifying climate-induced disasters FMs have a knowledge gap in climate-related risks (Warren, 2010). Even though FMs have to play a significant role in improving organizational resilience to disasters, there is unclear facilities management (FM) responsibilities in strategic and operational levels (Jones et al., 2023). Therefore,

this study aims to evaluate the adequacy of facilities managers' involvement in climate-induced disaster management in Sri Lanka.

Methodology

This study adopts a qualitative research approach to explore the adequacy of FMs' involvement in climate-induced disaster management. To collect primary data, semi-structured interviews were employed, enabling flexible exploration of participant knowledge. The experts were built environment-related professionals with more than 7 years' experience in their sector and were engaged in both research and practical work related to climate change impacts, disaster management and sustainability. Eight expert interviews provided sufficient, meaningful insights and data saturation. The participants were selected through purposive sampling and their profiles are listed in Table 1. To analyses expert survey data, thematic analysis was selected, utilizing pre-established themes, categories and codes derived from the literature.

Table 1*:* Profiles of the experts

Expert	Designation	Experience
E1	Facilities Engineer	09 years
E2	Energy Manager, Climate action researcher	11 years
E3	Senior Facilities Manager	12 years
E4	Sustainable design engineer, energy auditor	11 years
E5	Assistant Facilities manager	08 years
E6	River and Tsunami Simulation Engineer, climate modelling researcher	07 years
E7	Disaster management Programme coordinator, climate researcher	15 years
E8	Senior Facilities Manager	13 years

Results/ Findings

Majority of experts (6/8) stated that there is a medium level of awareness among professionals on climate change, highlighting those sustainable considerations driven by market. E4 stated that awareness is high as climate change is currently a hot topic. However, E8 questioned the practical commitment of FMs to mitigate the impact of disasters in their daily operations, as priority is often given to routine maintenance and uninterrupted building services. This variation suggests that awareness levels are not uniform across the built environment sector, and may depend on individual exposure and engagement with climate-related issues. Table 2 reports the experts' experience on climate-induced disasters in Sri Lanka.

Table 2: Experts' experience on climate-induced disasters in Sri Lanka

Theme	Experts' Experience
Disaster Exposure	Floods, heavy rains, land instabilities, heat waves were experienced.
Impact on Buildings	Health issues, overheating, high energy usage, increased maintenance costs, foundation damages, premature degradation
Impact on Built-infrastructure	Service interruptions, impact on information and communication systems, damages on urban drainage systems.
Impact on Land use	Impact on hydrological aspects, changes in vegetation, effect on drinking water bodies, soil cracks were detected.
Impact on FM functions	Increase maintenance costs and frequency Impact on occupational health and safety, building performance and emergency preparedness
Data-driven decision making	Flood modelling for disaster management Lack of data-driven decision-making due to less accessible climate databases.

Although E1 stated about no seasonal variations in Sri Lanka, E4 and E2 emphasized the recent escalation of climate-induced disasters, mentioning major floods in 2016 and 2022 as well as heat warnings in 2024. These contrasting experiences highlight a shift from stable climate conditions towards more irregular and hazardous conditions, leading to unpredictable disasters. Experts explained their experience on decision-making related to disaster management, including E6 involvement in flood modeling. As available climate data sources are complex for FMs there is no effective use of climate data for disaster reduction. Current roles of FMs in climate-induced disaster management is listed in Table 3.

Table 3: Current roles of FMs in climate-induced disaster management

Role/ involvement	Level of engagement	Current involvements
Design stage	Low	Few FMs participated in design stage of buildings. No/ low support for climate resilience decision making.
Operations and maintenance	Moderate	Adjustments made to maintenance schedules during heavy rains. No/low predictive approaches.
Climate science and engineering	Low	Limited climate science and engineering knowledge among FMs.
Stakeholder management	Moderate	Concerns raised by stakeholders about risk mitigation but minimal support into long-term planning and budgeting.

Policy and governance	Low	Minimal representation in climate/ disaster policy discussions.
Sustainability	Moderate	Moderate involvements, focused on mitigation (reducing CO2 emissions, green certification), not adaptation.
Risk Management	Moderate	Moderate effort raises due to concerns to senior management and emergency preparedness plans

E5 explained the necessity of identifying monsoon periods and implementing preparedness actions such as cleaning gullies and rooftops. Further, experts suggested using climate data for simulations and predictive decision-making in maintenance and design, highlighting the need for a centralized database to guide risk assessments. To obtain budgets and investment, E2 suggested using visualization tools to effectively communicate disaster risk to top management. E3 suggested improving emergency evacuation plans and building shutdown procedures. Also, FM involvement in design stage and the need of training in climate science were highlighted.

Discussion

The study confirms that climate change causes a substantial risk to the built environment, through floods, heavy rainfall, and rising temperatures. However, this study reveals that FMs in Sri Lanka remain unevenly aware of these risks, with many demonstrating only moderate awareness and less engagement in proactive disaster management. These findings are aligned with previous international researches that identified inadequate FM involvement due to other priorities such as routine maintenance and uninterrupted building services, unclear responsibilities, limited personals and lack of institutional support. While global studies highlighted the requirement of FM participation in climate risk assessment, in Sri Lanka there is a low or moderate level of engagement is shown in each identified role. In Sri Lanka, FMs follow reactive practices rather than predictive, such as adjusting maintenance schedules during extreme weather instead of applying climate data for weather forecasting and maintenance planning. The lack of accessible climate databases and limited technical capacity further restrict their contribution. In addition, built environment experts recommendations such as scenario modeling, simulations, introducing visualization tools for decision-making and new policy integration highlight a growing recognition of the FM role in disaster resilience-buildings. The study highlighted the need for structured policy frameworks, technical training, and data-driven adaptation for increasing the involvement of FMs

in disaster-resilience buildings. Therefore, future research should explore the FM capacity enhancement for climate adaptation and digital tools to enhance FM engagement in disaster resilience.

Conclusions

FMs in Sri Lanka play a limited or emerging role in addressing climate-induced disasters. Their current involvement remains reactive, with less use of climate data for predictive planning and decision-making. This limited engagement is caused due to their other priorities, lack of clear responsibilities, lack of FM personnel, inadequate disaster policies, and insufficient technical knowledge. Although global researches emphasize FM engagement in climate risk assessment, governance, and sustainability, Sri Lankan practice remains at a moderate or low level across most roles. To strengthen the FM participation in disaster management requires structured policies, defined responsibilities, targeted training in climate science and digital tools such as climate modelling, simulation and visualization platforms, and access to climate databases for decision-making. Enhancing these areas will be critical in upcoming years to improving disaster resilience in built environment with rapidly changing climate.

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Digital Commerce and Carbon Mitigation: Comparative Insights Across Advanced, Emerging, and Frontier Economies

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Introduction

The contemporary global economy increasingly relies on information and communication technologies (ICTs) to enhance efficiency and sustainability. Nevertheless, rising carbon dioxide (CO_2) emissions driven by fossil fuel combustion, industrial activities, and unsustainable land-use practices such as deforestation remain a critical challenge, intensifying the greenhouse effect and elevating global temperatures by approximately 1.1℃ above pre-industrial levels (Yoro & Daramola, 2020; Li et al., 2024). International trade, which is responsible for 20-30% of global CO_2 emissions through the production and transportation of goods (Cristea et al., 2013), is expected to exceed US$35 trillion by 2025 (UNCTAD, 2025), thereby amplifying environmental pressures. Transitioning to carbon-neutral trade practices is therefore imperative.

Embracing digital technologies is essential to this transformation, as they substantially reduce transaction costs, improve market accessibility, and promote energy efficiency and carbon reduction (Li et al., 2024). Digital commerce, encompassing e-commerce, mobile commerce, and social commerce, has evolved into a dominant global trade modality (Kumari, 2023), expected to reach 3.4 billion users by 2030, underscoring its significance in shaping a sustainable trade ecosystem (Statista, 2025). Despite its extensive adoption, existing research predominantly focuses on e-commerce, examining its effects on national infrastructures and socio-economic implications (Xie et al., 2022).

Additionally, some studies argue that e-commerce can enhance environmental sustainability through socio-economic channels such as green transportation and improvements in green factor productivity (e.g., Escursell et al., 2021; Cao et al., 2021). While e-commerce can reduce emissions

by minimizing physical mobility (Rao et al., 2021), expedited delivery demands may increase fuel consumption, undermining sustainability (Yuan et al., 2022). Moreover, empirical studies largely focus on single economies or developed regions, leaving scarce cross-country evidence on the environmental impact of digital commerce (Wang et al., 2023; Cai, 2024).

This study addresses two critical gaps: (1) the narrow emphasis on e-commerce without considering the broader digital commerce ecosystem; and (2) the lack of comprehensive, cross-country empirical evidence on its environmental implications. By systematically evaluating digital commerce development across diverse economies and quantifying its impact on CO_2 and GHG emissions, this study aims to inform evidence-based policy interventions for sustainable trade.

Data and Methodology

In the empirical analysis, this study obtained data from two primary sources: the Statista website for the transaction value of digital commerce per user, and the World Development Indicators database for dependent variables (CO_2 and GHG emissions per capita) and control variables. The dataset spans 113 countries from 2017 to 2023, consistent with the availability of the principal variable of interest. Thus, this study investigated the relationship between digital commerce and CO_2 and GHG emissions, a key indicator of environmental impact. To operationalize this relationship, the following econometric model is specified:

$$lnEmissions_{it} = \beta_0 + \beta_1 Digital\_Com_{it} + \beta_2 X_{it} + n_i + \varepsilon_{it}$$

Where $lnEmission_{it}$ denotes the dependent variable, measured by the total CO_2 or GHG emissions for the country i in year t. $Digital\_Com_{it}$ represents the independent variable, defined as the transaction value of digital commerce per user (USD), sourced from the Statista website. The vector of control variables is denoted by X_{it}, including gross domestic product (GDP) per capita, internet penetration (percentage of population using the internet), research and development expenditure (% of GDP), educational attainment (tertiary education level), population growth, and trade openness (% of GDP). Additionally, n_i captures the fixed effects, and ε_{it} is the random error term. The data for the dependent and control variables were obtained from the World Development Indicators database.

The study employed a static panel data approach utilizing a random effects model, complemented by clustered standard errors to ensure robustness in a balanced panel with a limited temporal

dimension. Deviating from conventional country classifications, this study employed the MSCI framework, which categorizes countries as advanced, emerging, and frontier economies (MSCI, 2025), for comparative analysis. Developed or advanced economies are characterized by high gross national income (GNI) per capita, substantial liquidity, and full accessibility. In contrast, emerging economies are those experiencing rapid growth but encountering more barriers; frontier economies are typically smaller, less liquid, or operating with more restrictive markets.

Results and Discussion

Table 1 illustrates the empirical results of the analysis. Columns (1)-(4) report the estimated effects on CO_2 emissions for all countries, advanced, emerging, and frontier economies, respectively, while columns (5)-(8) indicate the corresponding results for GHG emissions.

Table 1: Impact of Digital Commerce on CO_2 and GHG Emissions

Variables	(1) CO2 All	(2) CO2 Advanced	(3) CO2 Emerging	(4) CO2 Frontier	(5) GHG All	(6) GHG Advanced	(7) GHG Emerging	(8) GHG Frontier
D-Com.	-0.055**	-0.046**	0.005	-0.033	-0.040*	-0.039**	0.028	0.006
	(0.025)	(0.022)	(0.093)	(0.047)	(0.023)	(0.019)	(0.090)	(0.040)
Internet	-0.001	-0.002**	-0.000	0.004**	-0.000	-0.002**	0.000	0.003***
	(0.001)	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)	(0.003)	(0.001)
Education	-0.013***	-0.013**	-0.014**	-0.002	-0.012***	-0.012**	-0.010	-0.004
	(0.004)	(0.006)	(0.007)	(0.006)	(0.003)	(0.005)	(0.007)	(0.004)
GDP	0.499***	0.563***	0.488**	-0.226	0.283***	0.455***	0.232	-0.326**
	(0.121)	(0.158)	(0.193)	(0.222)	(0.105)	(0.136)	(0.156)	(0.165)
Trade Op.	0.000	-0.000	-0.000	0.004***	0.001	0.000	-0.000	0.003***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
R & D	-0.085***	-0.071**	-0.187	-0.308***	-0.054**	-0.034	-0.162	-0.235***
	(0.033)	(0.033)	(0.178)	(0.091)	(0.027)	(0.026)	(0.179)	(0.047)
Population	-0.007	-0.004	0.004	-0.005	-0.003	-0.002	0.008	0.001
	(0.009)	(0.009)	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.005)
Constan	-0.251	-1.072	1.324	5.185**	2.258**	0.194	4.092***	6.792**

t								*
	(1.156)	(1.535)	(1.800)	(2.219)	(0.997)	(1.279)	(1.392)	(1.658)
Observations	236	164	57	69	236	164	57	69
Number of C_ID	66	38	16	22	66	38	16	22
R-Sq.	0.396	0.482	0.486	0.316	0.347	0.458	0.342	0.350

Note: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
Source: Author's computations using Stata 15

The empirical analysis reveals that digital commerce exerts a significant negative effect on global CO_2 and GHG emissions, supporting the hypothesis that digital trade contributes to carbon mitigation. Accordingly, a one-unit increase in digital commerce transactions per user (equivalent to USD 1000) is associated with an approximately 5.5% reduction in total CO_2 emissions and a 4.0% decrease in total GHG emissions, holding other factors constant. This effect likely operated through mechanisms such as reduced physical trade, lower transportation emissions, and efficiency gains. These findings align with prior research examining e-commerce within specific economic or regional contexts (e.g., Cai, 2024; Xie et al., 2022).

Comparative analysis reveals that digital commerce is associated with a statistically significant reduction in total CO_2 and GHG emissions in advanced economies. In contrast, while the estimated coefficients for emerging economies suggest a positive relationship between digital commerce and CO_2 and GHG emissions, these effects are statistically insignificant. Similarly, in frontier economies, digital commerce transactions do not exert a statistically significant influence; however, the results indicate a negative association with total CO_2 emissions and a positive association with total GHG emissions.

This suggests that the digital economy in advanced economies exerts a stronger influence on carbon reduction compared to developing countries (Al-Mulali et al., 2015; Cai, 2024; Zuo et al., 2024). Advanced economies, characterized by greater economic power and larger trade volumes, exhibit a more pronounced low-carbon effect (Li et al., 2024).

The stronger emission-reduction effect in advanced economies can be attributed to mature digital infrastructure, efficient logistics, and robust regulatory frameworks. These conditions enable transaction efficiency gains to translate into lower energy and carbon intensity. Digital platforms

facilitate automation, optimized routing, paperless trade, and advanced inventory management, reducing transportation needs, warehousing footprints, and supply-chain emissions (Li et al., 2024; Zhu et al., 2024). Conversely, in emerging and frontier economies, digital commerce often coincides with rapid industrialization and urbanization, limiting its immediate impact on emissions. Structural constraints, such as inadequate digital infrastructure, high carbon intensity, and reliance on carbon-intensive manufacturing and transport, diminish the potential for digital efficiencies to yield absolute emission reductions (Li et al., 2024; Wan et al., 2024).

Conclusion and Policy Implications

This study demonstrates that digital commerce has a significant negative impact on CO_2 and GHG emissions, indicating its potential role in promoting environmental sustainability, especially in advanced economies. The results underscore the need for differentiated strategies to leverage digital commerce for carbon mitigation. Advanced economies should continue investing in digital infrastructure and regulatory frameworks that enhance efficiency and sustainability in trade. For emerging and frontier economies, policies must prioritize improving digital infrastructure quality, reducing carbon electricity intensity, and integrating low-carbon technologies into logistics and manufacturing. International cooperation and technology transfer can help bridge structural gaps, ensuring that digitalization contributes meaningfully to global emission reduction goals and environmental sustainability. Policymakers should also address rebound effects to prevent offsetting gains from digital commerce.

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Television News Framing of CPEC in Pakistan: Economic Benefits vs. Environmental Concerns

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Keywords: CPEC, media framing, content analysis, sustainability, economic benefits, environmental concerns, Pakistani news channel.

Introduction

Despite CPEC's transformative economic potential and significant environmental implications for a climate-vulnerable country such as Pakistan, there is a lack of systematic knowledge about the framing of this flagship BRI project by Pakistani television news channels. Although there has been research on the print media coverage of CPEC, the visual and rhetorical role of prime-time TV news in constructing public discourse about the economic-environmental trade-offs of CPEC has not been adequately investigated (Hussain et al., 2020; Asim & Yousaf, 2023; Shams, Sibtain&Ahmad,2025; Yousafa, Ahmed & Fiaz, 2018)

This research fills this gap by analyzing the dominance of economic over environmental frames in Pakistani television news coverage of CPEC, and how these frames are created using tone, sustainability focus, and sources. The study measures the weightage of alternative narratives, and their implications for public understanding of sustainability issues, and how media framing trends could shape policy talk about the long-term implications of CPEC.

Through the analysis of prime-time news bulletins of the top news channels in Pakistan during a crucial phase of the implementation of CPEC and climate emergencies, this research study intends to highlight the role of television journalism in facilitating or hindering informed public discourse on the priorities of sustainable development.

Methodology

The current research employed quantitative content analysis to analyze the prime-time news bulletins of Pakistan's two most popular news channels: Geo News (market leader with around 35% viewership) and ARY News (second most popular with 28% viewership). The selection of the news channels was done on the basis of the PEMRA ratings of 2023-2024 and ensures a wide range of ownership patterns and ideological leanings, Geo News belonging to the Jang Media Group and ARY News belonging to the ARY Group.

Sample of the Study

The Sample consisted of 200 news segments (100 for each channel) from Jan 2024 to Jan 2025, employing systematic sampling (every third CPEC news segment >60 seconds) on major projects: Thar Coal, Suki Kinari Hydropower, Karot Hydropower, Gwadar Port, and Bahawalpur Solar Park. Variables: Dominant frames (economic/environmental), Tone (positive/neutral/negative), Sustainability emphasis, Source, Visuals.

Reliability

Krippendorff's alpha >0.80; data analyzed via SPSS with chi-square tests.

Results/Findings

Economic perspectives were dominant (65% of segments, e.g., jobs/GDP growth), while environmental issues were mentioned in 22%, tone was positive (56%), neutral (24%), negative (20%). Sustainability issues were mentioned very rarely (15%), with a focus on risks to coal/hydropower rather than on green projects such as Bahawalpur Solar; pro-government sources were dominant (70%).

Discussion and Conclusion

Findings resonate with previous research on the optimistic print media coverage of CPEC, which cited the role of state power and economic nationalism as factors for the imbalance, but emphasize the visual emphasis of infrastructure rather than environmental damage on TV. This creates a distorted perspective, which hampers the Green Corridor objectives of Phase II of CPEC in the face of climate crises in Pakistan.

The media needs to use balanced hybrid frames to facilitate informed debate on the trade-offs of CPEC, to inform NDMA guidelines and seminars on sustainable narratives. Future studies may conduct audience impact surveys or comparisons with Chinese media.

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Enhancing Disaster Resilience at the Micro-Level: A Multi-Agent AI Approach for Landslide Early Warnings

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Keywords: Landslide Early Warning Systems, Multi-Agent AI, Grama Niladhari Division, Edge Computing

Introduction

In recent years, the central highlands of Sri Lanka have become more vulnerable to landslides caused by rainfall, a danger starkly demonstrated by the 2016 Aranayake event that revealed the critical necessity for fast and accurate warning systems (Konagai et al., 2022; Bandara & Jayasingha, 2018). Although the National Building Research Organization (NBRO) provides area-wide alerts using rainfall thresholds, these broad-scale warnings usually do not have the detailed precision needed for smaller community-level units such as the Grama Niladhari Division (Wada et al., 2021; Jayasekara et al., 2021). This gap in delivering information to the "last-mile" commonly results in low rates of evacuation and overlooks site-specific causes, including particular ground conditions or anthropogenic activities (Pitigala Liyana Arachchi et al., 2021; Fujita, 2022).

Methodology

The suggested Landslide Early Warning System (LEWS) follows a Multi-Agent AI approach that will be developed to perform the functions of the system at the Grama Niladhari (GN) Division level (as on Figure 1). Compared to the traditional centralized models, which are mainly based on the area-wide rainfall threshold, this model combines local environmental sensing with socio-demographic factors to produce context-dependent dynamic landslide risk predictions. The system architecture will include three dedicated agents known as Rainfall Agent, Soil Agent, and Population Agent that manipulate heterogeneous data streams independently and send the

summarized risk indicators to the central Main AI System in order to make decisions and disseminate alerts.

The Rainfall Agent monitors meteorological triggers using a combination of real-time and historical rainfall data. Real-time precipitation inputs are obtained from low-cost IoT rain gauges deployed within the GN division, while historical rainfall records are sourced from national meteorological archives and prior NBRO datasets. In addition, short-term rainfall forecasts are incorporated from numerical weather prediction models. These inputs are used to compute cumulative rainfall indices, including the Soil Water Index (SWI), which has been validated as an effective predictor for rainfall-induced landslides in Sri Lanka. By integrating forecasted rainfall, the system is designed to extend warning lead times beyond traditional threshold-based methods.

The Soil Agent evaluates slope stability using in-situ soil moisture sensors and soil composition profiles derived from prior geotechnical surveys. Soil saturation levels are continuously assessed to detect conditions that may precede slope failure. A Human Activity Monitor is embedded within this agent to account for anthropogenic factors such as construction activity, slope cutting, and land-use changes, which are identified through field reports or periodic remote sensing updates. Data preprocessing and preliminary inference are executed locally using Edge-AI techniques to minimize latency and ensure system operability in areas with limited connectivity.

The Population Agent incorporates socio-demographic data, including population density, housing distribution, and vulnerability indicators obtained from GN-level census records. This agent contextualizes the physical hazard outputs by estimating exposure and prioritizing alerts for high-risk population clusters. The inclusion of population vulnerability enables targeted warning dissemination, aligning with evidence that localized and relevant alerts significantly improve evacuation compliance.

The Main AI System aggregates feature-level outputs from the three agents and performs integrated risk assessment using supervised machine learning models such as Random Forest classifiers or Convolutional Neural Networks, selected based on data availability and spatial resolution. Model training is conducted using labeled historical landslide event data, with input

features derived from rainfall indices, soil moisture levels, human activity indicators, and population exposure metrics. Model performance is evaluated using standard metrics such as accuracy, precision, recall, and false-alarm rate through cross-validation on historical event records. When the predicted landslide probability exceeds an adaptive risk threshold, the system generates a binary alert. Alerts are disseminated directly to residents and local authorities via mobile communication platforms, ensuring timely delivery of warnings and addressing the last-mile information gap common in centralized early warning systems.

Results/ Findings

This study's primary outcome is the design and specification of a Multi-Agent AI framework intended to refine landslide early warning to the scale of the Grama Niladhari Division. As illustrated in Figure 1, the proposed architecture decentralizes analysis by assigning responsibilities to three specialized agents, namely Rainfall, Soil, and Population, whose outputs are integrated by the Main AI System to support alert generation.

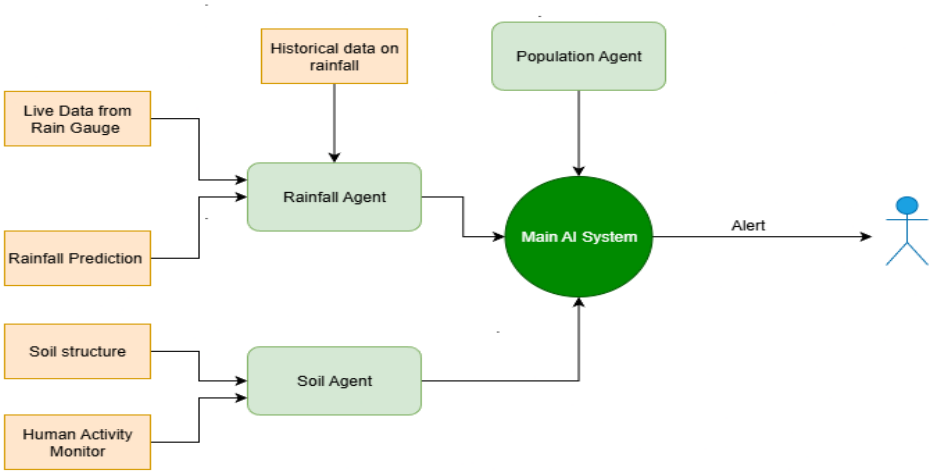

Figure 1: Proposed Architecture of the Multi-Agent Landslide Early Warning System

The Rainfall Agent is designed to integrate real-time IoT-based precipitation measurements with historical rainfall records and short-term rainfall forecasts. Through the computation of cumulative rainfall indices such as the Soil Water Index, the agent is expected to identify critical rainfall conditions earlier than conventional centralized monitoring approaches. Prior studies conducted in

Sri Lanka indicate that the inclusion of localized rainfall indices and forecast information can enhance warning lead times, particularly for rainfall-induced landslides (Wada et al., 2021; Konagai et al., 2022).

The inclusion of the Soil Agent enables the framework to conceptually differentiate between slope instability driven purely by meteorological factors and instability influenced by human activities such as slope modification or land-use change. Existing literature suggests that incorporating such non-meteorological factors can reduce uncertainty and potentially lower false alarm rates in landslide warning systems (Fujita, 2022; I et al., 2024).

From a societal perspective, the Population Agent introduces a mechanism for associating physical hazard indicators with population exposure at the GN division level. While empirical testing is beyond the scope of this study, prior research in Sri Lanka demonstrates that warnings perceived as locally relevant and directly delivered to communities are more likely to be trusted and acted upon (Pitigala Liyana Arachchi et al., 2021; Thirugnanam et al., 2020).

Discussion

The proposed Multi-Agent Landslide Early Warning System represents a shift from centralized, macro-scale warning practices toward a decentralized and community-focused approach. In Sri Lanka, current operational warning mechanisms primarily rely on rainfall thresholds applied over large administrative regions such as Divisional Secretariat areas, which can overlook localized variations in rainfall, soil conditions, and human activity. By structuring analysis at the Grama Niladhari Division level, the proposed framework addresses these spatial limitations highlighted in previous studies (Wada et al., 2021; Jayasekara et al., 2021).

A central contribution of the framework is the explicit inclusion of the Soil Agent and its Human Activity Monitor. Prior research has emphasized that anthropogenic factors, including unregulated construction and agricultural encroachment, play a significant role in slope failures in Sri Lanka (Fujita, 2022; Bandara and Jayasingha, 2018). Existing rainfall-based warning systems are not designed to capture these triggers. The proposed architecture conceptually responds to this gap by integrating environmental sensing with contextual human activity indicators.

The system's alert dissemination strategy also reflects social dimensions of disaster risk management. Empirical studies in the Sri Lankan context show that communities exhibit higher trust and responsiveness to warnings delivered through personal mobile communication channels than to generalized public announcements (Pitigala Liyana Arachchi et al., 2021). By incorporating population exposure into the warning logic, the framework aligns technical risk assessment with social behavior, which is particularly relevant in extreme rainfall events such as Cyclonic Storm Ditwah, where widespread flooding and landslides resulted in significant loss of life despite existing large-area warnings.

Conclusions

This research presents a Multi-Agent AI framework aimed at improving landslide early warning capabilities at the Grama Niladhari Division level in Sri Lanka. The proposed system addresses key limitations of current national warning practices by conceptually integrating localized rainfall monitoring, soil condition assessment, human activity awareness, and population exposure into a unified decision-making process. Rather than reporting empirically validated performance, this study establishes a technically and socially grounded framework that aligns with documented challenges in Sri Lanka's existing landslide warning mechanisms, particularly the lack of micro-scale analysis and population-specific alerting. The findings suggest that refining early warning systems to this localized scale has the potential to improve warning relevance, community trust, and evacuation responsiveness. Future work will focus on implementing the proposed architecture through sensor deployment, historical data-driven model training, and pilot testing in selected high-risk GN divisions. Such validation will enable quantitative evaluation of system accuracy, lead time improvement, and false alarm reduction under real-world conditions.

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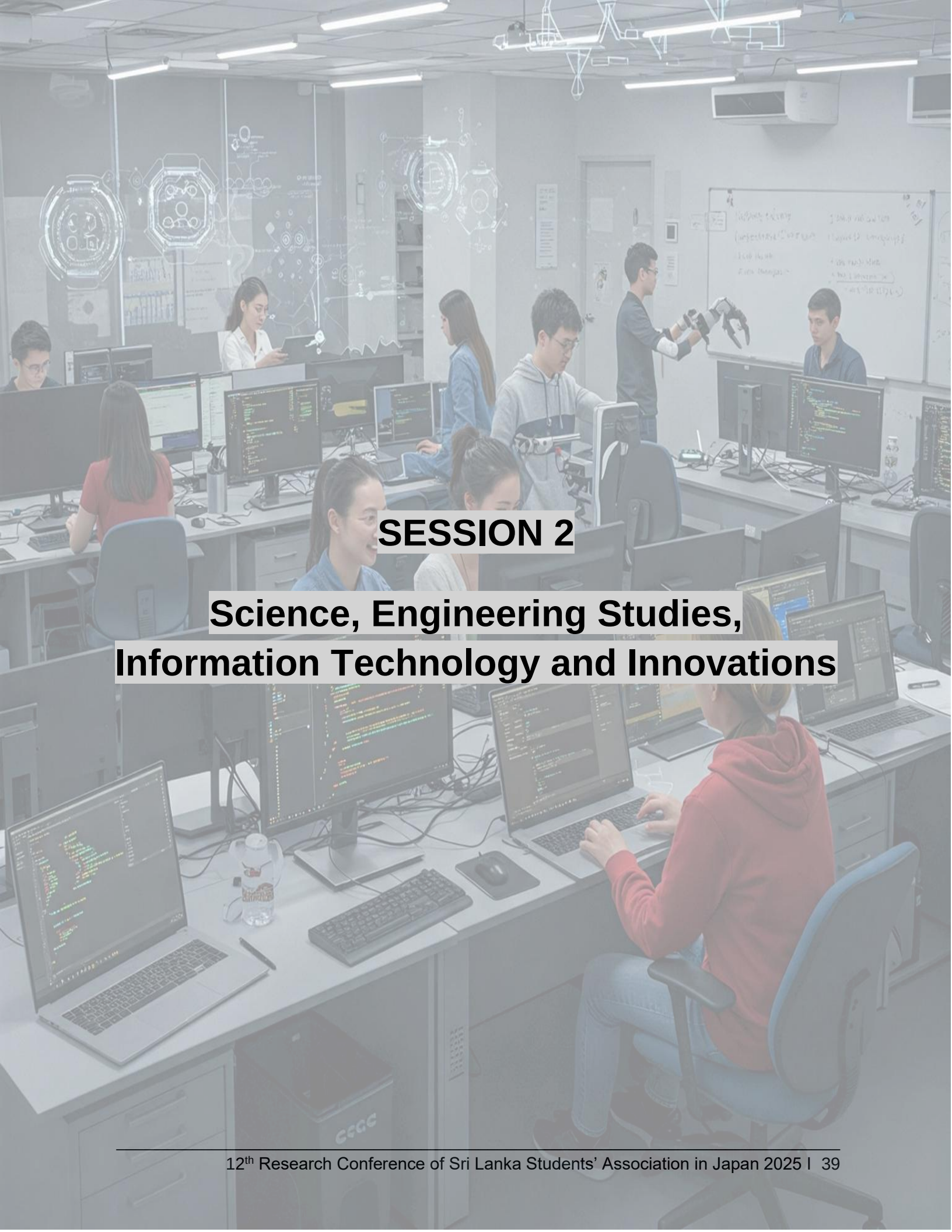

SESSION 2

Science, Engineering Studies, Information Technology and Innovations

Enhancing Cyber Protection in University Networks Using an AI-Assisted Threat Detection Model

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Keywords: University Network Security , Artificial Intelligence, Anomaly Detection, Machine Learning, Cyber Threat Intelligence

Introduction

Schools have been a major target of cybercriminals because of the sheer volume of intellectual property, personal student information as well as monetary data, academic institutions hold. In contrast to corporate, university networks, in addition to supporting BYOD, various scholarly research, and cloud learning environments, demand open architecture, which makes them intrinsically vulnerable (Sarker et al., 2020). Moreover, contemporary higher education institutions are progressively moving towards the hybrid infrastructure where they outsource the essential services such as email to the third-party vendors (e.g., Google Workspace/Gmail). Although this causes the provider to have certain security burdens, it introduces visibility blinds in local networks. Outdated perimeter protection measures such as basic firewalls and signature-based antivirus are the minimal protection yet do not help much with complex attacks such as polymorphic malware and zero-day attacks that circumvent external filters. Recent literature suggests that manual monitoring leads to long response times, which gives the time to proliferation of threat before it is detected. The result is the immediate need to develop automated systems capable of learning the behavior of the network to make deviations denoting malicious activity. The primary activity of this project is to develop and test an AI-based threat detecting model that is specific to the university environment, including hybrid cloud environments, and that is aimed at identifying an anomaly activity in real time.

Methodology

The study adopted a quantitative experimental study design with the use of simulated university network testbed to assess the effectiveness of the proposed AI model. The study also employed CIC-IDS2017 dataset to render the training realistic because the dataset represents common traffic patterns and attacks like DDoS, Brute force, and Web Attacks. Normalization of features and removal of overlapping variables were carried out to bring to the maximum possible computational power. The conceptual model integrated a hybrid machine learning system feature selection was done through a Random Forest to identify the key traffic features, and then sequence-based anomaly detection was implemented with a Long Short-Term Memory (LSTM) neural network.

Most importantly, the model will work at the egress and ingress points of the network. This enables it to track the metadata of traffic and the behavior of the packets even when the university uses an external mail server such as Gmail. The model can detect abnormalities in data flow between internal and external cloud endpoints by analyzing the flow of data between nodes within the campus and external cloud endpoints, independent of the location of the mail server hosting. The data was divided into 70 and 30 percent and trained on the first part and tested on the latter. Accuracy, precision, recall and F1-score were used to make performance comparisons.

Results/ Findings

The experimental data was analyzed which showed that the AI-assisted model works considerably better in comparison to the traditional rule-based detection systems. The LSTM-based structure offered in the proposed research showed a combined detection rate of 98.4 percent on the various attack types. Specifically, the system demonstrated a recall rate of 97.8 percent of individual malware signatures, as well as intrusion attempts. The false positive rate stood at 0.03 which is a vital parameter in the university networks where the traffic of legitimate traffic is high. Concerning processing speed, the model processed traffic packets at an average latency of 12 milliseconds, which made it viable in real-time application. When using the standard firewalls, 100 percent of known signatures were blocked, but only 85 percent of zero-day anomalies simulated could be detected using standard firewalls; on the other hand, the AI model detected 92 percent of the new threats.

Discussion

The research results of this study are correlated with the current developments in the field of cybersecurity, which supports the statement that machine learning is an effective defense line against evolving threats. One of the issues that have been considered as specific to the review is the high presence of third-party mail services such as Gmail in universities. Although other services such as Gmail offer their own in-house filtering services, they do not cover the university network in terms of the effects of a successful attack. As an example, when a user clicks a harmful link on a Gmail interface, the malware download, subsequent lateral network movement and subsequent data exfiltration happen all on top of the local infrastructure of the university.

This gap is addressed by the proposed AI model which oversees the network layer instead of the application content. It is able to identify the command and control (C2) callbacks and internal scanning following the email threat that has bypassed the cloud filters. This renders the implementation of AI a necessity in the reduction of the so-called alert fatigue in the context of a massive traffic setting. One of the weaknesses that was observed was the large computational power needed to train LSTM networks. Moreover, although the system is superior regarding the detecting side, the difficulty of adapting it to the old campus equipment and the encrypted traffic streams across cloud (HTTPS/TLS) should be taken into account. These results indicate that AI cannot be fully used in place of firewalls or cloud-provider security systems, but rather it is a proactive complement that can keep track of the east-west traffic and the cloud-to-edge transitions.

Conclusions

In conclusion, this study demonstrates that the implementation of an AI-powered threat detection model on university networks, including those that use outsourced network services such as Gmail leading to the deployment of outsourced services, can result in the mass improvement in cybersecurity. The research confirms the fact that machine learning algorithms can mitigate highly dynamic and advanced threats that have bypassed traditional security controls and third-party filters. The suggested system changes the security paradigm to be more proactive than reacting due to the real-time analysis and warning. This builds a scalable and resilient security framework which protects sensitive academic data without hindering the openness of the higher education system.

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Association Between ABO/Rh Blood Group Phenotypes and Type 2 Diabetes Mellitus

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Keywords: Association, Type2 Diabetes Mellitus, ABO / Rh blood phenotypes

Introduction

Type 2 diabetes mellitus (T2DM) represents a major global health burden, accounting for over 90% of diabetes cases worldwide and contributing substantially to cardiovascular disease, renal failure and premature mortality (International Diabetes Federation [IDF], 2023). The prevalence of T2DM continues to rise rapidly, particularly in low- and middle-income countries, driven by demographic transitions and lifestyle changes. While modifiable risk factors are well established, growing attention has turned toward genetic and biological determinants that may influence individual susceptibility to T2DM.

This study examines the association between ABO and Rh blood group types and T2DM. ABO and Rh blood groups are genetically determined, stable throughout life, and routinely documented in clinical practice. Beyond their established role in transfusion medicine, ABO antigens are expressed on endothelial cells and have been implicated in inflammatory, metabolic and coagulation pathways relevant to T2DM pathogenesis (Legese et al., 2020). However, the extent to which these blood group systems contribute to diabetes risk remains uncertain. In this context, blood group type serves as the primary independent variable, with T2DM status as the outcome of interest.

The necessity for this research arises from both theoretical and practical gaps. Previous studies have suggested associations between specific ABO blood groups and T2DM, potentially mediated through chronic inflammation and insulin resistance, yet findings remain inconsistent across populations with blood group B often showing elevated risk in Ethiopian and North Indian cohorts (Legese et al., 2020; Keisam et al., 2018; Getawa et al., 2022; Liumbruno, & Franchini, 2013). Notably, evidence from South Asian populations including Sri Lanka, where T2DM prevalence

reaches 10-15% amid rapid urbanization remains sparse and no prior studies have examined ABO/Rh phenotypes in this context. This inaugural Sri Lankan investigation addresses these voids by analyzing a Colombo Clinic sample, uniquely incorporating the Rh factor underexplored regionally, to identify population-specific risk patterns for enhanced genetic risk stratification. Many investigations are limited by small sample size, lack of adjustment for confounders or exclusion of the Rh factor. Clarifying these associations could support the identification of non-modifiable risk markers relevant to early risk stratification.

Despite increasing global research, evidence from South Asian populations remains limited and the role of the Rh factor is particularly underexplored. This study aims to determine whether ABO and Rh blood group types are significantly associated with T2DM and to identify blood group patterns linked to increased disease prevalence. Grounded in genetic epidemiology, the findings may contribute to improved risk assessment models and support population-level strategies for diabetes prevention and management.

Methodology

This study employed a cross-sectional design to examine the association between ABO/Rh blood group phenotypes and T2DM among adults attending Aventra Health Care (Pvt) Ltd, Colombo, Sri Lanka. The study was conducted over a six-month period from December 2024 to May 2025. Adults aged 18 years and above who attended the laboratory for routine investigations or volunteered for participation were recruited. The study population consisted of individuals with diagnosed T2DM and apparently healthy controls.

A total sample of 272 participants was determined using a standard sample size calculation method for case control comparisons, with an equal ratio of cases to controls. Individuals with type 1 DM, gestational diabetes, other metabolic disorders, or those who declined consent were excluded. Fasting blood samples were collected following 12 hours overnight fast using standard aseptic techniques. Fasting blood glucose was measured using the glucose oxidase-peroxidase method on an automated biochemistry analyzer, with routine quality control procedures applied.

ABO and Rh blood grouping were performed using standard tube agglutination techniques with commercial antisera. Ethical approval was obtained from ethics review committee, Teaching

Hospital, Peradeniya, Sri Lanka and written informed consent was secured from all participants prior to data collection.

Results/ Findings

A total of 272 participants were included in the study, comprising individuals with T2DM and apparently healthy controls in a 1:1 ratio. Among participants with T2DM, the mean ± SD age was 53 ± 12 years, and the mean FBS level was 189.2 ± 75.6 mg/dl. Females constituted 59% (n=80) of the diabetic group, while males accounted for 41% (n=56). Most patients with T2DM were aged between 38 and 57 years (54%, n=73), following by those older than 58 years (36%, n=49) and those aged 18-37 years (10%, n=14).

In control group, the mean ± SD age was 49 ± 15 years, and the mean FBS level was 87.2 ± 10.8 mg/dl. Females comprised 60% (n=81) of the controls and males 40% (n= 55). The largest proportion of controls belonged to the 38–57-year age group (42%, n=57), followed by those above 58 years (35%, n=47) and 18-37 years (24%, n=32).

Blood group O was the most prevalent phenotype among both control (42%) and T2DM patients (36%). However, phenotype B was more frequent among individuals with T2DM (35%) compared to controls (22%). Rh-positive status predominated in both groups, with no statistically significant association observed between Rh factor and T2DM. A chi-square analysis demonstrated a significant association between ABO blood group distribution and T2DM status (χ^2=16.06, p=0.0011). Phenotype B was associated with a significantly increased risk of T2DM (OR=1.87: 95% CI: 1.29-3.19), while phenotype A was associated with a reduced risk (OR=0.56; 95% CI: 0.32-0.99). There was no statistically ($p>0.05$) significant between ABO and Rh groups with age group and gender.

Discussion

Type 2 diabetes mellitus is widely recognized as a complex disorder arising from interactions between genetic predisposition and environmental exposures. Given that ABO and Rh blood group systems are genetically determined, their potential contribution to diabetes susceptibility has been explored, although previous findings remain inconsistent across populations. The present study, the inaugural investigation in Sri Lanka adds novel evidence by demonstrating a significant ABO-

T2DM association in a Colombo clinic sample (n=272), with phenotype B showing elevated risk (OR 1.87) and uniquely incorporating Rh factor, underexplored in South Asian contexts despite regional T2DM surges (10-15% prevalence). This extends sparse Indian data while highlighting population specific patterns, suggesting that inherited blood group characteristics may influence metabolic disease risk.

Increased susceptibility observed among individuals with blood group B aligns with several studies conducted in Northwest Ethiopia (Legese et al., 2020), India (Akshaya, 2020), Qatar (Bener & Yousafzai, 2014), France (Abegaz, 2021), supporting the possibility of a biologically meaningful association. One plausible explanation is the reported link between certain ABO phenotypes and elevated inflammatory and endothelial markers, which are known to contribute to insulin resistance and β-cell dysfunction (Legese et al., 2020). However, conflicting finding from other regions indicate that this association is not universal and may be modified by population-specific genetic structure, environmental exposures or lifestyle factors (Yahaya et al, 2021; Keisam et al., 2018).

Conversely, blood group A appeared to be associated with a lower risk of T2DM in this study, suggesting a potential protective role. Evidence regarding this phenotype remains mixed in the literature, highlighting unresolved inconsistencies that warrant further investigation. Blood group AB showed no association with T2DM, reinforcing the heterogeneity reported across studies (Aggarwal et al., 2018; Dali et al., 2014). No significant relationship was observed between Rh factor and T2DM, consistent with several reports, although isolated studies have suggested otherwise.

No statistically significant associations ($p>0.05$) emerged between ABO/Rh blood groups and age groups or gender, supporting balanced demographic distributions between T2DM cases and controls. This minimizes confounding by these factors in the observed ABO-T2DM link, consistent with prior studies where blood groups showed independence from gender or age (Legese et al., 2020).

Conclusions

This study confirms a significant association between ABO blood group phenotypes, particularly elevated risk with group B and T2DM in a Sri Lankan cohort, marking the first local evidence with Rh factor inclusion. Blood group B showed higher prevalence in T2Dm cases (OR 1.87), while group A appeared protective; Rh factor was neutral, with no links to age or gender. These patterns extend inconsistent South Asian data, highlighting population specific genetic risks amid Colombo urban diabetes burden. Findings advocate blood group screening as a simple, non-modifiable T2DM risk marker for Sri Lankan risk models. Future multicenter trials with adjusted logistic regression (Age/gender/BMI) and longitudinal designs are essential to validate causality and mechanisms.

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Gelatine Extraction from Sea Chicken Fish (*Canthidermis maculata)* By-Products for Waste Reduction and Produce Value Added Products in The Seafood Industry

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Keywords**:** Fish gelatine, *Canthidermis maculata*, Extraction yield, Acid treatment, Cost-effectiveness

Introduction

Fish processing recovers only 20-50% of raw materials as edible product, while 50-80% discarded as by product such as skin, bones, heads and viscera. A small portion of these by-products is used to produce low-value products such as fertiliser, fish feed and fish oil. The major portion is dumped causing environmental, social and economic problems. Fish skin constitutes a main component of these by-products with gelatine accounting for the highest component of protein within it. Gelatine is an important biopolymer used in sectors such as food, cosmetics, pharmaceuticals and photography. Gelatine primarily arises from pig skin (46%), bovine hide (29.4%), and pork & cattle bones (23.1%). In 2007 Fish gelatine constituted less than 1.5% of the total production but had doubled since 2002 emphasizing the growing importance of non-mammalian sources in gelatine manufacturing (Gómez-Guillén *et al*., 2009). Sea chicken fish with its tough skin and bones is therefore suitable as raw material for gelatine manufacture. Presently only the meat is used resulting to up to 51% wastage level. Therefore, utilization of this type of fish's skin and bones would reduce waste and increase value from discarded components (Arpi *et al*., 2016). This research assessed how two acid pre-treatments affected the physiochemical properties of extracted gelatine during gelatine production from skins of sea-chicken fish.

Methodology

The skins were precisely cut into small pieces measuring 2cm by 2cm. These pieces were then carefully stored in polyethylene bags at a temperature of -20°C for preservation. The skins were thawed, and their weight was recorded (100 g), followed by a water wash. To remove non-collagenous proteins, the skins underwent a one-hour immersion in 0.1 M NaOH solution at a ratio of 1:6 (w/v) with continuous stirring at 125 rpm. Then, the skins were compressed for 5 minutes in a cotton mesh covered funnel, and the washing procedure was repeated twice. The next step

treated the fish skins with HCl or acetic acid (CH_3COOH) solutions at concentrations of 0.15 M and 0.2 M (1:6 w/v ratio) under constant stirring at 125 rpm for 1 hour. The acid solution was then drained off, and this acid treatment process was repeated twice (Mazorra-manzano *et al*., 2018). The acid pre-treatments were followed by extracting gelatine using distilled water (1:6, w/v) at 60 °C for 3 hours. The solution containing residual skins was subjected to filtration using a Büchner funnel equipped with Whatman no. 4 filter paper (Mazorra-manzano *et al*., 2018). The recovered gelatine solutions were allowed to cool to room temperature, and their total volume was measured. Finally, the gelatine solutions were dried with vacuum oven at 50°C. Then quality of the extracted gelatine was tested

Results/Findings

This research assessed the impact of HCl and CH_3COOH effect, at 0.15 M, and 0.2 M, on extraction yield, gel strength, viscosity, colour, pH, protein, ash, minerals, melting point of sea chicken fish skin gelatines.

Table 1 : Physicochemical properties of gelatine from sea chicken fish obtained from different acid treatments and commercial sample

Treatments	**HCL 0.15**	**HCL 0.20**	**CH_3COOH 0.15**	**CH_3COOH 0.20**	**COMMERCIAL**
Yield (%)	8.99	7.35	7,18	5.41	-
Gel strength (N)	0.539 ± 0.0128^{ab}	0.5830 ± 0.0496^{b}	0.490 ± 0.0069^{a}	0.509 ± 0.0087^{ab}	0.042 ± 0.0003^{c}
Viscosity (cP)	3.21 ± 0.176^{a}	4.51 ± 0.99^{c}	3.95 ± 0.408^{a}	4.51 ± 1.422^{b}	4.55 ± 0.609^{c}
pH	6.0667 ± 0.31^{a}	5.25 ± 0.01^{b}	4.94 ± 0.06^{c}	4.7067 ± 0.023^{d}	6.04 ± 0.052^{a}
Melting point (°C)	27 ± 1.000^{a}	25.33 ± 0.577^{a}	25.33 ± 1.155^{a}	22.33 ± 0.577^{b}	22.67 ± 0.577^{b}
Proximate analysis					
Crude protein (%)	74.38 ± 2.175^{a}	75.61 ± 0.175^{a}	82.75 ± 1.100^{b}	72.70 ± 1.515^{a}	88 ± 0.000^{c}
Ash (%)	0.0831 ± 0.0068^{a}	0.0689 ± 0.0007^{b}	0.0623 ± 0.0022^{bc}	0.0645 ± 0.003^{bc}	0.0467 ± 0.0004^{c}
Ca (mg/kg)	0^{a}	2.753 ± 0.394^{b}	13.162 ± 0.355^{c}	10.438 ± 0.849^{d}	7.805 ± 1.099^{e}
Mg (mg/kg)	1.738 ± 0.1157^{a}	3.720 ± 0.0121^{b}	12.325 ± 0.0594^{c}	18.147 ± 0.7823^{d}	0.43 ± 0.0025^{e}
P(mg/kg)	53.821 ± 3.199^{a}	82.527 ± 1.550^{b}	59.308 ± 1.297^{c}	74.616 ± 0.283^{d}	0^{e}
Colour					
Colour L*	4.0767 ± 0.087^{a}	6.7133 ± 0.480^{b}	6.5033 ± 1.237^{b}	9.3967 ± 0.679^{c}	11.4 ± 0.981^{c}
Colour a*	-5.447 ± 0.055^{a}	-2.94 ± 0.64^{a}	-5.8 ± 0.41^{a}	-4.877 ± 0.080^{a}	-7.393 ± 1.065^{c}
Colour b*	8.83 ± 1.61^{a}	5.89 ± 0.18^{b}	4.95 ± 0.52^{b}	6.78 ± 0.35^{ab}	18.67 ± 0.27^{c}

Discussion

Factors such as acid content, extracting temperature, soaking time and extraction duration play pivotal roles in gelatine production. Increasing acid concentration led to a decrease in yield. Gelatine strength is important for quality and applications, increase with acid concentration. HCl exhibited higher gel strength values compared to CH_3COOH, particularly at 0.2 M concentration, where maximal gel strength was achieved (0.5830 ± 0.0247N, $P < 0.05$). Compared to the commercial sample, all acid-treated gelatines from sea chicken showed notably high gel strength. High gel strength indicates superior quality. Variations in gel strength values of the two acid gelatines can be linked to the specific amino acid profiles of collagen sources and the distribution of various components present in the manufactured product (Mazorra-manzano *et al*., 2018).

Viscosity, another characteristic of gelatine in the industry, with high viscosity gelatines producing tough, extensible gels while low viscosity gelatines result in short, brittle gels (Mazorra-manzano *et al*., 2018). Low viscosity gelatine solutions tend to produce thin gels, while high viscosity solutions yield stiff, extensible gels with greater commercial value. In the study, the viscosity of gelatine increased with higher acid concentrations. The viscosity for the samples ranged from 3.21 to 4.51 cP. Gelatine extracted from sea chicken fish skin typically exhibited viscosity values within the standard commercial range of 2.0 to 7.0 cP (Rafieian *et al*., 2015).

The colour values ("L" and "a") of gelatine samples increasing with higher acid concentration. The treatments exhibited yellowish and greenish hues, with no presence of blue or red tones. Inorganic, proteinaceous, and mucosubstance impurities introduced or retained during the extraction process contribute to the coloration of gelatine.

The pH values of gelatine samples ranging from 6.07 to 4.70 for sea chicken fish gelatine. According to the Gelatine Quality Standard (GMIA, 2012), the recommended pH range is between 3.8 and 5.5. This requirement was satisfied by the acid pre-treatments using 0.20 M HCl, 0.15 M CH_3COOH, and 0.20 M CH_3COOH, ensuring compliance with industry standards. The melting point range from (22-27) ℃ Lower melting point in fish gelatine was associated with enhanced flavour release, improved smell, and better control of texture and flavour release during product mastication (Koli *et al*., 2013).

Conclusion

This study evaluated the impact of hydrochloric acid (HCl) and acetic acid (CH_3COOH) concentrations (0.15 M and 0.2 M). pre-treated with HCl and CH_3COOH (0.15M and 0.2M) gave the highest yield (8.99%), at the same time 0.15 CH_3COOH achieved the highest protein content (82.75%). Additionally, the pH and viscosity levels were 4.94 and 3.95 cP, respectively, meeting standard requirements. Additionally, gel strength from all treatments exceeded that of commercial gelatine, indicating its potential for various food-related applications. Notably, HCl at 0.2 M exhibited the highest gel strength (0.5583 N). Overall, the extraction of gelatine from sea chicken fish skin was found to be suitable and cost-effective, utilizing discarded waste product effectively.

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Examining The Role of Psychological Interventions in Enhancing Cognitive and Physical Recovery in Stroke Survivors: A Longitudinal Comparative Study on Mental Health Support in Stroke Rehabilitation.

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Keywords: Stroke rehabilitation, psychological interventions, Inpatient care, Outpatient care, Emotional well-being

Introduction

Stroke remains a major global health concern and a leading cause of long-term disability, resulting in significant physical, cognitive, and psychological impairments among survivors (Feigin et al., 2025; Tsao et al., 2023; GBD 2021 Stroke Study, 2024). Although advances in medical treatment and physical rehabilitation have improved survival outcomes, psychological sequelae such as depression and anxiety continue to be insufficiently addressed, particularly in low- and middle-income countries, including Sri Lanka (Hackett & Pickles, 2014; Ministry of Health Sri Lanka, 2023). These psychological challenges negatively influence motivation, rehabilitation participation, and overall recovery outcomes (Choi et al., 2021; Volker et al., 2018). Emerging evidence demonstrates that structured psychological interventions, including cognitive behavioral therapy and counselling, can enhance emotional well-being, engagement in rehabilitation, and functional recovery (Zhao et al., 2024; Choi et al., 2025).

The objective of this study is to examine the impact of psychological interventions on cognitive and physical recovery among stroke survivors, comparing inpatient and outpatient rehabilitation settings.

Methodology

A comparative longitudinal design was employed to examine the impact of structured psychological interventions on emotional, cognitive, and physical recovery among stroke survivors. The study conducted in a rehabilitation setting in Sri Lanka included 60 participants, comprising 30 inpatients receiving structured psychological interventions by professional counsellors, psychiatry medical officers, and psychiatrists alongside rehabilitation, and 30 outpatients receiving standard rehabilitation without structured psychological support. Participants

were assessed at baseline and after three months using the Hospital Anxiety and Depression Scale (HADS) to measure anxiety and depression, and the Stroke Impact Scale (SIS) to evaluate cognitive and functional outcomes. Purposive sampling was used to recruit medically stable adults with ischemic or hemorrhagic stroke. Inpatient interventions included counselling, psychoeducation, coping skills training, emotional regulation strategies, and behavioral activation. Data were analyzed using SPSS. Descriptive statistics summarized participant characteristics, while paired-sample and independent-sample t-tests were conducted to assess within-group changes and between-group differences. Assumptions of normality and homogeneity of variance were tested before analysis.

Table 1: Interpretation of HADS Scores

Score	Interpretation
0–7	Normal
8–10	Borderline / Mild
11–21	Clinically significant anxiety/depression

Table 2: SIS Interpretation Ranges

Score Range	Interpretation
0–25	Severe limitation
26–50	Moderate–Severe limitation
51–75	Moderate limitation
76–100	Mild/No limitation

Results/ Findings

Table 3: Frequency and Percentage Distribution- Gender of the Sample (N = 60)

Gender * Group Crosstabulation

			Group			
				Inpatient	Outpatient	Total
Gender		Count	0	0	0	0
		% within Group	100.0%	0.0%	0.0%	0.0%
	Female	Count	0	19	21	40
		% within Group	0.0%	63.3%	70.0%	66.7%
	Male	Count	0	11	9	20
		% within Group	0.0%	36.7%	30.0%	33.3%
Total		Count	0	30	30	60
		% within Group	100.0%	100.0%	100.0%	100.0%

Table 4: Frequency and Percentage Distribution- Age Categories (N = 60)

Age Group (5 Categories)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25–34 years	3	5.0	5.0	5.0
	35–44 years	6	10.0	10.0	15.0
	45–54 years	11	18.3	18.3	33.3
	55–64 years	16	26.7	26.7	60.0
	65–75+ years	24	40.0	40.0	100.0
	Total	60	100.0	100.0	

At baseline (T_1), stroke survivors exhibited substantial emotional distress and marked functional impairments, with high HADS Anxiety (M ≈ 17.50) and Depression (M ≈ 17.40) scores, and low SIS domain scores across ADL, Mobility, Hand Function, and Social Participation, reflecting significant pre-intervention limitations.

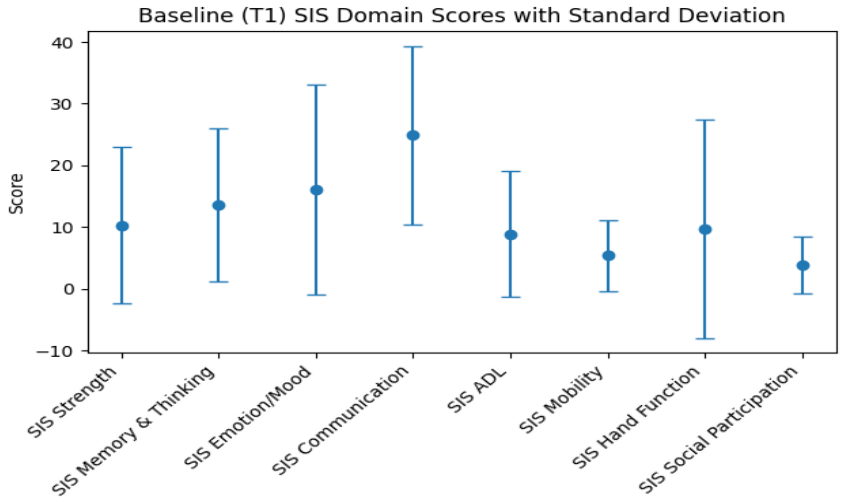

Figure 1: Baseline (T1) SIS scores

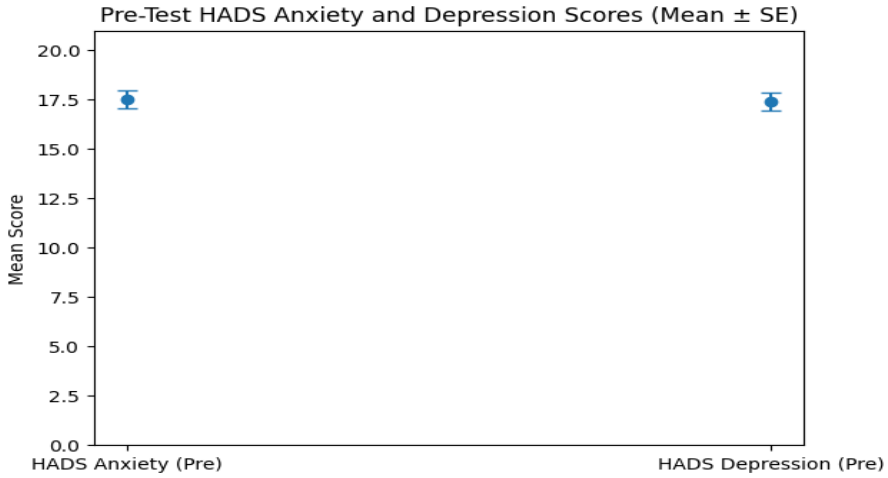

Figure 2: Baseline (T1) HADS scores

Note: HADS = Hospital Anxiety and Depression Scale; SIS = Stroke Impact Scale. Lower SIS scores indicate greater functional impairment; higher HADS scores indicate greater emotional distress.

Post-intervention (T_2), both emotional and functional outcomes improved across the sample, but improvements were markedly greater among inpatients who received structured psychological interventions. Paired-samples analyses demonstrated that inpatients experienced large, statistically significant reductions in HADS Anxiety ($\Delta M = 10.47$, $p < .001$, $d = 3.42$) and Depression ($\Delta M = 10.67$, $p < .001$, $d = 3.45$), along with substantial gains across all SIS domains (e.g., Communication $\Delta M \approx 75.83$, $d > 13$). Outpatients showed modest improvements, with smaller

reductions in anxiety (ΔM = 2.33, p < .001, d = 0.67) and depression (ΔM = 1.40, p = .007, d = 0.53) and limited functional gains, significant only in Emotion/Mood, Hand Function, and Social Participation.

Figure 3: T2 HADS – Anxiety scores

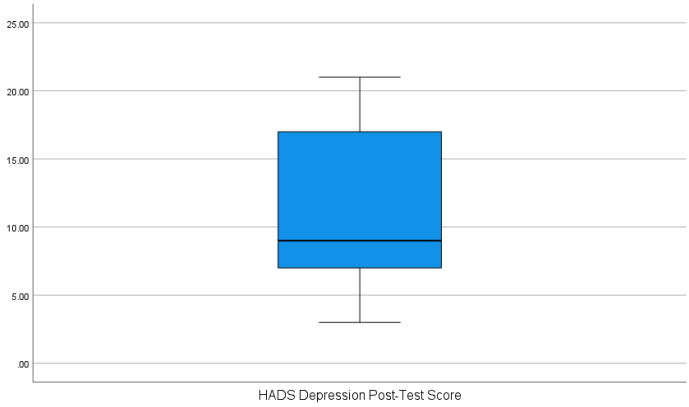

Figure 4: HADS-Depression scores

Between-group comparisons confirmed that inpatients had significantly lower post-test HADS scores (Anxiety M = 6.80 vs. 15.40; Depression M = 6.80 vs. 15.93; p < .001, d > 2.6) and markedly higher SIS domain scores across all eight functional areas (p < .001, d = 6.76–19.04), demonstrating overwhelmingly superior recovery compared with outpatients.

All inpatients received psychological support, reporting high satisfaction (M = 4.63/5), whereas only 16.7% of outpatients received support, with low satisfaction (M = 2.00/5).

Overall, these findings indicate that intensive inpatient rehabilitation combined with structured psychological interventions significantly enhances both emotional well-being and functional recovery, whereas outpatient rehabilitation without such support yields more modest improvements. Access to and quality of psychological care emerged as a critical determinant of post-stroke recovery outcomes.

Discussion

The findings of this study demonstrate that structured psychological interventions significantly enhance emotional and functional recovery among post-stroke survivors, particularly in inpatient rehabilitation settings. In patients who received consistent psychological support, exhibits large reductions in anxiety and depression, along with marked gains across all functional domains, confirming the critical role of integrated psychological care in optimizing recovery. These outcomes align with prior research emphasizing the importance of routine interventions, social support, and multidisciplinary rehabilitation in improving post-stroke outcomes (Lincoln et al., 2013; Langhorne et al., 2011; Wade & Halligan, 2017).

Outpatients, in contrast, experienced only modest improvements, reflecting systemic limitations such as irregular access to psychological services and lower therapy intensity. This disparity highlights a significant equity gap, suggesting that insufficient psychological care may impede adherence, limit social reintegration, and slow long-term recovery (Ayerbe et al., 2013; Pandian et al., 2011). The results support the biopsychosocial model, emphasizing the interplay between emotional regulation, cognitive engagement, and functional performance in stroke rehabilitation.

Clinically, the study underscores the necessity of expanding psychological support to outpatient and community settings through routine counseling, psychoeducation, and telehealth interventions. Future research should investigate scalable models of psychological care and assess long-term outcomes associated with varying rehabilitation intensities. Overall, structured psychological interventions are essential for enhancing recovery and addressing disparities in post-stroke rehabilitation.

Conclusions

This study highlights the critical role of psychological interventions in promoting emotional and functional recovery among post-stroke survivors. Inpatients receiving structured psychosocial support demonstrated significant improvements across anxiety, depression, mobility, communication, cognition, daily activities, hand function, and social participation, whereas outpatients with limited access showed modest gains. These findings underscore the interplay between emotional well-being, social support, and functional outcomes, reflecting the relevance of the biopsychosocial model in health and rehabilitation.

From a governance and institutional perspective, the disparities between inpatient and outpatient outcomes reveal systemic inequities in access to psychological care, particularly in resource-limited settings like Sri Lanka. Addressing these gaps requires policy reforms to integrate psychosocial care into national stroke rehabilitation frameworks, strengthen outpatient services through telehealth and hybrid models, and enhance the capacity of multidisciplinary teams in foundational psychosocial skills. Furthermore, institutional emphasis on structured patient and caregiver education can support home-based recovery and social reintegration.

Overall, this study demonstrates that equitable, well-governed, and institutionally supported psychological interventions are essential not only for optimizing individual recovery but also for building resilient, inclusive rehabilitation systems that ensure all stroke survivors receive comprehensive care.

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Rising Male Burden in Oropharyngeal Cancer in Sri Lanka

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Keywords: Oropharyngeal cancer, Epidemiology, Sri Lanka, Incidence, Cancer registry

Introduction

Oropharyngeal cancer (OPC) is a growing public health concern worldwide. According to GLOBOCAN 2022, there were over 106,000 new OPC cases globally in 2022, accounting for 52,268 deaths (Bray et al., 2024). When grouped with oral cavity cancers, OPC contributes to the sixth most common cancer category worldwide (Warnakulasuriya, 2009). Notably, recent decades have seen significant increases in OPC incidence across many countries – one analysis found rising OPC trends in 19 countries for men and 23 for women (1993–2012) (Zumsteg et al., 2023). This surge in incidence, especially in economically developed nations, has been linked to changing risk factor patterns (Chaturvedi et al., 2013). Historically, tobacco smoking and heavy alcohol use were the predominant drivers of OPC, often acting synergistically (Barón et al., 1993). More recently, human papillomavirus (HPV) infection (particularly HPV-16) has emerged as an established cause of OPC and has been linked to rising incidence in several settings (Chaturvedi et al., 2013). HPV-related OPC is associated with sexual behaviours and commonly involves the tonsils and base of tongue subsites (Cohan et al., 2009).

Given these global patterns, it is important to examine whether similar trends are occurring in South Asia. Sri Lanka, a country with high tobacco use (including betel-quid chewing) and emerging HPV vaccination programs, lacked a detailed analysis of OPC incidence trends. This study thus aimed to assess temporal trends in OPC incidence in Sri Lanka from 2005 to 2021, and to characterize changes in sex distribution, anatomical subsite composition, and age-wise burden using national cancer registry data. To our knowledge, this is the first national analysis of Sri Lankan OPC incidence trends (2005–2021) disaggregated by sex and ICD-10 oropharyngeal subsites.

Methodology

This analysis utilized retrospective data from the Sri Lankan National Cancer Registry (National Cancer Incidence and Mortality Data series) for the years 2005–2021. OPC was defined using ICD-10 and aggregated into three oropharyngeal subsites: base of tongue (C01), tonsillar sites

(C09: tonsil, tonsillar fossa, and pillars), and oropharynx (C10: including lateral/posterior pharyngeal walls, vallecula, branchial cleft, and unspecified oropharynx) (Zumsteg et al., 2023). Data were extracted on annual case counts by subsite, sex, and 5-year age group. Along with Crude incidence, Age-standardized incidence rates (ASIRs) were calculated by direct standardization using the WHO world standard population across 5-year age groups. Age patterns were summarised to identify peak-burden age groups. Analyses were performed in Joinpoint (version 5.4.0).

Results

From 2005 to 2021, 9,616 OPC cases were recorded in Sri Lanka. Males comprised 88.6% of cases (n=8,604) and females 11.4% (n=1,012), yielding an overall male-to-female case ratio of approximately 9:1. Female case counts remained low (26 in 2005; 80 in 2021), whereas male cases increased substantially (232 in 2005; 767 in 2021), widening the absolute sex disparity (Figure 1). By 2021, crude incidence was 7.34 per 100,000 in males versus 0.67 per 100,000 in females, indicating a near tenfold difference.

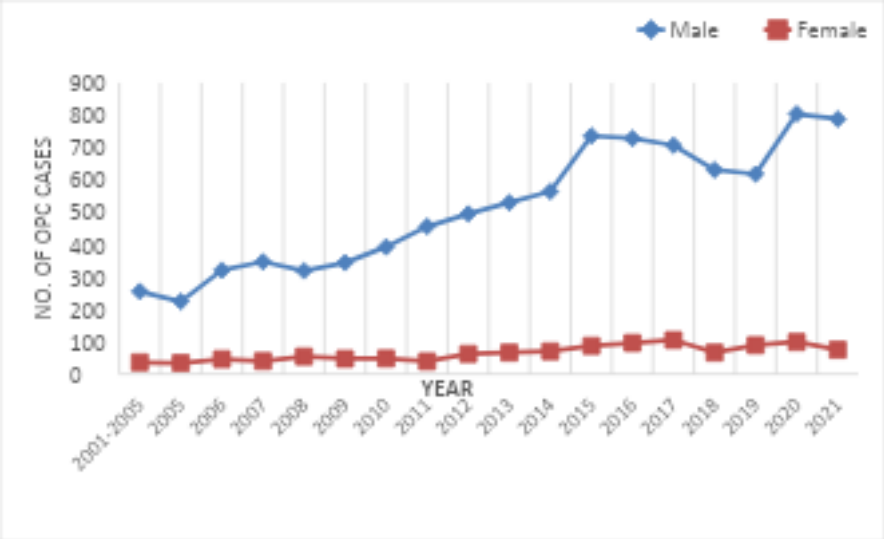

Figure 1. *Sex-specific trends in OPC incidence, Sri Lanka 2001–2021.* Annual number of new OPC cases by sex (blue – males; red – females).

Total annual cases rose from 258 in 2005 to 863 in 2021, and crude incidence more than doubled from 1.31 to 3.89 per 100,000 (AAPC: 5.9%, 95%CI: 4.74; 7.53, $p<0.05$). All major subsites showed increasing incidence, but the steepness differed (Figure 2). C10 (oropharynx) rose from 0.10 to 1.08 per 100,000 between 2005 and 2021 (20 to 245 cases/year), highest among subsites. C09 (tonsil) remained the most frequent subsite throughout but increased more modestly from 0.59 to 1.10 per 100,000 (120 to 250 cases/year). C01 (base of tongue) increased from 0.41 to 0.90 per 100,000 (83 to 205 cases/year). C10 accounted for under 8% of cases in 2005 but ~29% in 2021, indicating a shift in recorded site distribution. In 2021, tonsil (C09), base of tongue (C01), and C10 each contributed roughly one-quarter to one-third of cases (C10: 28.9%).

Age patterns showed increasing burden with age, peaking at 70–74 years (followed closely by 65–69 and 60–64), with very few cases below age 40 (Figure 3). Most diagnoses occurred between 40 and 75 years, and the median age at diagnosis was approximately the mid-60s, consistent with the general observation that OPC commonly presents in later adulthood (Orlandi et al., 2019).

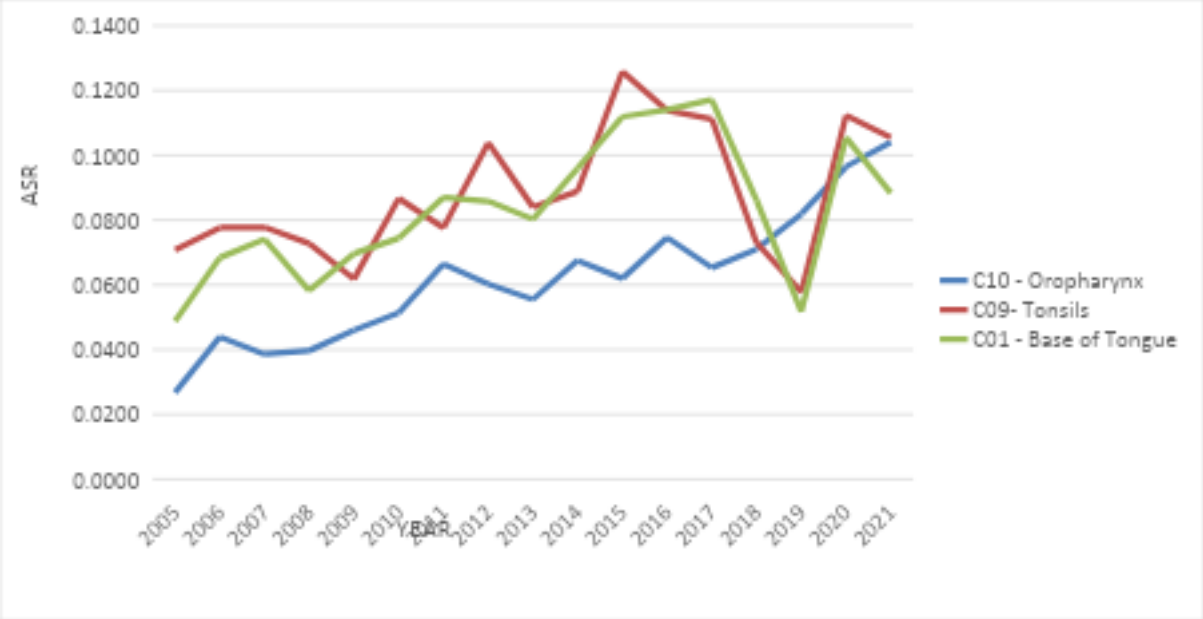

Figure 2. *Trends in Age-standardized incidence (ASR) of OPC by subsite (2005–2021)*. Incidence rates (per 100,000) are shown for base of tongue (green), tonsillar (red), and oropharynx (blue) subsites.

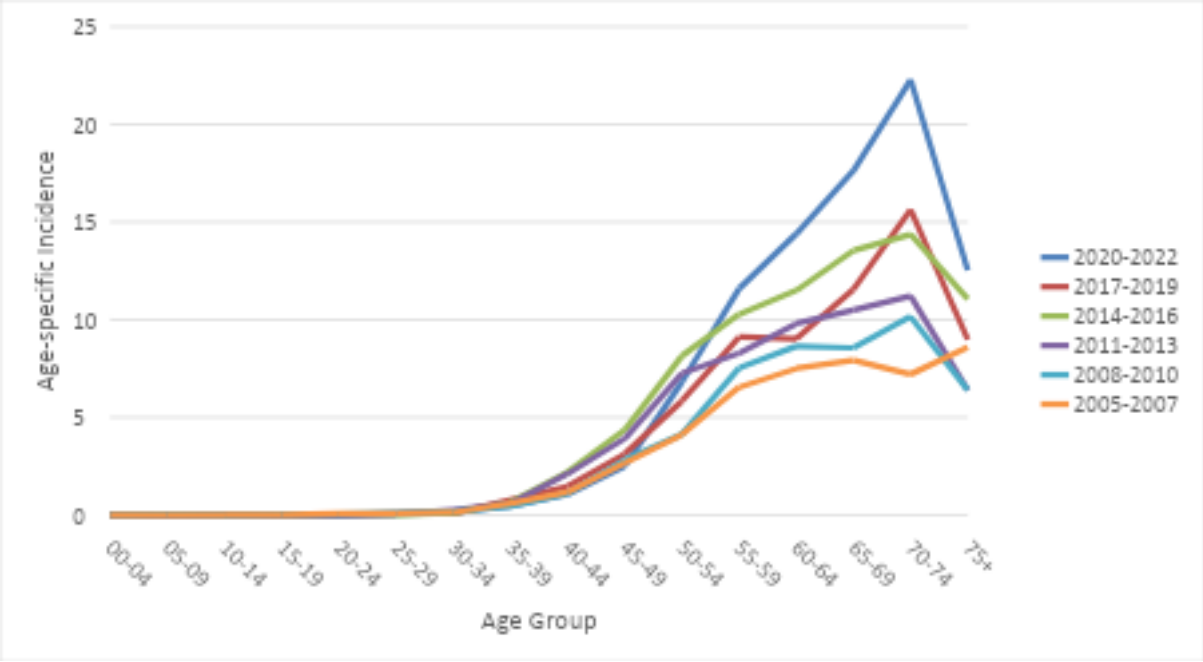

Figure 3: *Trends in Age-specific incidence rates per 100,000 by 5-year age group, 2005-2021, for total OPC cases.*

Discussion

Our analysis demonstrates a clear upward trend in OPC incidence in Sri Lanka from 2005 to 2021, with a strong male predominance and shifting subsite profile. These findings mirror global patterns and likely reflect both traditional risk factors and emerging HPV-related influences. The pronounced male excess (nearly 9-10:1) is consistent with reports from other regions that rising OPC rates are disproportionately affecting men (Zumsteg et al., 2023). One explanation is the higher prevalence of risk behaviors such as tobacco smoking and alcohol use among men historically (Barón et al., 1993). Additionally, the surge of HPV-associated OPC in males, linked to sexual behavior changes over birth cohorts, has been a major driver of incidence increases in developed countries (Chaturvedi et al., 2013; Zumsteg et al., 2023). Our data shows the steepest increase in the oropharynx (C10) subsite and significant gains in tonsil/base-of-tongue cancers. These subsites are anatomically part of the oropharynx, where HPV-positive tumors most often arise (Cohan et al., 2009). The rising incidence in older male cohorts, despite relatively low female rates, parallels observations in North America and Europe, where HPV-driven OPC has created an "epidemic" among middle-aged men (Chaturvedi et al., 2013). As specific HPV status data were not available in the registry, etiologic attribution cannot be made; however, the epidemiologic pattern (male dominance, tonsillar region involvement, midlife peak) is consistent with a possible contribution of HPV to Sri Lanka's OPC trend, alongside continued tobacco and alcohol exposure.

It is noteworthy that Sri Lanka's OPC trends occurred during a period when overall smoking prevalence has been gradually declining in the country due to tobacco control measures (Alcohol and Drug Information Centre, 2022). Thus, the increasing OPC incidence, particularly for males, cannot be readily explained by tobacco alone, reinforcing the likelihood of other etiologic factors (HPV infection) playing a role, as has been documented globally (Chaturvedi et al., 2013). Among females, the relatively stable and low incidence could indicate less impact of HPV or lower exposure to risk factors. Some countries have seen rising OPC rates in women as well, linked to changing lifestyles (Zumsteg et al., 2023), so continued monitoring of female OPC trends in Sri Lanka is important.

From a public health perspective, these findings carry several implications. First, the growing burden of OPC, especially in older men, calls for enhanced awareness and early detection efforts in Sri Lanka's healthcare system. Second, the enduring importance of tobacco and alcohol control is underscored by our data. While HPV is an emerging factor, a substantial proportion of OPC in South Asia likely remains attributable to smoking, smokeless tobacco, betel quid chewing, and heavy alcohol use. Integrated efforts to reduce these exposures (through taxation, public

education, and cessation support) alongside vaccination and safe-sex education could synergistically reduce future OPC incidence.

Conclusions

OPC incidence in Sri Lanka increased substantially between 2005 and 2021, driven largely by rising case counts in men and increasing incidence across all major subsites. The sustained male predominance, rising burden in tonsillar and base-of-tongue cancers, and the expanding share of C10 cancers together suggest changing disease patterns that warrant closer etiologic investigation and improved subsite classification. Strengthening tobacco and alcohol control, maintaining and expanding HPV vaccination programmes, improving registry coding practices, and supporting HPV testing in OPC will be important to guide targeted cancer control strategies in Sri L

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SESSION 3

Development economics and public policy

Determinants of Export Diversification at Intensive and Extensive Margins in South Asia

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Keywords: Export Diversification, Extensive margin, Intensive margin, Theil's Index

Introduction

Export is widely recognized as a foundation of long-term economic growth and development. The highest world share of exports is recorded by Asia in 2024 (43 percent) while South Asia only accounts for around 2.6 percent of global export share (UN Trade and Development, 2025) which indicates the lack of export orientation in South Asia as a region. South Asia also shows a persistent pattern of concentrated exports on few areas over the decades which is even higher than the average export concentration for Asia (Figure 1). This indicates the lower export diversification in South Asia. Economies that rely on a limited set of exports are highly vulnerable to external shocks leading to frequent fluctuations around the business cycles, delaying sustained economic growth (Papageorgiou et al., 2015).

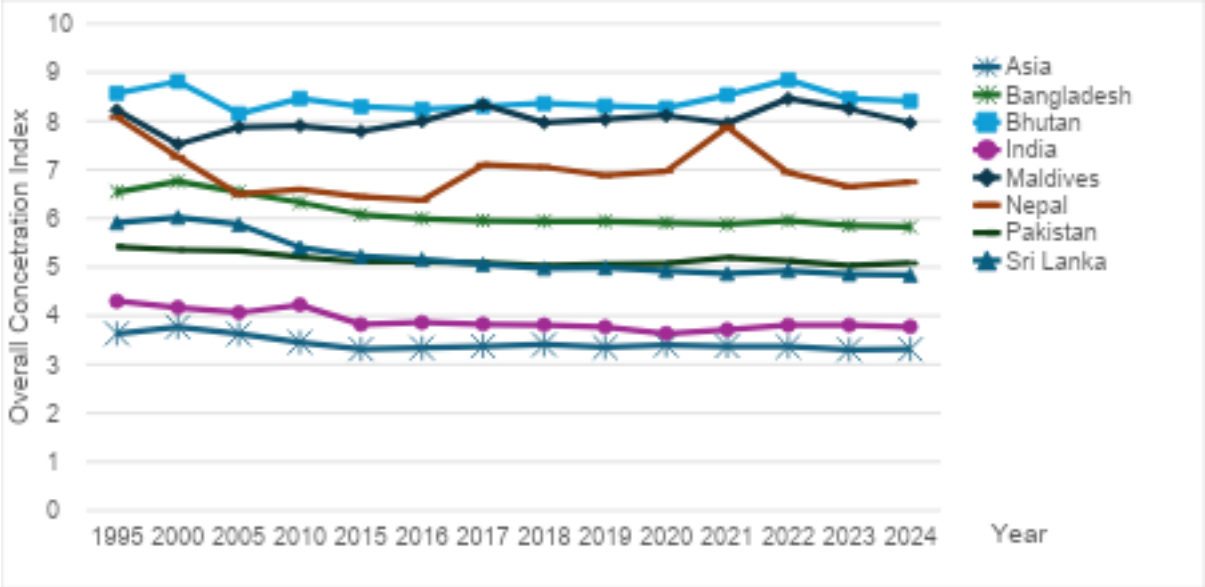

Figure 1: Overall export concentration index, South Asia

Source: UN Trade and Development, 2025

South Asia accounts for around 2.6 percent of world share of exports while it exhibits broadened export concentration for products. This indicates the limited export diversification in South Asia and its heavy reliance on a few export categories. Though the benefits of export diversification have been widely recognized in economic literature, sufficient focus has not been given to understand how exports evolve through changes in product varieties (extensive margin) and export volumes of existing products (intensive margin) in South Asia. Further, existing research has rarely disaggregated these margins in South Aisa using six-digit HS code, nor has it adequately examined the determinants of these margins. Therefore, there is a pressing need to empirically assess the determinants of export diversification at intensive and extensive margins to better understand the drivers of export diversification in South Asia. Thus, the objective of this research is to explore the determinants of export diversification at intensive and extensive margin in South Asia.

Methodology

This study employes a panel dataset from 2010 to 2024 for South Asian countries namely India, Sri Lanka, Pakistan, Maldives, and Nepal. Based on the theoretical review of the literature, conceptual framework is presented in Figure 3.

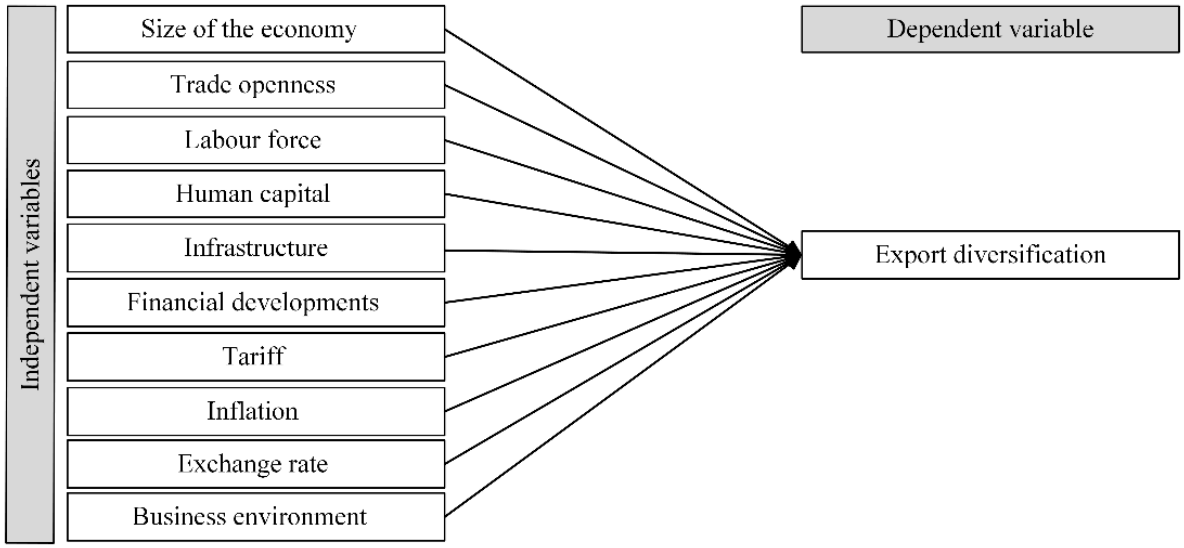

Figure 3: Conceptual Framework

Variable measurements of the study are chosen following empirical literature and are collected from the World Development Indicators, Human Development Report, United Nations Development Programme and World Integrated Trade Statistics (WITS). Accordingly, export diversification and its margins are measured by Theil's Index calculated from WITS data. For the independent variables, size of the economy is captured by Gross Domestic Product (GDP) per capita at current dollar prices, and trade openness is indicated by the sum of exports and imports to GDP. To denote the resource endowment of the economy, labour force, human capital and infrastructure are included to the model via total labour force participation rate, Human Development Index and the percentage of population having access to electricity respectively. In addition, financial development is captured by the domestic credit to private sector as a percentage of GDP whereas tariff rate is demoted by the weighted mean tariff rate for all products. Macroeconomic stability is included to model by inflation and exchange rate measured by annual growth of consumer price index and official exchange rate respectively. The business environment of the economy is proxied by regulatory quality estimate.

The level of export diversification is measured by the Theil's index (Balavac, 2012; Cadot et al., 2011; Papageorgiou et al., 2015). The calculation of Theil's Index and its decomposition is done using Six-digit HS code data (2007 classification) collected for 5039 export lines in South Asia. The study employes equation 01 to calculate the Theil's index. Equation 03 gives the decomposition of Theil's Within index which captures the intensive margin (changes in the export values of

existing products) while equation 04 provides the computation of Theil's Between index measuring extensive margin (variations in exports arising from the introduction of new product lines).

$$T = \frac{1}{n}\sum_{i=1}^{n} \frac{x_i}{\mu} ln\ ln \left(\frac{x_i}{\mu}\right) \quad \text{Equation 01}$$

where; $\mu = average\ exports = \frac{1}{n}\sum_{i=1}^{n} x_i$; T = Theil's index; n = number of export lines (n=5039); i = export line (i.e. HS code); x_i = export value in export line i

$$T = T_W + T_B \quad \text{Equation 02}$$

Theil's Within index □ $$T_W = \sum_k \frac{N_k}{N}\frac{\mu_k}{\mu} T_k \quad \text{Equation 03}$$

Theil's Between index □ $$T_B = \sum_k \frac{N_k}{N}\frac{\mu_k}{\mu} ln\ ln \left(\frac{\mu_k}{\mu}\right) \quad \text{Equation 04}$$

where; T_W = Theil's Within index; T_B = Theil's Between index; k = number of export sub-groups (k=6); N_k = number of product lines in the export sub-group k; μ_k = average export value of export sub-group k; T_k = Theil index for export sub-group k

Analysis and Results

Three panel data models are regressed considering Theil's index, Theil's Within index, and Theil's Between index as the dependent variable in Model 01 to 03 respectively. Stationarity levels were identified using panel unit roots. Variance Inflation Factor values confirmed the absence of multicollinearity. The key advantage of using a panel dataset is its ability to mitigate omitted variable biasness. Further, the panel fixed effect estimator is reasonably preferred over panel random effect as the dataset contains time invariant country specific characteristics which are most likely to correlated with independent variables. Robust standard errors are estimated in all regressions, and the model results are presented in Table 1.

Table 1: Determinants of export diversification

Variables	Model 01	Model 02	Model 03
Dependent Variable	Theil's Index	Theil's Within	Theil's Between
Per capita GDP	**0.0227****	**0.0289*****	**-0.00622*****
	(4.549)	(5.124)	(-8.123)
Trade openness	0.0951	0.456	**-0.361*****
	(0.141)	(0.659)	(-7.853)
Labour force participation	-9.694	**-12.57***	**2.879****

	(-2.067)	(-2.541)	(3.420)
Human capital	-1,881	**-2,388***	**506.9****
	(-1.747)	(-2.233)	(4.065)
Infrastructure	-1.268	**-1.213***	-0.0542
	(-2.118)	(-2.355)	(-0.464)
Financial developments	**2.479****	**3.336****	**-0.857*****
	(3.500)	(4.443)	(-6.310)
Tariff rate	2.158	3.004	-0.845
	(0.979)	(0.784)	(-0.501)
Inflation	-1.053	-0.974	-0.0794
	(-0.881)	(-0.749)	(-0.249)
Exchange rate	0.555	0.552	0.00286
	(1.577)	(1.310)	(0.0246)
Business environment	**123.9***	**153.4***	**-29.55***
	(2.327)	(2.376)	(-2.391)
Constant	99.56	67.14	32.42
	(2.126)	(1.206)	(1.065)
Observations	47	47	47
R-squared	0.449	0.511	0.308

Note: Robust t-statistics in parentheses and *** p<0.01, ** p<0.05, * p<0.1

The model 01 shows that the overall export diversification reduce for an increase in per capita GDP (Parteka & Tamberi, 2008; Yasmin et al., 2020), financial developments and improvement in business environment in South Asia. Confirming the findings of this study, Cadot et al. (2011) observed a reversal of the negative relationship between income and diversification once the income surpasses a certain threshold level (Cadot et al., 2011). Model 02 claims that the intensive margin is positively affected by a rise in labour force participation rate (Giri et al., 2019; Handoyo & Ibrahim, 2021; Oliveira et al., 2020), human capital (Agosin et al., 2012; Espoir, 2020; Giri et al., 2019; Handoyo & Ibrahim) and infrastructure (Alkhathlan et al., 2020; Espoir, 2020; Giri et al., 2019) in Soth Asia. However, per capita GDP, financial developments and business environment are related negatively to export diversification at intensive margin. According to model 03, extensive margin increases due to a growth in per capita GDP, trade openness (Espoir, 2020), financial developments (Giri et al., 2019; Oliveira et al., 2020; Shakib et al., 2023) and business environment improvements (Shakib et al., 2023). However, labour force participation rate and human capital inversely affect the export diversification at extensive margin in South Asia.

Conclusion

To promote the export diversification in South Asia, it is recommended to focus on its margins. Enhance the export diversification at extensive margin—introducing new product lines—by increasing capita GDP, trade openness, financial developments and business environment. Further, it is also recommended to improve the export diversification at intensive margin—increase volume of exports within the available export lines—by increasing the labour force participation rate, human capital and infrastructure in Soth Asia.

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Effectuation as a Resilience Practice: Adaptation Pathways of Sri Lankan Small-Scale Businesses in Polycrisis

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Keywords: Effectuation, entrepreneurial adaptation, small-scale businesses, crisis resilience, Sri Lanka, polycrisis.

Introduction

Small and medium enterprises (SMEs) are vital for economic stability and employment in developing nations (Acs & Audretsch, 1988). These enterprises face existential threats during consecutive, overlapping crises, as witnessed globally during the COVID-19 pandemic and subsequent economic instability (Eggers, 2020). In Sri Lanka, these exogenous shocks were compounded by a severe domestic economic crisis characterized by hyperinflation and institutional fragility, creating a context of extreme uncertainty (Jochheim, 2022; World Bank, 2021). Such environments challenge traditional, predictive (causal) entrepreneurial models that rely on stable goals and forecastable returns (Sarasvathy, 2001).

Effectuation theory provides a powerful alternative lens, proposing entrepreneurs navigate uncertainty by leveraging available means, focusing on affordable loss, building partnerships, and leveraging contingencies (Sarasvathy, 2008). While studied in various contexts, *how* effectual principles combine and operate during prolonged, compound crises in Asian developing economies remains critically underexplored (Sarasvathy et al., 2014). This gap is significant, as SMEs in these regions are crucial for community resilience yet operate within distinct institutional voids. This study addresses this gap by posing two research questions:

1. What adaptation strategies do small-scale business operators in Sri Lanka employ to survive and sustain their businesses during consecutive crises?
2. How entrepreneurial specifically, how effectual are these strategies, and what patterns do they form?

Methodology

A qualitative, exploratory multiple-case study design was employed (Yin, 2018). The study was conducted in the Kurunegala and Narammala districts of Sri Lanka. The target population was small-scale business operators who had successfully adapted during the dual crises.

Purposive snowball sampling was essential to access this "hidden population" of resilient entrepreneurs, who were not publicly listed but known within trusted community networks. This method overcame reluctance to share sensitive information through referral-based trust (Saunders et al., 2016). Sampling continued until theoretical saturation, yielding 21 cases across industrial (38%), trading (33%), services (19%), and agricultural (10%) sectors. "Successful adaptation" was defined as business survival, maintenance of core operations, and owner-reported stability/improvement in sales, customer base, or employment.

Data Collection & Analysis: Data were collected between September and October 2022 through in-depth interviews aided by a topic guide, conducted in Sinhala, enabling participants to narrate their lived experiences of business adaptation in their own words. Given the exploratory nature of the study, interviews were intentionally flexible rather than time-bound, typically lasting around 60 minutes. In several cases, interviews were conducted over multiple sessions across different days to accommodate participants' availability and capture evolving reflections. Repeated visits to participants' business sites across different locations further supported contextual understanding. All interviews were audio-recorded with informed consent, transcribed, translated into English for analysis, and securely discarded after use.

To enhance trustworthiness, data triangulation was employed by combining interview data with direct observations and contextual artifacts such as photographs of business premises. Prolonged engagement through repeated interactions facilitated rapport building and validation of emerging insights, while a clear audit trail documented coding decisions and theme development. A hybrid thematic analysis approach was adopted (Braun & Clarke, 2006). Deductive coding was guided by the five principles of effectuation, followed by inductive coding to capture emergent patterns and contextual nuances. Themes were iteratively refined through constant comparison across cases. Ethical clearance was obtained from the relevant university ethics committee. Participation was

voluntary, and anonymity and confidentiality were ensured through the use of pseudonyms and the removal of identifying details.

Results/Findings:

Analysis revealed adaptation was a dynamic process driven by effectual logic, crystallizing into three primary pathways.

Pathway 1: Means-Driven Experimentation under Constrained Risk. This initial response combined the *bird-in-hand* and *affordable loss* principles. Entrepreneurs rapidly deployed existing skills, assets, and social networks while strictly bounding potential downsides. A brick manufacturer, for instance, leveraged knowledge of local soil sources and bought a second-hand machine, stating: *"I couldn't afford to risk [the cost of] a new one."* Many pivoted to home-based operations or used personal savings to test new, low-cost avenues, preserving core viability.

Pathway 2: Relational Stabilization and Contingency Leveraging. As crises persisted, the *patchwork quilt* (partnerships) and *lemonade* (leveraging surprises) principles became central. Entrepreneurs deepened ties with suppliers, customers, and community actors to create stability. A coir exporter's long-term agreement with a foreign buyer later resulted in a gift of generators during power cuts. Simultaneously, constraints were reframed as opportunities. A pharmacist launched a channeling center above her pharmacy during the pandemic, significantly increasing drug sales and community service.

Pathway 3: Iterative Control and Gradual Formalization. This pathway featured the *pilot-in-the-plane* principle of iterative action and control. Entrepreneurs acted, gathered feedback, and adjusted continuously. Following small wins, several began reintroducing elements of causal planning (e.g., bookkeeping, quality standards), demonstrating a dynamic interplay between effectual action and deliberate structuring as a new normal coalesced.

Discussion and Contribution

This study confirms effectuation as a critical framework for resilience but extends the theory in significant ways:

1. Specifying Contextual Adaptation Pathways: It moves beyond listing principles to identify three *empirical pathways* (Means-Driven Experimentation, Relational Stabilization, and Iterative Formalization). This delineates how principles *combine and sequence* during prolonged adversity in a resource-scarce context.
2. Elucidating Dynamic Logic Interplay: Evidence challenges a rigid effectuation-versus-causation dichotomy. The transition observed in Pathway 3 suggests a *phased relationship* where effectuation dominates survival, potentially blending with causation during stabilization a crucial theoretical refinement.
3. Conceptualizing Effectuation as Community-Level Resilience: By situating analysis in institutional failure, the study frames effectual practices as a *micro-institutional mechanism* sustaining local economies. Entrepreneurs' network-based bricolage and adaptation maintained local supply chains and employment, linking micro-entrepreneurship to macro-level resilience in the Global South.

Conclusion

Small-scale operators in Sri Lanka navigated polycrisis through effectual logic, manifested in three identifiable adaptation pathways. This study's contribution lies in extending effectuation theory by specifying its operational pathways in crisis, clarifying its dynamic interplay with causal logic, and elevating it as a practice for socio-economic sustainability. The findings advocate for support systems focused on building capabilities in means-driven experimentation, network facilitation, and affordable-loss financing to strengthen entrepreneurial resilience in uncertain times.

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Productive Use of Cross-Border Remittances on the Sustainable Livelihoods of Migrant Households in Bangladesh

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Keywords: Remittances, Productive Investment, Sustainable Livelihoods, Bangladesh

1.Background of the Study

International migration and remittances are now a key part of how many households in developing countries make a living. People often migrate because of unemployment, low wages, or few job opportunities at home. The money migrants send back helps families cover basic needs like food, housing, education, and health care. According to the sustainable livelihood's literature, migration is just one of several ways households cope with economic uncertainty, not just a short-term or isolated choice (McDowell and de Haan, 1997). As remittances grow worldwide, policymakers are focusing less on how much money is sent and more on how it is used and whether it supports long-term stability.

So, this study aims at how cross-border remittances are used productively and their impact on the livelihoods of the migrant households in Bangladesh. Instead of viewing remittances only as income, it focuses on how households allocate these funds and whether using them for things like land, housing, or income-generating activities leads to better livelihoods. Using household-level data from Bangladesh, the study aims to clearly connect how remittances are used with sustainable livelihood outcomes.

Research on how remittances are used shows mixed results. Many studies find that remittances help households by increasing spending and reducing poverty. For instance, in Bangladesh, remittances boost household consumption and lower the risk of poverty (Raihan et al., 2009). Similar results appear in other developing countries, where remittances reduce vulnerability and improve living standards, especially in rural areas (Quartey, 2006). Still, several studies note that most remittances go toward daily expenses and social needs, with only a small share used for productive investments (Zárate-Hoyos, 2004; Thapa and Acharya, 2017).

Other studies suggest that remittances help families build assets and maintain their livelihoods, even if the money is not used to generate income directly. Research from semi-arid regions and African countries shows that remittances can help people buy land, build homes, and make small investments, which strengthens household livelihoods over time (Samal, 2007; Ajefu, 2018). These studies also point out that the local economic and institutional context affects whether remittances become productive investments.

Although research on this topic is expanding, a key gap still exists. Most studies look at either the effects of receiving remittances or general spending patterns, but they do not clearly separate the choice to use remittances productively from the outcomes of that choice. Therefore, it is still uncertain whether using remittances in productive ways, rather than just the amount sent, actually helps improve sustainable livelihoods.

Therefore, this study explores two main questions: 1) What factors influence how cross-border remittances are used productively, and 2) Does this productive use help improve the sustainable livelihoods of migrant households in Bangladesh? By connecting how remittances are used with the sustainability of livelihoods, this study adds to the migration and development literature and provides useful insights for policies that encourage productive remittance use in Bangladesh.

2.Data and Methodology

2.1 Data Source and Sample

This study uses household-level data from the 2022 Household Income and Expenditure Survey (HIES), conducted by the Bangladesh Bureau of Statistics (BBS). The HIES covers the whole country, using a two-stage sampling method to include both rural and urban areas in every administrative division. It provides detailed information on household demographics, migration histories, remittance inflows and use, and consumption spending. The observations missing information on migration status, remittances, investment behavior, or expenditure are left out. After cleaning and merging the data by household identification number, the final sample includes about 2,400 migrant households.

2.2 Variable Construction

2.2.1 Productive Use of Remittances

This variable is set to 1 if a household used any remittance money for productive investments, such as buying land, building or repairing homes or other structures, purchasing agricultural equipment, or making other income-generating investments. If no remittance money was used for these purposes, the variable is set to 0. This measure shows whether a household chose to use remittances for productive rather than only for consumption.

2.2.2 Sustainable Livelihood Outcome

Sustainable livelihood is measured using the natural logarithm of total household consumption expenditure. In development economics, consumption expenditure is a common and reliable way to assess household welfare and livelihood sustainability because it shows long-term living standards and is less variable than income (Deaton, 1997).

Table 2.1: Variables Description

Variable	Description	Unit of Measurement
Inv	Productive use of remittances	Dummy variable: 1 = household used remittances for any productive investment ; 0 = otherwise
TE	Sustainable livelihood outcome	Natural logarithm of total household consumption expenditure
TR	Remittance volume	Natural logarithm of total remittances sent over the last two years
Age	Age of migrant household member	Measured in years
Gen	Gender of migrant	Dummy variable: 1 = Male, 0 = Female
Edu	Educational attainment	Total years of schooling completed
ML	Migration location	Dummy variable: 1 = International migrant, 0 = Domestic migrant
YM	Migration experience	Number of years since migration

Source: Author's Compilation (2025).

2.3 Empirical Strategy

To meet the research goals, this study uses a two-model empirical framework. This method clearly separates the factors that influence productive remittance use from the effects of such use on the livelihoods. By estimating these relationships separately, the study avoids mixing up the decision-making process with the outcomes.

2.3.1 Determinants of Productive Use of Remittances

The equation (1) looks at what affects whether a household uses remittances in a productive way. Because the outcome is binary, a probit model is used. This model assumes that the decision to invest is based on an underlying tendency to invest, which is shaped by demographic factors, migration experience, and remittance inflows. The model is specified as:

$$P\ (Inv_i = 1|X_i = \Phi\ (\beta_1 Age_i + \beta_2 Gen_i + \beta_3 ML_i + \beta_4 Edu_i + \beta_5 YM_i + \beta_6 lnTR_i + \varepsilon_i) \qquad (1)$$

Where, $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. The estimated coefficients show how changes in household and migration characteristics can influence the likelihood of investing remittances in a productive way.

2.3.2 Effect of Productive Use of Remittances on the Livelihoods

The equation (2) looks at whether using remittances productively leads to better household livelihood outcomes. The dependent variable is continuous, and the model uses ordinary least squares (OLS) with robust standard errors. The specification is given by:

$$lnTE_i = \alpha_0 + \alpha_1 Inv_i + \alpha_2 Age_i + \alpha_3 Gen_i + \alpha_4 ML_i + \alpha_5 Edu_i + \alpha_6 YM_i + \mu_i \qquad (2)$$

The total remittance (TR) is not included in the livelihood model. Remittance volume is closely tied to investment decisions and is an important way that productive use influences household welfare. Including it in this model would be over-controlling and could weaken the estimated effect of productive investment.

3. Results and Discussion

3.1 Overview of Sample Characteristics

Table 3.1 shows summary statistics for the main variables in the analysis. There is a wide range in household spending (TE) and remittance inflows (TR), which points to significant differences

among migrant households. On average, households spend about BDT 127,821 each year, but the high standard deviation means some households have much higher living standards than others. This kind of variation is typical in developing countries, where remittances affect household welfare in different ways (Raihan et al., 2009). The data show that about 42 percent of migrant households use remittances for productive investment, but most do not. This suggests that using remittances productively is not guaranteed and depends on each household's situation and limitations. This finding matches earlier studies that found remittances are used in different ways (Zárate-Hoyos, 2004; Samal, 2007). Migrants are, on average, about 36 years old, which shows that most are of working age. They have nearly 9 years of schooling, suggesting a moderate level of human capital that could affect how they send money home and make investments. Around 32 percent of migrants move internationally, highlighting the role of cross-border migration in generating remittances. The average migration duration is about 8 years, so many households have had time to stabilize the money they receive. This table gives a first look at the range of backgrounds among migrant households and sets the stage for the next part of the analysis.

Table 3.1: Summary Statistics of Key Variables

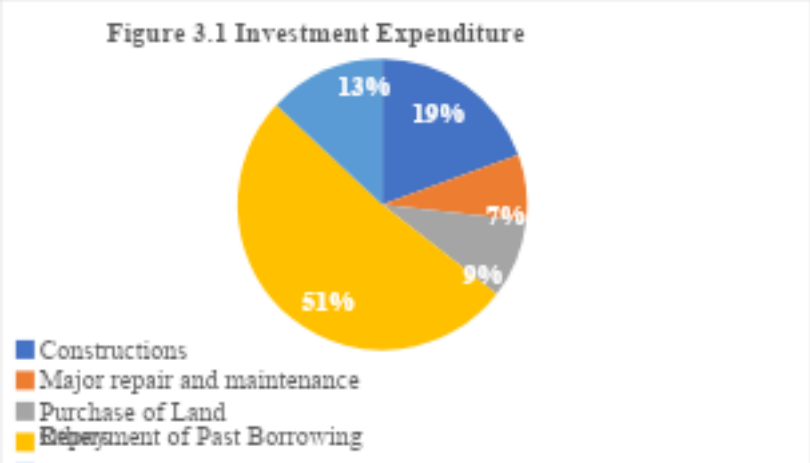
Variable	Obs	Mean	Std. dev.	Min	Max
TE	2126	127820.7	133755.1	0.00	960000
Inv	2510	0.42	0.49	0.00	1.00
TR	2380	317797.4	499118.9	0.00	7200000
Age	2428	35.90	10.63	15.00	85.00
Gen	2428	1.09	0.28	1.00	2.00
ML	2510	0.32	0.47	0.00	1.00
Edu	2355	8.76	4.26	0.00	18.00
YM	2428	8.09	8.41	0.00	50.00

Source: Author's Compilation (2025).

3.2 Composition of Remittance-Financed Investment Expenditure

Figure 3.1 shows how remittances are spent on investments. More than half of remittance-based investment, or 52 percent, goes toward repaying previous loans. This means families often use remittances to pay off debt, especially migration-related loans, before they can invest in new

opportunities. Studies from Nepal and Zimbabwe also found that households receiving remittances tend to focus on debt repayment to help stabilize their livelihoods (Khatri, 2017; Nzima et al., 2016). About 19 percent of spending goes to construction, indicating that many migrant households use remittances to improve their homes as a long-term investment. Spending on land (9 percent) and other assets (13 percent) also shows that some families can build up physical assets with remittances. Research has shown that using remittances for assets helps improve livelihood security and resilience, even if it does not bring immediate income (Mohammed and Tolossa, 2016). However, a large share of remittances goes toward paying off debt, which can slow down broader investment and changes in livelihoods.

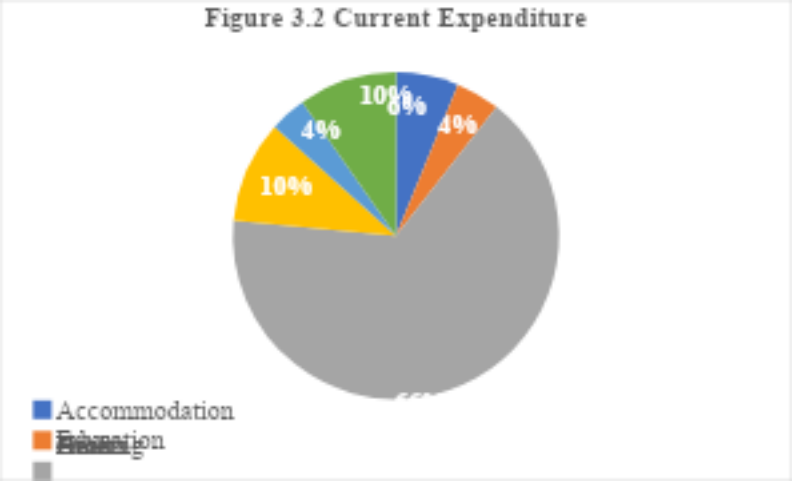


Source: Author's Compilation (2025).

3.3 Composition of Remittance-Financed Investment Expenditure

Figure 3.2 shows how remittances are used for current household expenses. Most remittances, 66 percent, go toward food, highlighting their importance for household food security and daily needs. This supports the idea that remittances mainly help migrant households manage their spending, especially in developing countries where incomes are often unstable (Quartey, 2006). Spending on health and other needs each makes up 10 percent, showing that remittances help cover basic services and needs beyond just food. Accommodation takes up 6 percent, while education and clothing each account for 4 percent. Even though these amounts are smaller, spending on health and education is widely seen as important for long-term livelihood sustainability, even if they are considered current rather than productive expenses (Sikder and Higgins, 2017). Overall, the data shows that while most

remittances go toward immediate needs, they also help build human capital and improve household well-being.



Source: Author's Compilation (2025).

3.4 Relationship among Remittance, Investment, and Household Characteristics

Table 3.2 shows the pairwise correlations between the main variables in the analysis. Most correlations are low to moderate, so multicollinearity should not be a major issue for the regression models. Household total expenditure (TE) has a strong positive correlation with total remittances (TR), which means that households receiving more remittances tend to spend more. This pattern is well documented in studies on remittances and household welfare (Raihan et al., 2009). The use of remittances for productive investment (Inv) is also positively linked to remittance inflows, suggesting that households with higher remittances are more likely to invest, as seen in other developing countries (Ajefu, 2018). These results show that the variables represent different aspects of household characteristics and remittance behavior, which supports their use in the following econometric analysis.

Table 3.2: Correlation Analysis

Variables	TE	Inv	TR	ML	Edu	YM
TE	1.00					
Inv	0.16	1.00				

TR	0.68	0.34	1.00			
ML	-0.35	-0.21	-0.40	1.00		
Edu	0.01	-0.08	0.04	0.14	1.00	
YM	0.03	-0.13	0.04	0.03	0.06	1.00

Source: Author's Compilation (2025).

3.5 Determinants of Productive Use of Remittances

Table 3.3 shows the results of the probit model that examines what influences migrant households to use remittances productively. The dependent variable is set to 1 if a household uses remittances for productive investment, and 0 if not. The findings show that remittance size, migration characteristics, and human capital all play important roles in shaping how households invest.

The coefficient for total remittances (lnTR) is positive and highly significant. This means that households receiving more remittances are more likely to use them for productive investments. This makes sense because higher remittance inflows help ease liquidity constraints, allowing households to go beyond basic consumption and invest in assets or income-generating activities. Ajefu (2018) and Adams (2006) also found that larger remittance receipts increase the chances of asset accumulation and productive use.

The migration location (ML) coefficient is negative and statistically significant. This means households with international migrants are less likely to use remittances for productive purposes than those with domestic migrants. One reason may be that international migration usually requires higher upfront costs and leads to more debt, so families focus on repaying loans and meeting basic needs instead of investing. This trend matches findings from Zimbabwe and Nepal, where international remittances often go toward loan repayment and daily expenses rather than productive uses (Nzima et al., 2016; Samal, 2006).

Surprisingly, education (Edu) shows a negative and significant effect, meaning that households with more educated migrants are less likely to use remittances for productive investment. This could mean that these households prefer to spend on human capital, smoothing consumption, or buying goods that improve social status instead of traditional productive assets. Other studies have found

similar results, suggesting that education leads to remittances being used for welfare-improving but not income-generating expenses (Koç and Onan, 2004; Zárate-Hoyos, 2004).

The results show that the coefficient for years of migration (YM) is negative and highly significant. This means that the longer someone migrates, the less likely they are to make productive investments. Instead, remittances may become a steady source of income for everyday household expenses rather than for investment. As time goes on, households might rely more on remittances, which can lower their motivation to take part in productive activities.

Table 3.3: Determinants of Productive Use of Remittances by the Migrant Households

Variables	Coefficient	Std. err.	z	P>|z|
lnTR	.3104***	.0220	14.09	0.00
Age	-.0008	.0031	-0.28	0.78
Gen	.0409	.1032	0.40	0.69
ML	-.1375**	.0661	-2.08	0.04
Edu	-.0237***	.0067	-3.54	0.00
YM	-.0260***	.0046	-5.71	0.00
Constant	-3.3943***	.2908	-11.67	0.00

Source: Author's Compilation (2025).

3.6 Effect of Productive Use of Remittances on Household Livelihood

Table 3.4 shows how using remittances productively affects the livelihood of migrant households, measured by their household spending. The results show that using remittances in productive ways is important for improving household livelihoods.

The results show that when households invest remittances in productive activities, they see much better livelihood outcomes than those who do not. Using remittances in this way helps households earn more income, build assets, and become less vulnerable to income shocks. As a result, these households can move from just meeting short-term needs to making lasting improvements in their lives. This supports earlier research that found remittances have a bigger impact on long-term welfare when used for productive purposes instead of only for consumption (Adams, 2006; Ajefu, 2018).

The results show that migration location has a negative and significant effect, meaning households with international migrants usually have lower livelihood outcomes than those with domestic migrants, even when other factors are considered. This is likely because international migration comes with higher costs and risks, such as debt repayment, which reduce the benefits from remittances. Similar trends have been seen in Zimbabwe and other developing countries, where international remittances are often used to pay back loans and cover basic needs instead of being invested in ways that generate income (Nzima et al., 2016; Samal, 2007).

More years of schooling have a clear, positive effect on household livelihood. Education helps families use remittances and other resources to improve their living standards. It also leads to better financial decisions, access to good jobs, and smarter management of remittance income. These results support earlier research that highlights how human capital boosts the welfare benefits of remittances (Koç and Onan, 2004; Zárate-Hoyos, 2004).

The results show that using remittances productively is an important channel migration helps create sustainable livelihoods. Although remittances by themselves do not always improve welfare, investing them wisely can improve household outcomes and lower long-term risks.

Table 3.4: Effect of Productive Use of Remittance on the Livelihood of the Migrant Households

Variables	Coefficient	std. err.	t	P>|t|
Investment	.3027***	.0628	4.82	0.00
age	.0052	.0034	1.46	0.15
Migration Location	-1.0877***	.0723	-15.05	0.00
Years of Schooling	.0229***	.0075	3.04	0.00
Years of Migration	.0051	.0049	1.04	0.30
Constant	10.8828***	.1359	80.09	0.00

Source: Author's Compilation (2025).

4. Conclusion and Policy Implication

This study looks at how migrant households in Bangladesh use cross-border remittances and whether using them for productive purposes helps improve their livelihoods. The results show that remittances alone do not guarantee better livelihoods; their effect depends on how households spend them. While larger remittance amounts make productive investment more likely, international

migration and longer stays abroad actually lower this chance. Households that invest remittances in productive ways see much better outcomes, such as higher spending on goods and services, than those who use remittances mainly for non-productive reasons. These findings highlight that using remittances productively is an important way migration can support long-term household welfare.

These findings have important policy implications. First, policies should help people use remittances more productively by making it easier to access credit, land, and business support. Second, reducing the cost of migration and sending money home can lower household debt, so families can invest more in productive activities. Third, offering financial literacy and investment advice to families who receive remittances can help them make better decisions and improve their long-term well-being. By supporting productive use of remittances, these funds can become a long-term source of stability for households in Bangladesh, rather than just a short-term solution.

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Foreign Entrepreneurship in Japan: A Study of Market Entry, Adaptation, and Growth Dynamics

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Keywords: Foreign Startups in Japan, Market Entry, Adaptation, Growth Dynamics

Introduction

Japan has increasingly promoted foreign entrepreneurship as part of its broader economic revitalization strategy. In response to prolonged economic stagnation, demographic decline, and labor shortages, the Japanese government has introduced policies aimed at attracting foreign founders and international investment. Programs such as the Startup Visa initiative and various regional revitalization measures reflect these efforts.

Despite these initiatives, foreign entrepreneurs in Japan continue to encounter significant structural and cultural barriers. Administrative complexity, legal compliance requirements, language challenges, and deeply embedded business customs often create obstacles during business establishment and expansion. While previous academic literature has examined foreign direct investment (FDI), internationalization strategies, and startup ecosystems in Japan, limited research has systematically explored the lived experiences of foreign small- and medium-sized enterprise (SME) owners operating within the Japanese market.

This study addresses this gap by investigating how foreign entrepreneurs navigate the Japanese business environment across three critical phases:

1. Market Entry (ME)

2. Adaptation (A)

3. Growth Dynamics (GD)

By examining these three dimensions, the paper provides an integrated framework for understanding foreign entrepreneurial success and challenges in Japan.

Research Objectives

The primary objectives of this study are:

• To identify the main barriers faced by foreign entrepreneurs during market entry.

• To examine how foreign entrepreneurs adapt to Japanese business culture and institutional systems.

• To evaluate whether foreign-owned SMEs achieve sustainable growth after overcoming initial barriers.

• To compare the relative difficulty of each phase using systematic statistical analysis.

The study seeks to contribute to both academic research and policy discussions by offering evidence-based insights grounded in field-level data.

Literature Background

Existing literature on entrepreneurship in Japan has largely focused on domestic startups, innovation systems, and large-scale foreign investment. Studies in international business highlight institutional distance, cultural differences, and regulatory frameworks as key determinants of foreign firm performance.

Japan is often characterized by high-context communication, relationship-based transactions, and strong regulatory compliance expectations. These institutional and cultural characteristics create both barriers and opportunities for foreign founders.

However, there remains limited empirical research based on qualitative interviews with foreign SME owners operating within Japan. This study contributes to closing this gap by combining qualitative insights with non-parametric statistical testing to compare experiences across entrepreneurial phases.

Methodology

4.1 Research Design

This study adopts a qualitative research design based on semi-structured interviews. A total of 26 foreign entrepreneurs currently operating SMEs in Japan were interviewed.

4.2 Sample Characteristics

The participants represent diverse industries, including:

• Retail

• Food and beverage

• Hospitality

• Education

• Technology

• International trade

• Human resource services

The businesses are located across multiple geographic regions in Japan, ensuring variation in local regulatory and market environments.

4.3 Data Collection
Semi-structured interviews were conducted to gather detailed insights into business registration and visa processes, legal and administrative procedures, access to financing, cultural adaptation experiences, relationship-building strategies, and business performance outcomes.

4.4 Analytical Framework
Responses were categorized using positive versus negative difficulty or barrier-based indicators across the three main dimensions: Market Entry (ME), Adaptation (A), and Growth Dynamics (GD).

To systematically compare phases, non-parametric statistical techniques were employed:

• Friedman Test (to compare related samples across three phases)

• Wilcoxon Signed-Rank Test (for pairwise comparisons)

This approach enabled structured comparison despite the qualitative nature of the data.

Findings

5.1 Market Entry: The Most Difficult Phase
The results indicate that Market Entry (ME) is the most challenging phase for foreign entrepreneurs.

The most frequently cited difficulties include:

• Bureaucratic complexity

• Lengthy administrative procedures

• Legal documentation requirements

• Visa-related constraints

• Language barriers

The statistical analysis confirms that market entry difficulties were significantly higher than those in the other two phases.

5.2 Adaptation: Gradual Cultural Integration

In contrast, the Adaptation (A) phase showed predominantly positive evaluations. Entrepreneurs reported improvements over time in understanding business etiquette, establishing trust-based relationships, navigating communication styles, and developing local partnerships. Cultural learning and network building emerged as critical success factors.

5.3 Growth Dynamics: Positive Long-Term Outcomes

The most positive evaluations were recorded in Growth Dynamics (GD). After overcoming early-stage barriers, many entrepreneurs reported stable revenue streams, loyal customer bases, sustainable expansion, and improved operational efficiency. This indicates that Japan offers long-term business stability once regulatory and cultural hurdles are managed.

Discussion

The findings suggest a three-stage trajectory of foreign entrepreneurship in Japan: high initial institutional barriers during market entry, cultural learning and network formation during adaptation, and stability and business prosperity during growth dynamics. This pattern implies that Japan presents a front-loaded difficulty structure where challenges are concentrated at the beginning, but long-term rewards may follow.

The study supports institutional theory by demonstrating how regulatory and cultural frameworks influence entrepreneurial outcomes while highlighting the resilience and strategic learning capacity of foreign founders operating in institutionally distant environments.

Policy Implications

For Policymakers:

• Simplify administrative procedures for foreign founders

• Improve multilingual government support services

• Expand advisory systems for early-stage foreign startups

• Strengthen regional-level entrepreneurship support

For Foreign Entrepreneurs:

• Invest early in professional legal and administrative guidance

• Prioritize Japanese language acquisition

• Focus on relationship-building and trust development

• Prepare for higher entry-phase effort but anticipate long-term stability

Contributions

This study contributes to the literature by providing empirical evidence based on field interviews, introducing a structured three-phase analytical framework, combining qualitative insights with statistical testing, and offering policy-relevant recommendations. It expands understanding of foreign entrepreneurship beyond macro-level FDI analysis by focusing on SME-level lived experiences.

Conclusion

Foreign entrepreneurship in Japan is characterized by significant early-stage institutional and bureaucratic challenges. However, once entrepreneurs overcome market entry barriers and successfully adapt to the cultural and relational environment, they often achieve stability and sustainable growth.

Japan therefore represents a market with high initial entry costs but strong long-term potential. The findings offer valuable insights for scholars, policymakers, and international entrepreneurs considering entry into the Japanese market.

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Exploring The Influence of Job Strain on Non-Executive Employees' Performance In Selected Government Organization In Sri Lanka

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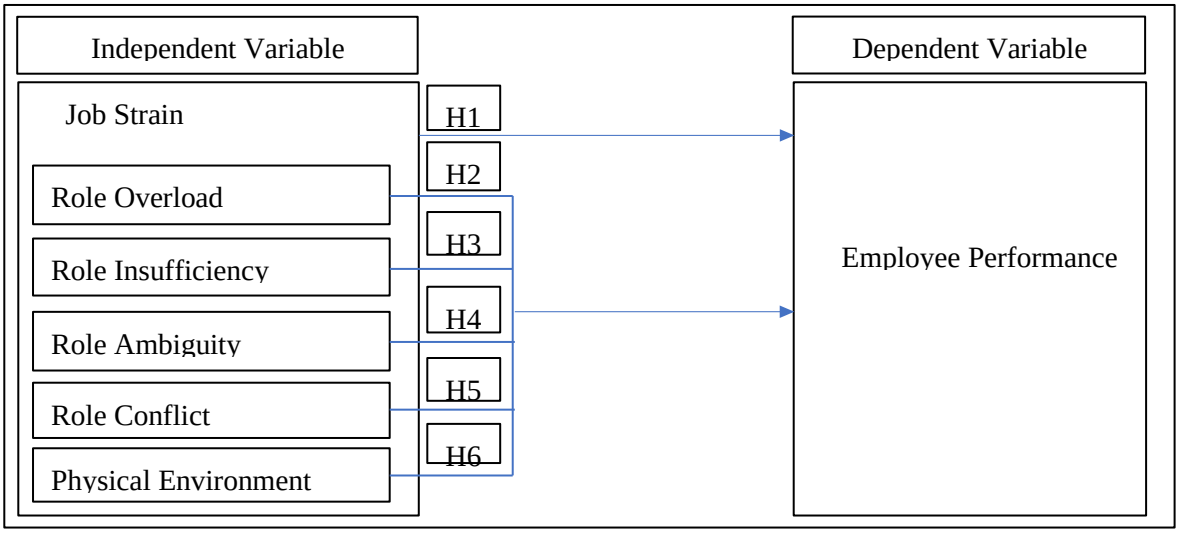
Keywords: Employee Performance, Job Strain, Physical Environment, Role Ambiguity, Role Conflict, Role Insufficiency, Role Overload

Introduction

Job strain (JS) is widely recognized as a critical psychosocial hazard in contemporary workplaces and represents a major challenge to employee well-being and organizational effectiveness worldwide. In recent years, organizations have put into place various work practices in accordance with globalization, and continually upgrading to improve their entire working culture, environment. Hence, employees have been prompted to work beyond their pay grade, capacity, and capabilities that lead to JS. McGrath (1987) conceptualized job strain as a condition in which individuals are required to meet job demands that surpass their abilities and resources, particularly under circumstances characterized by a substantial imbalance between effort and rewards. Extensive empirical evidence suggests that prolonged exposure to job strain is associated with adverse outcomes, including employee disengagement, burnout, diminished job performance, impaired interpersonal relationships, absenteeism, and reduced organizational commitment. Consequently, job strain imposes significant economic and human costs on organizations.

JS is a problem of growing concern in developing countries like SL due to significant advancements in globalization and the evolving nature of work in the modern world. The selected government organization, the sphincter of SL's Economy, deals with other countries, various government agencies and corporation bodies. Therefore, the employees who employed in that organization cope with job challenges which lead to stress eventually. Hence, this study is to examine how JS impact on EP of selected employees in selected government organization in Sri Lanka. Despite the growing importance of this issue, existing research on job strain and employee performance has largely focused on private-sector organizations and developed-country contexts. Empirical studies examining job strain within Sri Lankan government institutions remain scarce, and the limited available research often treats job strain as a unidimensional construct. As a result, there is insufficient empirical understanding of how specific dimensions of JS individually influence EP within strategically significant public-sector organizations. Accordingly, the present study seeks to examine the impact of JS and its key dimensions on EP in a selected government organization in Sri Lanka. By providing empirical evidence from a public sector context in a developing economy,

the study aims to contribute to the existing literature on job strain and inform organizational policies and interventions designed to mitigate JS and enhance EP.



H1 - Job strain significantly influences on employees' performance
H2 - Role overload significantly influences on employees' performance
H3 - Role insufficiency significantly influences on employees' performance
H4 - Role ambiguity significantly influences on employees' performance
H5 - Role conflict significantly influences on employees' performance
H6 - Physical environment significantly influences on employees' performance

Methodology

This research is conducted under a quantitative approach. The rationale behind selecting this approach lies in the fact that the study aims for hypothesis testing, involving analytical and predictive aspects. The chosen research strategy is the survey research method, as the data is going to be collected as primary data through a self-administrated questionnaire that distributed in online mode as survey link. Research setting of this study is non-contrived. The research utilized simple regression analysis to find out the impact of independent variable on dependent variable. Further, data were analyzed using the SPSS statistic software to measure the validity, reliability testing and univariate and bivariate analysis.

The population under consideration comprises all the non-executive officers who employed in selected organization amounting to 431 individuals. To ensure representative sampling, the simple random sampling technique was employed as the chosen method for selecting participants in this study and as sample 205 of employees was selected.

Results

Out of 205 sample, 205 completed questionnaires were received. Considering the univariate analysis, a frequency distribution analysis was carried out on the respondents' demographic

features. There were 56.1% of males and 43.9% of females. There are 107 respondents who are married, 78 respondents who are not married and 20 respondents who are divorced. There were five working experience categories that were used for this study. The data found that most of the respondents were in the 3 to 4 years' category with 35.6% and the minority of the respondents were in the category with 12.2%. In terms of monthly income, most employees, which is 65 employees, have monthly income in between Rs. 100,000 to Rs. 150,000 while the minority of employees, which is 34, have monthly income above Rs. 150,000.

According to results of the distribution of JS and EP within the total sample, it seems that the data set is distributed as a normal distribution. The skewness and kurtosis values of OS and EP are 0.019, -0.314 and 0.950, 0.423 respectively. The mean of JS and EP under the study was 1.9659 and 2.1463 which indicate lower degree of both variables.

According to the following table, results of regression analysis was done to determine the impact of JS on EP. The results of the analysis found that all hypotheses were accepted, and all variables have highly significant impact on EP except PE. PE hasn't highly significant impact but has significant impact on EP.

Variable	R	R Square	Unstandardized Coefficients		Standardized Coefficients	t	F	Sig. Value/ P Value	Hypotheses	Hypotheses Supported
			B	Std. Error	Beta					
JS	.410[a]	.168	.476	.074	.410	6.413	41.123	.000	H1	Yes
RO	.394[a]	.155	1.670	.274	.394	6.100	37.216	.000	H2	Yes
RI	.432[a]	.187	2.067	.303	.432	6.823	46.559	.000	H3	Yes
RA	.394[a]	.155	1.711	.280	.394	6.106	37.288	.000	H4	Yes
RC	.397[a]	.159	1.518	.274	.397	6.103	31.916	.000	H5	Yes
PE	.183[a]	.034	.539	.203	.183	2.655	7.050	.009	H6	Yes

Discussion

The primary objective of this study was to examine the impact of JS on EP among non-executive officers in selected government organizations in Sri Lanka. Specifically, the study assessed the

prevailing levels of job strain and employee performance and investigated whether five commonly identified job stressors; RO, RI, RA, RC, and PE significantly influence EP.

JS is a complex and dynamic phenomenon, and excessive or unmanaged stress negatively affects both individual performance and overall organizational effectiveness. The descriptive analysis revealed a low level of occupational stress within the organization, with a mean value of 1.9659. Similarly, EP was also found to be low, with a mean value of 2.1463.

Regression analysis indicated that JS has a highly significant impact on EP, with a significance value of .000 ($p < 0.001$) and a t-value of 6.413. The R^2 value of 0.168 demonstrates that 16.8% of the variance in EP is explained by JS, thereby supporting the first hypothesis (H1). These findings align with prior studies by Yeboah-Kordee et al. (2018) and Aroosiya and Ali (2016), both of which reported a significant negative relationship between JS and EP.

Further analysis of individual stressors revealed that RO, RI, RA, and RC exert a highly significant impact on EP ($p < 0.001$), supporting hypotheses H2 to H5. These findings are consistent with earlier research by Zangmo and Chhetri (2022), Worku (2021), Hoboubi et al. (2017), June and Mahmood (2011), Joy (2020), and Adam et al. (2020). Although PE did not demonstrate a highly significant effect, it showed a statistically significant impact on EP ($p = .009$; $t = 2.655$), supporting H6 and aligning with Worku (2021).

Hence, the findings underscore the importance of effective JS management. Organizations must prioritize stress-reduction strategies and coping mechanisms to enhance EP and sustain organizational productivity.

Conclusion

In the realm of organizational success, human resources play a pivotal role. Research suggests that the unwanted JS is crucial for the failure of EP as well as organizational performance. The research objectives were crafted based on these insights, aiming to investigate the impact of JS on EP and explore the specific influences of RO, RI, RA, RC, and PE on EP. The study, conducted at selected government organization, revealed noteworthy findings. Firstly, it confirmed a highly significant impact of JS on EP of non-executive officers in selected government organization in SL. Further, as factors of JS, RO, RI, RA, and RC have highly significant impact on EP, while PE hasn't highly significant impact but has a significant impact on EP. The study contributes to the existing literature by offering context-specific evidence from the public sector in a developing economy, where empirical research on job strain remains limited. By decomposing job strain into distinct role-related and environmental dimensions, the research advances a more nuanced understanding of how different stressors uniquely affect employee performance, thereby addressing an important conceptual and empirical gap in prior studies.

From a policy and management perspective, the findings highlight the necessity for government organizations to prioritize job design and role management interventions**.** Policies aimed at balancing workloads, clarifying role expectations, reducing conflicting demands, and aligning

employee competencies with job requirements are likely to yield substantial improvements in performance. Additionally, continued investment in improving physical working conditions can further support employee well-being and productivity. Effectively managing job strain is essential not only for enhancing employee performance but also for ensuring the long-term effectiveness and sustainability of public-sector organizations in Sri Lanka.

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Impact of Online Tax System on Tax Compliance Among Individual Tax Payers in Sri Lanka

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Introduction

The opening chapter sets the stage for the research by contextualizing the significance of tax compliance and the growing role of technology in tax administration, specifically focusing on Sri Lanka. Tax compliance is the extent to which taxpayers fulfill their tax obligations voluntarily and honestly, remains a persistent challenge for governments worldwide. Effective tax collection is crucial for funding public services, infrastructure, and development projects, making the efficiency and effectiveness of tax systems a national priority.

In recent years, technological advancements have revolutionized tax administration. Automated online tax systems have been introduced to streamline procedures, reduce administrative costs, minimize manual errors, and control tax evasion. In Sri Lanka, these systems are considered vital to transforming the traditional tax landscape, increasing compliance, and widening the tax base.

Problem Statement

Despite the adoption of automated tax systems, there exists a gap in understanding how these technological changes impact taxpayer behavior and compliance rates. Various factors such as taxpayer awareness, technological literacy, system usability, and demographic variables may influence whether taxpayers embrace or resist these new systems. The potential benefits of automation can only be realized if taxpayers are willing to adopt and effectively utilize these platforms.

This study aims to explore the impact of the automated online tax system on tax compliance among individual taxpayers in Sri Lanka. It seeks to identify the factors that influence compliance and examine how perceptions, knowledge, and system usability contribute to taxpayer behavior.

Research Objectives

The primary objectives outlined include:

1. To investigate the influence of automated tax systems on the compliance behavior of individual taxpayers.
2. To identify the key factors, such as taxpayer knowledge, awareness, and ease of use that affect compliance.
3. To analyze demographic variables that may impact the acceptance and utilization of online tax systems.

4. To provide recommendations for policymakers to enhance the system's effectiveness.

Research Questions

According to problem statement following are the research questions.:

- Main question:
    - What is the impact of the automated tax system on tax compliance among individual taxpayers in Sri Lanka?
- What is the impact of an online self-assessment system on tax compliance?
- What is the impact of taxpayers' knowledge about the automated tax system on tax compliance?
- What is the impact of the ease of use of the tax system on tax compliance?
- What is the impact of taxpayers' awareness on tax compliance?

Significance of the Study

The research offers vital insights for tax authorities, policymakers, and other stakeholders. By understanding the factors that promote or hinder compliance, authorities can improve system design, develop targeted educational campaigns, and create policies that foster trust and engagement among taxpayers.

Furthermore, the study contributes academically to existing literature on tax compliance and technological innovation, especially within the context of Sri Lanka's unique socio-economic environment.

Scope and Limitations

The scope of the study is confined to individual taxpayers in Sri Lanka who utilize or are potential users of the automated tax system. It examines variables like taxpayer knowledge, perceptions of ease of use, demographic factors, and compliance levels. However, the chapter acknowledges certain limitations, such as the geographical concentration of respondents, potential biases in self-reported data, and the rapidly evolving nature of technology that can quickly change the context.

Methodology Overview

While a detailed methodology is discussed in subsequent chapters, the introduction hints at the use of questionnaires as the primary data collection tool. The study employs quantitative analysis techniques, including regression and correlation analyses, to understand relationships between variables.

Literature Review

Tax Compliance: Concepts and Significance

Tax compliance refers to the extent to which taxpayers adhere to tax laws, meet their tax obligations, and accurately report income and pay taxes on time. It is a central concern for tax authorities

worldwide because compliance levels directly influence government revenue and the effectiveness of fiscal policies.

Tax compliance is driven by a complex interplay of factors including individual taxpayer characteristics, perceived fairness, trust in government, and the perceived risks of detection. The chapter highlights that compliance can be broadly categorized into *voluntary* compliance motivated by the taxpayer's internal willingness and *enforced* compliance driven by coercion or penalties.

Theoretical Frameworks Explaining Tax Compliance

Various theories underpin the understanding of taxpayer behavior and compliance:

- **Theory of Planned Behavior (TPB):** Proposes that behavioral intention, shaped by attitudes, subjective norms, and perceived behavioral control, influences compliance behavior.
- **Technology Acceptance Model (TAM):** Focuses on predictors of system adoption, including perceived ease of use and perceived usefulness, which influence users' intention to use technological systems like online tax platforms.

Factors Influencing Tax Compliance

The chapter extensively discusses both intrinsic and extrinsic factors affecting compliance:

- **Knowledge and Awareness:** Taxpayers understanding of tax laws and procedures significantly correlates with compliance. Knowledgeable taxpayers are less likely to make errors or evasion attempts.
- **Perception of Fairness and Trust:** Fairness perceptions regarding tax policies and the administration influence voluntary compliance. When taxpayers perceive high fairness and trustworthiness, compliance tends to improve.
- **Ease of Use of Tax Systems:** Complex, time-consuming, or cumbersome processes discourage compliance. Ease of system use, clarity, and accessibility foster higher participation rates.
- **Economic and Demographic Variables:** Factors such as income level, education, age, and occupation influence taxpayer behavior. For instance, higher education levels are generally associated with better understanding and higher compliance.
- **Perceived Risks and Penalties:** The likelihood of being audited or penalized acts as a deterrent to non-compliance.

Role of Automated Tax Systems

Automation in tax administration has gained importance as a means to improve compliance through various mechanisms:

- **Streamlining Processes:** Automated systems simplify tax filing, reduce paperwork, and minimize manual errors, making compliance easier and more accessible.
- **Real-time Feedback:** Instant notifications, reminders, and updates improve transparency and engagement.
- **Enhanced Data Accuracy:** Automated systems reduce opportunities for fraud and evasion by cross-checking data and flagging inconsistencies.
- **Transparency and Trust:** Digital platforms can increase transparency by providing clear records and easy tracking of obligations, payments, and refunds.
- **Data Analytics and Enforcement:** Automation allows for sophisticated data analysis, enabling authorities to identify patterns of non-compliance and target enforcement more efficiently.

Impact of Automated Systems on Tax Compliance

Studies across countries indicate that automated tax systems generally lead to:

- Increased voluntary compliance due to ease and convenience.
- Reduced processing time and administrative costs.
- Better compliance monitoring and enforcement capabilities.
- Improved taxpayer satisfaction and trust.

However, the effectiveness of automation depends on factors such as system usability, taxpayer's technological literacy, security, and acceptance.

Challenges and Barriers

Despite advantages, implementing automated tax systems encounters several hurdles:

- **Technological Barriers:** Limited access to the internet and digital devices in some regions hinders adoption.
- **Lack of Awareness and Knowledge:** Taxpayers unfamiliar with digital platforms may resist or misuse systems.
- **Security Concerns:** Privacy and data security issues can diminish trust in online systems.
- **User Experience:** Non-intuitive interfaces or technical glitches discourage usage.
- **Demographic Disparities:** Different demographic groups exhibit varied acceptance levels owing to differences in education, age, and socio-economic status.

Taxpayer Attitudes Toward Automation

Research indicates that taxpayer attitudes significantly influence system utilization. Positive perceptions such as perceived usefulness, trustworthiness, and ease of use result in higher engagement. Conversely, apprehensions about security, complexity, or lack of awareness reduce adoption and compliance.

Understanding these attitudes can help tailor strategies, such as targeted education, awareness campaigns, and system improvements, to foster greater acceptance.

Empirical Evidence from Prior Studies

The chapter reviews numerous empirical studies:

- In a study by Agus et al. (2006), the long-term outcomes of automated systems had a positive impact on compliance.
- Other research emphasizes that when users find systems user-friendly and trustworthy, compliance increases, reducing tax evasion and enhancing transparency.
- Studies indicate that in countries where automation is well-implemented, tax evasion declines, and voluntary compliance behaviors are reinforced.

Reviews and Limitations in Existing Literature

While the body of knowledge supports positive outcomes through automation, some studies caution against over-reliance on technology without addressing underlying issues:

- Overemphasis on automation can lead to neglect of the human element, such as taxpayer education and trust-building.
- Potential digital divide issues can exacerbate inequalities, disadvantaging less-tech-savvy or marginalized groups.
- There is a need for more longitudinal studies to assess the long-term effects of automation policies.

Future Directions and Recommendations

The chapter recommends future research to focus on:

- Comparing cross-country experiences with automation.
- Investigating long-term impacts of technological adoption on compliance.
- Exploring taxpayer attitudes and perceptions toward digital systems via qualitative methods.
- Addressing barriers related to infrastructure, security, and awareness.

Research Methodology

Research Philosophy and Approach

The chapter begins by emphasizing the importance of selecting an appropriate research philosophy. Given the exploratory and descriptive nature of the study, a positivism approach was adopted,

focusing on quantifiable data and objective analysis. The purpose of this study is to measure the Factors impacting the automated tax system on tax compliance among individual taxpayers in Sri Lanka.

The approach is quantitative, employing statistical tools to analyze numerical data derived from surveys. This approach enables the precise measurement of variables such as taxpayer attitudes, perceptions, and behaviors regarding automated tax systems.

Research Design

A descriptive research design was employed to understand and describe the current state of automated tax system adoption and its impact on compliance behaviors among Sri Lankan taxpayers. This design is suitable for capturing a snapshot of the variables at a particular point in time.

The research integrates cross-sectional data collection, implying that data were gathered once from respondents within a specified period, providing a broad overview of the current landscape.

Population and Sampling

Target Population: The population comprises individual taxpayers registered with Sri Lanka's Department of Inland Revenue who actively use or have had exposure to the automated tax system.

Sampling Frame: A comprehensive list of registered taxpayers served as the sampling frame. The focus was on taxpayers across diverse demographic and socio-economic backgrounds, including different age groups, income levels, educational backgrounds, and geographic locations.

Sampling Technique: A probability sampling method, specifically stratified random sampling, was employed. Stratification ensured representation across key demographic 'strata' such as income brackets, age groups, and regions, enhancing representativeness.

Sample Size Determination: Using Krejcie and Morgan Table for sample size calculation at a 95% confidence level and a 5% margin of error, the optimal sample size was calculated. Additionally, an allowance was made for non-response to ensure sufficient data for analysis. Ultimately, a sample of **385 respondents** was achieved.

Data Collection Instruments

Questionnaire Design: Data were primarily collected via a **structured questionnaire**, consisting of closed-ended questions to facilitate statistical analysis. The questionnaire was designed based on the literature review, encompassing sections such as:

- Demographic profile
- Awareness and knowledge of automated tax systems
- Perceptions of ease of use and usability
- Attitudes toward automation

- Tax compliance behavior (e.g., timely filing, accuracy)
- Trust and confidence in the system

Questions employed 5 Likert scales, multiple-choice, and dichotomous formats to measure attitudes, perceptions, and behaviors.

Data Collection Procedure

Distribution Methods: Data collection was conducted through a combination of self-administered questionnaires, distributed via online, to accommodate varied respondent preferences. This approach aimed to maximize response rates.

Data Collection Timeline: The data collection spanned approximately two months, from initial distribution to retrieval, ensuring ample response time and follow-up.

Ethical Considerations: Participation was voluntary, with assurances of confidentiality and anonymity. Respondents provided informed consent. Ethical approval was obtained from relevant authorities, aligning with research standards.

Variables and Measurement

The study identified **independent variables** and a **dependent variable**:

- **Independent Variables:**
- Self-assessment system
- Taxpayer knowledge
- Taxpayer awareness
- Ease of use (perceived usability)
- **Dependent Variable:**
- Tax compliance (measured by timely filing, accuracy, and frequency of compliance)

These variables were operationalized through specific questionnaire items, with constructs measured on 5 Likert scales to quantify attitudes and perceptions.

Data Analysis Techniques

The collected data were processed and analyzed using Statistical Package for the Social Sciences (**SPSS**). The analytical framework included:

- **Descriptive Statistics:** To summarize demographic data and initial variable distributions.
- **Reliability Analysis:** Cronbach's alpha tested internal consistency of measurement scales, with values above 0.7 indicating acceptable reliability.

- **Correlation Analysis:** To examine the relationships between variables, such as the association between ease of use and compliance.
- **Regression Analysis:** Multiple linear regressions determined the impact of independent variables on tax compliance, testing hypotheses regarding the significance and strength of predictors.
- **Hypothesis Testing:** Null hypotheses were tested at a 5% significance level. Path analysis and regression coefficients were scrutinized to establish causality.

Validity and Reliability

Validity: Content validity was ensured through literature-based question development, expert review, and pilot testing. Construct validity was reinforced via factor analysis, confirming the coherence of measurement scales.

Reliability: Cronbach's alpha values were computed for multi-item scales values exceeding 0.7 confirmed high internal consistency.

Limitations Addressed: Potential biases, such as social desirability response bias, were minimized through anonymity assurances and neutral question wording. The stratified sampling procedure further mitigated sampling bias.

Ethical Considerations

The research adhered to ethical standards mandated by academic and national bodies. Key considerations included voluntary participation, confidentiality, and data protection. Participants were informed about the study's purpose, their rights, and the use of data for research purposes.

DATA PRESENTATION AND ANALYSIS

4.1 Demographic Profile of Respondents

The first section of Chapter 4 discusses the demographic characteristics of the respondents, which is crucial in understanding the context and distribution of the data. The demographic variables include gender, age, educational qualification, income level, and geographic location.

- **Gender Distribution:** The sample comprises approximately 60% males and 40% females. This distribution indicates a relatively balanced representation of genders among respondents.
- **Age Groups:** This illustrates the age distribution, with the majority of respondents falling into the 30-40 age bracket (around 35%), followed by 20-30 years (25%), 40-50 years (20%), and above 50 years (20%). This suggests a predominantly middle-aged taxpayer base.
- **Educational Qualification:** The educational levels of respondents show diversity, with 40% holding bachelor’s degrees, 35% possessing master’s degrees, and the remaining 25%

with diplomas or other qualifications. A higher educational background is correlated with a higher awareness and understanding of tax systems.

- **Income Levels:** Here, it reveals that 45% of respondents belong to middle-income brackets, 35% to higher-income, and 20% to lower-income groups. Income level can influence tax compliance behavior due to financial capacity and tax liability.
- **Geographic Distribution:** The respondents are distributed across urban, suburban, and rural areas, with a larger proportion from urban zones, reflecting higher exposure or familiarity with automated systems in urban centers.

This demographic analysis highlights that the sample represents a diverse cross-section of the taxpayer population, thereby enhancing the generalizability of the findings.

Descriptive Statistics of Variables

The next section explores the descriptive statistics concerning the core variables: self-assessment system, taxpayer knowledge, taxpayer awareness, perceived ease of use, and tax compliance.

Self-Assessment System

Respondents' familiarity and experience with the self-assessment system are captured through statements such as "I am comfortable using the self-assessment system" and "I regularly utilize online platforms for tax filing." The responses, measured on Likert scales (1-Strongly Disagree to 5-Strongly Agree), reveal that approximately 70% of taxpayers agree or strongly agree that they are familiar with and comfortable using the system. This indicates a positive perception of the self-assessment process.

Taxpayer Knowledge

Taxpayer knowledge impacts compliance behavior. The average score for knowledge-related statements (e.g., understanding of tax obligations, filing procedures) is high (mean = 3.8), indicating a moderate to high level of awareness among respondents.

Taxpayer Awareness

Awareness of the benefits and functionalities of automated tax systems was assessed, illustrating that 65% of respondents recognize the advantages, such as time-saving and accuracy enhancement.

Perceived Ease of Use

The perceived ease of use, a critical construct, was measured via statements such as "The automated system is user-friendly." The mean score of 4.0, signifying that respondent generally find the system accessible and manageable.

Tax Compliance

Tax compliance is measured through respondents' self-reported behaviors such as timely filing, accurate declarations, and payment regularity. The results show that approximately 75% of the respondent's report compliance with tax obligations, suggesting the initial positive influence of automation.

Reliability Analysis

The internal consistency of the multi-item scales was tested via Cronbach's alpha:

- **Self-assessment system:** $\alpha = 0.82$
- **Taxpayer knowledge:** $\alpha = 0.85$
- **Taxpayer awareness:** $\alpha = 0.78$
- **Perceived ease of use:** $\alpha = 0.81$
- **Tax compliance:** $\alpha = 0.87$

All values exceed the minimum threshold of 0.7, indicating high reliability of the scales used in the questionnaire.

Correlation Analysis

Pearson correlation coefficients provide preliminary insight into relationships among variables. The key findings include:

- **Self-assessment system** correlates positively with **tax compliance** ($r = 0.524$, $p < 0.01$).
- **Taxpayer knowledge** exhibits a positive correlation with **tax compliance** ($r = 0.471$, $p < 0.01$).
- **Taxpayer awareness** shows a significant correlation ($r = 0.456$, $p < 0.01$).
- **Perceived ease of use** correlates strongly with **tax compliance** ($r = 0.589$, $p < 0.01$).

These correlations suggest direct relationships, with perceived ease of use being the most strongly associated with compliance, highlighting its importance.

Hypotheses Testing

Based on expectations established in the research hypotheses, the following tests were performed, summarized in **Table 10**:

Hypothesis	**Regression Coefficient (B)**	**p-value**	**Status**
H1: Self-assessment system positively affects tax compliance	0.183	0.000	Accepted
H2: Taxpayer knowledge positively influences tax compliance	0.169	0.002	Accepted
H3: Taxpayer awareness significantly impacts tax compliance	0.278	0.000	Accepted

H4: Perceived ease of use positively impacts tax compliance	0.205	0.000	Accepted

All hypotheses were supported, indicating statistically significant positive influences of the independent variables on tax compliance.

Regression Analysis

A multiple regression model examined the combined effect of the independent variables on tax compliance. The model summary shows:

- **R-squared (R^2) = 0.522**, meaning approximately 52.2% of the variance in tax compliance is explained by the four independent variables.
- The **F-statistic** is significant ($p < 0.001$), confirming the overall significance of the model.

Regression coefficients demonstrate that **perceived ease of use** had the highest standardized beta value ($\beta = 0.205$), emphasizing its dominant role. The model can be summarized as:

Tax Compliance = 0.183(Self-assessment system) + 0.169(Taxpayer knowledge) + 0.278(Taxpayer awareness) + 0.205(Perceived ease of use)

Additional Findings and Observations

- Respondents perceiving the system as user-friendly are more likely to comply.
- Higher taxpayer knowledge correlates with increased compliance, emphasizing educational initiatives.
- Urban residents demonstrate higher familiarity and compliance compared to rural counterparts.
- There exists a sizable proportion of taxpayers still hesitant or unsure about utilizing automated systems fully, highlighting areas for improvement in system design and awareness campaigns.

CONCLUSION

Effectiveness of Automated Tax Systems in Enhancing Compliance

The study robustly demonstrates that automated tax systems have a significant positive impact on tax compliance among individual taxpayers in Sri Lanka. The regression analysis conducted using SPSS revealed that key variables such as taxpayer knowledge, ease of use, awareness, and attitudes towards automation are directly linked to compliance behavior.

Taxpayers engaging with automated systems tend to comply more effectively due to streamlined processes that minimize bureaucracy, reduce errors, and provide real-time feedback. The automation simplifies tax filing procedures by offering online platforms that are user-friendly and accessible, which mitigates traditional barriers such as lengthy paperwork or manual calculations. This digital shift fosters a proactive compliance attitude, as taxpayers can easily access their tax obligations, track payments, and receive notifications about due dates.

Furthermore, the data indicates a clear correlation between increased use of automated systems and higher compliance rates. Taxpayers who are well-informed and comfortable with these platforms are more inclined to adhere to tax regulations consistently. Their familiarity reduces the likelihood of inadvertent errors and non-compliance driven by confusion or lack of understanding.

This positive trend underscores the transformative role of automation in boosting overall tax revenues and reducing evasion. As taxpayers find the system more accessible, their trust and willingness to comply grow, creating a more compliant environment.

Role of Technology in Combating Tax Evasion and Promoting Transparency

Automated tax systems are pivotal in enhancing transparency and curtailing tax evasion. The reduction of human discretion through automation helps eliminate opportunities for manipulation or fraudulent behavior. Thanks to functions like electronic audits, data matching, and real-time monitoring, tax authorities can detect discrepancies early, which acts as a deterrent to evasion.

The transparency offered by digitization allows taxpayers to monitor their payments and obligations transparently, fostering trust in the system. When taxpayers perceive that their compliance efforts are recognized and recorded accurately, their confidence in the tax authority improves, leading to increased voluntary compliance.

The use of technology also facilitates better data management, enabling authorities to generate insights into compliance patterns, identify risky taxpayers, and tailor interventions accordingly. Consequently, the automation of tax processes enhances overall system integrity and accountability.

Influence of Demographic Factors on Tax Compliance

Data analysis indicates that demographic variables such as age, education level, income, digital literacy, and geographic location significantly influence the effectiveness of automated tax systems on compliance behavior.

Younger taxpayers, particularly those with higher education and digital literacy, tend to embrace automated systems more readily. Their familiarity with technology allows them to navigate electronic platforms efficiently, resulting in higher compliance rates. Conversely, older taxpayers, especially in rural areas with limited technological access, face challenges that hinder their engagement with automated systems.

Socioeconomic status further impacts compliance. Higher-income taxpayers demonstrate better compliance, often due to greater awareness, resources, and perceived benefits of tax compliance. In contrast, lower-income individuals may struggle with understanding the digital procedures or may lack necessary infrastructure, leading to lower compliance levels.

Geographical disparities, such as urban versus rural residency, also influence usability and engagement levels with automated systems. Urban taxpayers benefit from better connectivity and technological infrastructure, reinforcing the need for targeted interventions in rural settings.

Taxpayer Perceptions and Attitudes Toward Automation

The research underscores that taxpayers' perceptions of automated systems—whether they view these as beneficial or taxing affect their compliance behavior. Factors influencing perceptions include ease of use, trust in the system, perceived fairness, security concerns, and the level of support available.

Participants who perceive automation as user-friendly and trustworthy are more likely to comply voluntarily. Conversely, those apprehensive about security risks or unfamiliar with digital processes may exhibit reluctance, leading to non-compliance or delays.

Educational initiatives and awareness campaigns can modify these perceptions positively. The study highlights that improving digital literacy, providing clear instructions, ensuring data security, and offering support can significantly enhance user acceptance.

Recommendations for Policymakers and Tax Authorities

Based on the empirical findings, several strategic recommendations emerge:

1. **Enhance Taxpayer Education and Outreach:** The success of automation largely depends on the taxpayer's understanding and comfort. Targeted training programs, workshops, and awareness campaigns are essential, especially for demographics with limited digital literacy or in rural areas. These initiatives should focus on explaining the benefits of automation, how to use tax portals, and addressing concerns about data security.
2. **Improve User Experience and System Accessibility:** The design of automated tax platforms should prioritize user-centric principles. Interfaces must be intuitive, accessible across devices, and available in local languages. Simplifying navigation and minimizing technical jargon will encourage wider adoption.
3. **Strengthen Support and Feedback Mechanisms:** Regular feedback channels allowing taxpayers to report issues, suggest improvements, and seek assistance can improve system responsiveness. Establishing helpdesks and chat support can alleviate user frustrations.
4. **Expand Infrastructure and Reduce Digital Divide:** Efforts should be made to improve internet access, especially in rural regions. Public-private partnerships may facilitate infrastructure development, ensuring equitable access to digital taxation services.
5. **Leverage Data Analytics for Policy and Enforcement:** Data generated from automated systems should be used to monitor compliance trends, identify non-compliant taxpayers, and tailor interventions accordingly. This proactive approach can further deter evasion.
6. **Implement Continuous System Evaluation and Upgrades:** An iterative process involving regular assessments, testing, and upgrades ensures that the system remains relevant, secure, and efficient. Incorporating taxpayer feedback improves acceptance and effectiveness over time.

7. **Focus on Corporate and Small Business Sector:** Since this study centers on individual taxpayers, future efforts should extend automation benefits to corporate and SME sectors, which face distinct compliance challenges.

8. **Address Demographic Disparities:** Special support measures should be introduced for less tech-savvy and marginalized groups to foster inclusive compliance.

Long-term Perspectives and Future Research

The chapter advocates for ongoing research focusing on taxpayers' attitudes toward automation—qualitative studies such as interviews and focus groups can enhance understanding of motivations, concerns, and expectations. These insights will guide the development of more user-friendly systems and targeted educational initiatives.

Additionally, examining the long-term effects of automation on compliance, tax revenue, and taxpayer satisfaction is crucial. Comparative studies across different regions or countries can offer valuable lessons and best practices.

The evolving nature of digital technology necessitates adaptive strategies, emphasizing the importance of feedback, continuous improvement, and capacity building among tax officials.

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Factors Affecting Employee Engagement Under Work from Home (WFH) During the COVID-19 Pandemic: Empirical Evidence from a Selected Financial Company in Sri Lanka

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***Keywords*:** Employee engagement, Work from home, COVID-19, Financial sector, Sri Lanka

Introduction

The COVID-19 pandemic triggered unprecedented disruptions to organizational operations worldwide, forcing many organizations to rapidly adopt work-from-home (WFH) arrangements to ensure business continuity and employee safety (World Health Organization [WHO], 2020). While WFH had been practiced in developed economies to promote flexibility and work–life balance, its sudden and large-scale implementation in developing countries presented significant challenges, particularly in sustaining employee engagement (Felstead & Jewson, 2000; Dingel & Neiman, 2020).

Employee engagement is widely recognized as a critical driver of organizational performance, productivity, and service quality, especially in essential service sectors such as financial services (Kahn, 1990; Bakker & Albrecht, 2018). In Sri Lanka, financial institutions were required to continue operations during the pandemic under strict health regulations, leading to an extensive reliance on remote work practices. However, limited digital infrastructure, minimal prior exposure to WFH, and socio-cultural constraints raised concerns regarding employees' ability to remain engaged.

Despite the growing global literature on WFH, empirical evidence from developing economies remains limited. Addressing this gap, the present study examines the impact of selected factors; access to internet and IT devices, work–life balance, specified work plans, and sense of belonging on employee engagement under WFH during the COVID-19 pandemic, using empirical evidence from a selected financial company in Sri Lanka

Methodology

This study adopted a quantitative, cross-sectional research design. The study population comprised employees working across the branch network of a leading licensed finance company in Sri Lanka. Using a cluster sampling technique, data were collected from 214 respondents, ensuring representation from different employee categories and geographical locations.

Demographic Factor	Component	Frequency	Percentage (%)	Median	Mode
Gender	Male	116	54.2	1	1
	Female	98	45.8		
Civil Status	Married	86	40.2	2	2
	Single	128	59.8		
Age	15-20	8	3.7	3	3
	21-25	24	11.2		
	26-30	111	51.9		
	31-35	55	25.7		
	36-40	16	7.5		
Educational Qualification	A/L, O/L, or Less	10	4.7	4	4
	Certificate/Advanced certificate course	13	6.1		
	HND/Diploma	23	10.7		
	Bachelor's Degree	128	59.8		
	Post graduate diploma	6	2.8		
	Master's Degree	32	15.0		
	PhD	2	.9		
Family Members	2	18	8.4	4	4
	3	20	9.3		
	4	106	49.5		
	5	49	22.9		
	6	16	7.5		
	7	5	2.3		
Employment Category	Non-Executive	65	30.4	2	2
	Executive	115	53.7		
	Management	34	15.9		
Division	Marketing	29	13.6	2	2
	Operations	185	86.4		
Experience	Less than one year	17	7.9	4	3
	1-2	38	17.8		
	2.1-3	49	22.9		
	3.1-4	47	22		
	4.1-5	17	7.9		
	More than five years	46	21.5		
Average Salary	0-20000	20	9.3	4	5
	20001-30000	5	2.3		
	30001-40000	60	28		
	40001-50000	39	18.2		
	More than 50000	90	42.1		
Province of Residence	Western Province	29	13.6	5	1
	Central Province	24	11.2		
	Southern Province	21	9.8		
	Uva Province	27	12.6		
	Sabaragamuwa Province	22	10.3		

Primary data were gathered through a structured questionnaire. Employee engagement was treated as the dependent variable, while access to internet and IT devices, work–life balance, specified work plans, and sense of belonging were considered independent variables. Data analysis was conducted using SPSS version 26, employing descriptive statistics, correlation analysis, and multiple regression analysis. Reliability and validity were confirmed through Cronbach's alpha and factor analysis.

Results / Findings

Descriptive and inferential analyses revealed that all independent variables were positively correlated with employee engagement. However, results from the multiple regression analysis indicated that access to internet and IT devices and sense of belonging had a statistically significant positive impact on employee engagement under WFH conditions.

In contrast, work–life balance and specified work plans did not demonstrate a statistically significant influence on employee engagement in the selected financial company. These findings suggest that technological readiness and psychological connectedness to the organization play a more critical role in sustaining engagement during crisis-induced remote work environments.

Table 1: Correlation between Independent Variables and Employee Engagement

Variable	**Correlation with Employee Engagement**
Access to Internet & IT Devices	Positive and Significant
Work–Life Balance	Positive
Specified Work Plan	Positive
Sense of Belonging	Positive and Significant

Note: All correlations were positive; significance was tested at the 5% level.

The correlation analysis indicates that all selected factors are positively associated with employee engagement under WFH conditions. Notably, access to internet and IT devices and sense of belonging demonstrate stronger relationships with employee engagement.

Table 2: Summary of Multiple Regression Results

Independent Variable	Impact on Employee Engagement
Access to Internet & IT Devices	Significant
Work–Life Balance	Not Significant
Specified Work Plan	Not Significant
Sense of Belonging	Significant

Note: Model significance confirmed at 5% level.

The regression results reveal that access to internet and IT devices and sense of belonging have a statistically significant impact on employee engagement, while work–life balance and specified work plans do not significantly influence engagement under WFH conditions.

Discussion

The findings support the Job Demands–Resources (JD-R) model, which emphasizes the role of job resources in enhancing employee motivation and engagement (Bakker & Schaufeli, 2008). Adequate access to internet connectivity and IT devices functioned as essential job resources, enabling employees to perform their duties effectively while working remotely. This result aligns with previous studies highlighting the importance of digital readiness in remote work contexts (Chanana & Sangeeta, 2020).

Furthermore, the significant influence of sense of belonging underscores the relevance of attachment theory, which posits that emotional connection and perceived organizational support enhance individual engagement and commitment (Kahn, 1990). During prolonged remote working arrangements, feelings of isolation can weaken employee engagement if social and managerial connections are not maintained.

Conversely, the non-significant effects of work–life balance and specified work plans contrast with findings from studies conducted in developed economies, where these factors are often strong predictors of engagement (Felstead & Jewson, 2000). This divergence may reflect contextual realities in developing countries, where job security, technological access, and organizational support become dominant concerns during crisis periods.

Conclusion

This study provides empirical evidence that employee engagement under WFH during the COVID-19 pandemic in Sri Lanka's financial sector is primarily influenced by technological accessibility and a strong sense of organizational belonging. The findings highlight the importance of investing in digital infrastructure and fostering inclusive, supportive organizational cultures to sustain employee engagement during remote work arrangements.

The study contributes to the limited body of knowledge on WFH and employee engagement in developing economies and offers practical insights for managers seeking to design resilient human resource strategies in times of crisis.

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SESSION 4

Governance and Institutions, Social Sciences

Youth Participation in Policy-Making for Sustainable Development in Sri Lanka

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Key Words: Digital Engagement, Governance, Sustainable Development, Policy-Making, Youth Participation

Introduction

Youths' participation in policy development has gained increasing recognition over the years as a critical factor in realizing sustainable development worldwide. The United Nations (2015) points to the essential core of the SDGs, SDG 16 (Peace, Justice and Strong Institutions) and SDG 17 (Partnerships for the Goals), which underscore that participatory and inclusive governance is required to make development gains equitably and sustainably. Despite increased recognition of the importance of youth engagement, it is noted in different studies that deficits in meaningful engagement persist, in addition to institutional barriers, inadequate capacity-building programs, and limited access to decision-making forums (Checkoway, 2011; United Nations, 2018). Youths offer fresh perspectives, energy, and unique insights during policy formulation, especially in environmental sustainability, social inclusion, and technology-driven development. Active participation can lead to increased policy legitimacy, responsiveness, and sustainability by aligning government strategies with the priorities of the younger generation. Furthermore, contemporary global challenges such as climate change, resource depletion, and socio-political instability require cross-generational and collaborative approaches; hence, youth engagement is no longer just desirable but also imperative. This study aims to investigate the role that youth participation plays in contributing to policy-making for sustainable development. This study seeks to identify mechanisms that are either enabling or hindering the participation of young people, analyse the efficiency of existing frameworks, and emphasise how youth engagement has contributed to sustainable and inclusive governance.

Methodology of the Study

This study uses a descriptive qualitative research design based on secondary data sources. In order to derive information on participation of youth in policy-making, relevant literature consisting of government policy documents, international organisations' reports, such as UN, UNDP, and World Bank, peer-reviewed journal articles, and reports/publications by non-governmental organisations, was systematically reviewed. This study adopted a thematic content analysis approach to identify recurring patterns, best practices, and barriers regarding youth engagement. It targeted a review of policies and programs in various countries that incorporate youth voices into governance processes, with a particular interest in those that contribute to SDGs. Quantitative indicators were noted on a descriptive basis where available, such as the percentage of youth representation in consultative councils or decision-making bodies. It is supported by the conceptual framework of participatory governance theory, arguing that authentic citizen involvement-or, in this case, youth involvement-ensures the legitimacy, inclusiveness, and, thus, sustainability of policy (Arnstein, 1969). It also incorporates aspects of the civic voluntarism model and capacity-building models, which look at how access, motivation, and skills influence youth involvement in policy-making.

Results / Findings of the Study

Analysis revealed the following crucial findings regarding youth participation in policymaking for sustainable development:

Countries with structured participation channels, such as youth councils, advisory boards, and consultative committees, present higher levels of institutionalised engagement (Centre for Policy Alternatives, 2019; Ministry of Youth Affairs and Sports, 2014). Such platforms afford youth direct opportunities for contribution to policy formulation and monitoring processes (United Nations Development Programme Sri Lanka, 2017). For instance, youth parliaments in the European Union, and national youth councils in Sri Lanka provide avenues for representation and policy feedback (United Nations Development Programme Sri Lanka, 2020).

Policy Influence

While the participation of youth in many contexts is happening, their substantial influence on decision-making remains limited (Checkoway, 2011; Dodo, 2019). Policies often symbolically

include youth inputs rather than substantially, creating a gap between consultation and impact (United Nations, 2015).

Barriers to Participation

Common challenges include insufficient resources, lack of awareness about engagement opportunities, tokenism, and social or political marginalisation (United Nations Development Programme Sri Lanka, 2017; Department of Census and Statistics Sri Lanka, 2012). Cultural norms and hierarchical governance structures also impede youth influence in policy settings (Wickramasinghe, 2014).

Role in Sustainable Development

Youth involvement is particularly significant in sectors such as environmental protection, digital governance, and social innovation (Sharma & Gupta, 2020). Initiatives that integrate youth perspectives contribute to more relevant, future-oriented policies that address both current and emerging societal challenges (Checkoway, 2011).

Discussion of the Study

The current study is a great contribution to the literature that exists on the subject of youth participation and governance because it further develops conceptual and contextual insights on the way youth can be engaged in the process of sustainable development policy formulation. As past studies have widely emphasised the normative relevance of youth participation in the processes of democratization and development (Checkoway, 2011; United Nations, 2015), the majority of the current literature is either globally generalised or mostly concentrated on the developed democracies.

The focus of this research on Sri Lanka as a developing, post-conflict, and transitional governance setting is a significant geographical and empirical gap in the literature (Centre for Policy Alternatives, 2019; United Nations Development Programme Sri Lanka, 2017). In addition, the literature tends to understand the concept of youth participation through the lens of civic engagement, electoral participation, or activism, and little literature focuses on the role of youth involvement in formal policy-making systems and their substantive impact on policy outcomes (Dodo, 2019). The paper builds on the existing literature by analyzing in a systematic way the

institutionalised mechanisms of participation, including both youth councils and consultative bodies, and evaluating critically whether the mechanisms include more than mere inclusion, to substantive policy power.

This way, it empirically supports arguments touching on tokenism and lack of decision-making strength enshrined in the literature of participatory governance (Arnstein, 1969; Fung, 2015). The research is also related to the increasing literature which connects the youth participation with the realization of the Sustainable Development Goals, especially SDG 16 on peace, justice and strong institutions. Although the inclusion of youth as a cross-cutting principle is often argued by global policy frameworks (United Nations, 2018), empirical research showing how positive youth-engagement promotes the concept of inclusive and sustainable governance is still scarce. This study adding policy relevance, intergenerational equity, and long-term sustainability outcomes to the analytical connection between youth engagement and the practice of sustainable development directly connects youth participation to sustainability (United Nations Development Programme Sri Lanka, 2020).

Moreover, the study is also a contribution to the research since it highlights emerging role of digital engagement as a challenge and opportunity in youth participation in governance. Even though recent literature treats the digital platform as an agent of participation expansion (Sharma and Gupta, 2020), the study in question puts the digital engagement in the context of more profound structural and socio-political limitations and provides a more nuanced perspective on the success and failure of digital engagement in developing countries. On the whole, the study is a valuable addition to the literature that views the theory of participatory governance through the lens of empirical evidence in Sri Lanka, which offers policy-relevant information that supports the relevance of institutionalising the meaningful youth participation. It therefore adds value to academic discussions on the topic of normative significance of youth involvement in democratic governance and development processes (Checkoway, 2011; United Nations, 2015), and a lot of the current literature is either globalised or mostly confined to mature democracies. The focus of this research on Sri Lanka as a developing, post-conflict, and transitional governance setting is a significant geographical and empirical gap in the literature (Centre for Policy Alternatives, 2019; United Nations Development Programme Sri Lanka, 2017).

Additionally, the current literature tends to define youth engagement in the area of civic engagement, turning up to vote or be an activist, but it rarely focuses on youth involvement in formal policy-making systems and how they impact the policy outcomes in a substantive manner (Dodo, 2019). This research builds on the existing body of literature by reviewing the institutionalised participation in a systematic way e.g., youth councils and consultative bodies and evaluating critically how far the institutionalised mechanisms go beyond symbolic inclusion to actual policy impact. This way, it empirically supports arguments touching on tokenism and lack of decision-making strength enshrined in the literature of participatory governance (Arnstein, 1969; Fung, 2015)

Conclusion of the Study

This study has shown that meaningful youth participation in policy-making is important for the realization of sustainable development. Organized platforms of engagement, capacity-building programs, and digital means of participation promote effective contributions, while institutional, social, and political obstacles remain detrimental to effective youth involvement. Only policies that account for the active contribution of young people can take into consideration current and emerging societal challenges, add greater legitimacy to such policies, and make them more inclusive.

This requires governments, international organisations, and civil society actors to prioritise institutionalising youth participation, investing in capacity-building, and ensuring equitable access to engagement platforms. The findings highlight the practical effects of youth participation in policy-making, from increased policy relevance to intergenerational equity and achieving SDGs. Inclusion of young people's voices in governance empowers not only the younger generation but also secures the foundational pillars of global development: sustainability, inclusivity, and forward-lookingness.

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Beauty Consumption under Neoliberalism: Female Appearance Maintenance amid Sri Lanka's Post-2022 Economic Crisis

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Keywords: Economic Crisis, Gender, Female Physical Appearance, Consumer Culture, Neoliberalism

Introduction

Sex is biologically determined, whereas gender is socially constructed (Butler, 1999). As Beauvoir (1953) famously argued, women are not born but become women through social processes. In this sense, female physical appearance cannot be understood as a purely individual or aesthetic choice; rather, it is shaped and regulated by political, social, and economic structures. Norms of femininity, beauty, and bodily discipline are historically contingent and shift in response to broader structural transformations. In the contemporary global context, neoliberalism has emerged as a dominant economic and ideological framework shaping everyday life, including the governance of bodies and identities. In Sri Lanka, neoliberal reforms initiated in the late 1970s have significantly altered consumption patterns, gendered expectations, and lifestyles; within this neoliberal trajectory, the 2022 economic crisis characterized by inflation, declining incomes, and widespread economic insecurity, has further intensified pressures on women's appearance maintenance and identity formation. Although existing studies have examined neoliberalism's effects on women's labour and consumption, limited attention has been paid to how economic crises within neoliberal regimes reshape female appearance maintenance and identity among women in selected areas of the Colombo District

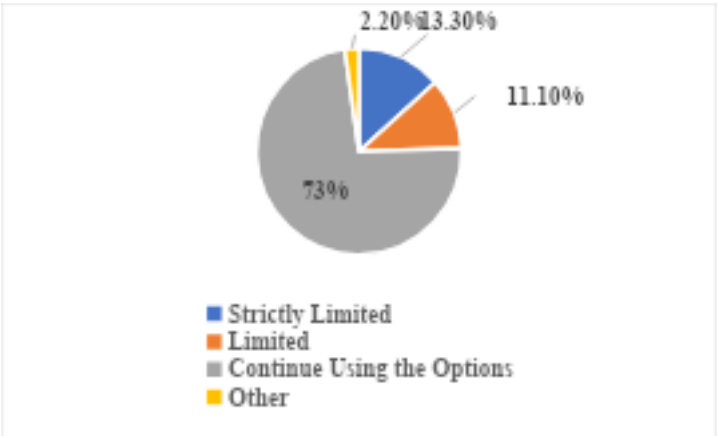
Methodology

Despite the economic crisis in Sri Lanka, which has led to a decline in individual living standards, women continue to be motivated to maintain their physical appearance. This persistence presents a significant research problem, raising questions about why physical appearance-maintenance practices endure under conditions of economic hardship. The study hypothesizes that women's continued engagement in appearance maintenance reflects the strategic influence of the neoliberal

market. The research draws on Feminist Political Economy, Feminist Consumption Theory, Cultural Capital Theory, and Gender Theory, alongside concepts such as the lipstick effect, beauty, and the male gaze, to analyze how social, cultural, and economic forces shape women's motivations and practices. Empirically, the study focused on three areas within the Colombo District: Borella, Kolonnawa, and Salawa. Data were collected from 60 women aged 18 to 60 using structured questionnaires to capture public opinion. In addition, in-depth interviews were conducted with 11 professionals from the beauty and cultural fields and 5 academics. Participants were selected using a random sampling method. A mixed-methods approach was employed, combining qualitative and quantitative techniques within a post-positivist framework. Quantitative data were analyzed using SPSS to conduct descriptive statistical analysis, while qualitative insights from interviews provided deeper contextual understanding of appearance-maintenance practices under economic constraints.

Findings

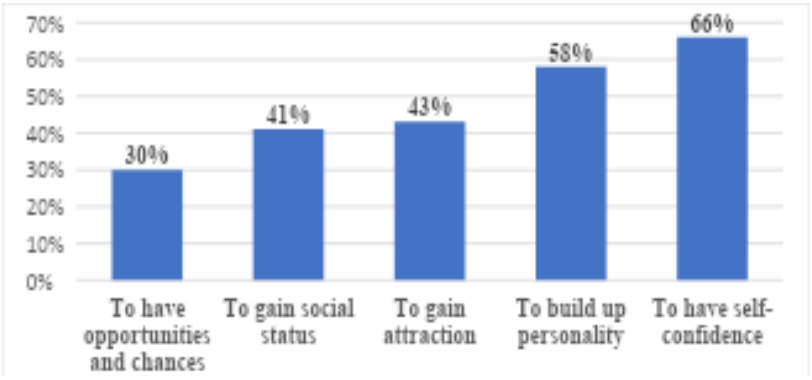
Figure 1: Female physical appearance practice during the economic crisis



- Despite an approximately threefold increase in the cost of beauty-related products and treatments during the economic crisis, 73% of women continued physical appearance-maintenance practices by adopting alternative strategies.

Figure 2: Reasons for maintain female physical appearance

- The findings indicate that the pursuit of social acceptance remains a key determinant (41%) shaping women's appearance-related practices. In the post-economic crisis context,



middle-class women experienced a pronounced identity crisis, as they negotiated declining material conditions alongside persistent expectations of femininity.

- Although the economic crisis created conditions that could potentially challenge traditional gender norms, these norms were not substantially disrupted. Instead, women were compelled to simultaneously perform modern and traditional roles while navigating significant structural and economic constraints.
- Fashion adoption is similarly constrained by social values. Sri Lankan women do not always follow global fashion trends, even outside times of crisis, as they consider how trends align with family expectations, class identity, and professional roles. In this study, 62% of women adopt fashion trends to some extent, reflecting the influence of broader societal structures on appearance-related choices, while 11% report fully following global fashion trends.

Discussion

Female physical appearance is not an individual choice but is structured by cultural hegemony. Drawing on Gramscian theory, dominant groups secure consent by normalizing specific beauty ideals that function as "common sense" in everyday life (Zandra & Nadia, 2024). In this study, 53.1% of women identify fair/white skin as a beauty ideal, reflecting the continued influence of neo-colonial power relations. Within this hegemonic framework, consumers are not dominant actors; rather, markets operate as sites where consent is produced and reproduced. This dynamic aligns with Adorno's (1991) concept of the culture industry, which explains how capitalist systems standardize desires and regulate consumer behavior. Consequently, appearance-related practices constitute a subjective reality shaped by ideological narratives and market representations (Zandra & Nadia, 2024).

During the economic crisis, these hegemonic processes have significantly reshaped class identities. Appearance-maintenance practices remain closely tied to social status, yet economic hardship has

limited women's ability to afford customary goods and services. This impact is most pronounced among middle-class women, whose identities were reconfigured after the 1970s through state-led economic policies and neoliberal reforms. In response, markets offer alternative strategies such as branded replicas, decanted products, second-hand consumption, discounts, and promotional offers. Social media functions as a contemporary hegemonic apparatus, intensifying appearance norms, with 87.8% of women aged 18–35 reporting its influence. While this study does not fully capture Generation Z practices, it provides a foundation for future research.

The findings can be examined through Gramsci's concept of cultural hegemony, which helps explain why market strategies operate within existing social orders rather than transforming them. Although new consumption patterns are visible, they remain regulated by dominant social norms and institutionalized rules, such as the mandatory saree dress code for female teachers. Survey data show that only 11% of women follow global fashion trends, while the majority 62% prioritize social norms and values when making fashion choices. This indicates that women's appearance practices are framed within a form of social soft power, where dominant cultural expectations are reproduced through consent rather than coercion. From a Foucauldian perspective, this framing operates through disciplinary power that regulates women's bodies via moral education, everyday rules, and institutional practices (Bartky,1988). Within a patriarchal system, the male gaze further structures women's lives by positioning them in less powerful roles within shared social spaces, shaping how women perceive, monitor, and manage their appearance (Bhasin, 1994). These empirical patterns reflect how women negotiate fashion and physical appearance within socially prescribed limits during the economic crisis.

Existing literature has examined female physical appearance practices in Sri Lanka during and after economic crises mainly through biological, financial, and industrial perspectives, emphasizing consumption capacity, labor market participation, and sectoral changes. This study contributes a political science perspective by situating women's appearance practices within structures of power and institutional regulation. Although the findings are based on the Colombo District, the interaction between economic constraints and institutionalized appearance norms is likely to extend beyond this region. However, the geographical focus on Colombo remains a limitation, as regional variations may produce different outcomes and warrant further research.

Conclusion

This study examined female physical appearance maintenance during Sri Lanka's economic crisis. Findings support the hypothesis that women's continued engagement reflects the strategic influence of the neoliberal market. However, the market operates within socially constructed gender norms. Sri Lankan society frames women as symbols of power, shaping identities to sustain patriarchal values. Under neoliberalism, the market reinforces these norms, often through the ideology of the "liberal woman," using strategies that maintain existing social expectations.

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The Impact of Financial Literacy on Investment Decisions among the Households in Gampaha District

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Keywords: Financial Literacy, Households, Investment Decisions

Introduction

In today's rapidly evolving financial landscape, individuals face increasingly complex financial products, diverse investment opportunities, and fluctuating economic conditions. As a result, financial literacy has become an essential life skill, enabling individuals to manage income and expenses, assess investment opportunities, and minimize financial stress. Financial literacy includes knowledge of everyday financial activities such as saving, borrowing, credit use, and insurance (Singh & Raj Kumar, 2017; Roy & Jain, 2018). De Silva, Vieira, and Potrich (2016) also noted that financially literate individuals are better positioned to make sound investment choices, contributing positively to household welfare, business performance, and national development.

More recent studies reaffirm the challenge of showing that low financial literacy continues to contribute to suboptimal investment behavior and vulnerability to financial shocks (Hashim et al., 2022; Nguyen & Nguyen, 2023). Previous research studies widely agreed that the impact of financial literacy on investment decision-making is significant and cannot be overlooked. However, studies focusing on the Sri Lankan context especially at the household level remain limited. This study addresses this gap by examining the impact of financial literacy on investment decisions among households in the Gampaha District. The core problem addressed in this study is the influence of financial literacy on household investment decisions. Research studies indicate that households in many developing economies lack a sufficient understanding of basic financial concepts and often show limited engagement in investment activities (Awasi et al., 2016; OECD, 2020). More recent studies confirm that inadequate financial literacy continues to hinder households' ability to evaluate financial products, resulting in poor investment behavior and increased vulnerability to financial shocks (Klapper et al., 2022; Nguyen & Nguyen, 2023).

Conversely, individuals with higher financial literacy tend to make more strategic, diversified, and long-term investment decisions, contributing to better financial outcomes (Hashim et al., 2022).

Therefore, the primary aim of this research is to explore the extent to which financial literacy influences household investment decisions by identifying four objectives as follows.

1. To examine the impact of financial knowledge on household investment decisions.
2. To evaluate the effect of financial skills on investment decisions.
3. To assess how financial attitudes shape investment decisions.
4. To investigate the influence of financial behavior on investment decisions.

Literature review

Financial literacy has emerged as a critical determinant of individuals' ability to make informed financial decisions and manage personal resources effectively. For laypersons, financial literacy is commonly understood as a combination of financial knowledge, financial skills, financial attitudes, and financial behaviors that enable sound financial decision-making in daily life. Financial knowledge refers to an individual's understanding of basic financial concepts such as budgeting, interest rates, inflation, savings, borrowing, and investment instruments (Lusardi & Mitchell, 2014). Financial skills reflect the practical ability to apply this knowledge, such as preparing household budgets, comparing financial products, and planning for long-term financial goals (Huston, 2010). Financial attitude represents psychological tendencies and beliefs toward money management, risk-taking, savings, and future planning, which influence motivation to engage in responsible financial practices (Atkinson & Messy, 2012). Financial behavior, in turn, refers to observable actions such as saving regularly, controlling expenditure, timely debt repayment, and making informed investment decisions (Xiao & O'Neill, 2016). Collectively, these components shape overall financial literacy and determine personal financial management outcomes.

A growing body of literature highlights that financial literacy significantly affects investment decisions and long-term financial well-being. Individuals with higher financial knowledge and positive financial attitudes are more likely to participate in formal financial markets, diversify investments, and engage in retirement planning (Van Rooij, Lusardi & Alessie, 2011). Conversely, limited financial literacy is associated with poor budgeting, excessive borrowing, and vulnerability to financial shocks (OECD, 2019). These findings suggest that understanding financial literacy at the household level is essential, particularly in developing economies where formal financial inclusion is still evolving.

Demographic characteristics have been widely recognized as influential factors shaping financial literacy and financial behavior. Prior studies indicate that gender, education level, income level, employment status, and household role significantly explain variations in financial knowledge and decision-making (Agarwal et al., 2009; Lusardi & Mitchell, 2014). For instance, higher education levels are consistently associated with stronger financial knowledge and better investment choices. Income level influences access to financial products and the capacity to save or invest. Gender differences in financial literacy have also been observed, with males often reporting higher financial knowledge, although this gap varies across cultural contexts. Moreover, identifying the head of the household as the primary financial decision-maker is particularly relevant in household-based financial behavior studies, as this individual typically determines savings, borrowing, and investment strategies. Therefore, incorporating demographic profiling in empirical analysis provides valuable insights into how financial literacy translates into actual financial decisions.

In the Sri Lankan context, research on household financial literacy remains limited, and existing studies suggest considerable variation across regions and socio-economic groups. Understanding how demographic factors interact with financial knowledge, attitudes, and behaviors is especially important in suburban and semi-urban districts where access to financial services and financial education may differ from major urban centers.

However, methodological considerations affect the generalizability of findings in household financial literacy research. Many empirical studies rely on convenience sampling due to data access limitations, which may restrict the representativeness of the sample. For instance, findings drawn from a single district such as Gampaha may not be fully generalizable to the broader Sri Lankan population, given regional differences in income distribution, education, and financial service availability. Previous methodological literature emphasizes that while convenience samples can provide valuable exploratory insights, caution is required when extending conclusions beyond the study area (Etikan, Musa & Alkassim, 2016). Acknowledging such limitations strengthens the credibility of empirical research and highlights opportunities for future studies using nationally representative samples.

Overall, the literature suggests that defining financial literacy through knowledge, skills, attitudes, and behaviors provides a comprehensive framework for assessing household financial management. Additionally, demographic characteristics play a vital role in shaping financial literacy and investment behavior, underscoring the importance of integrating these variables into empirical models. At the same time, careful consideration of sampling design and generalizability is essential to ensure robust and policy-relevant findings.

Methodology

The positivist research paradigm and deductive research approach was adopted to objectively examine the factors influencing household investment decisions. The study developed a set of hypotheses and quantitative methods for statistical verification. Primary data were collected using a structured questionnaire which consisted with three sections. The target population comprised households in the Gampaha District, and a sample of 384 households was determined using the Morgan sampling table, and convenience sampling was employed to select respondents. The reason for selecting Gampaha District was due to its economic significance and the increasing demand for informed financial decision-making within Sri Lanka's evolving economic environment. Then the collected data were analyzed using SPSS Version 26. Descriptive statistics and Regression analysis were conducted to evaluate the relationships among variables and test the following hypotheses.

H_1: There is a significant impact of financial knowledge on investment decisions. H_2: There is a significant impact of financial skills on investment decisions.

H_3: There is a significant impact of financial attitude on investment decisions.

H_4: There is a significant impact of financial behavior on investment decisions.

Results

Descriptive statistics

Variable	Minimum	Maximum	Mean	Std. Deviation
Financial Knowledge	1	5	3.9100	0.62078
Financial Skills	1	5	3.8647	0.62303
Financial Attitudes	1	5	4.0427	0.65621
Financial Behavior	1	5	3.9437	0.66809
Investment decisions	1	5	3.8536	0.66773

The above table shows the descriptive analysis of the data set which indicates that respondents exhibits a moderate to relatively high level of financial literacy across all dimensions. Financial

attitudes recorded the highest mean value which interprets that households generally possesses a positive perception towards financial management. Overall, the results suggest that respondent's sharp adequate financial literacy which may influence their investment decision making practices.

Regression analysis

Regression results revealed that financial knowledge, skills, and behavior significantly affect investment decisions, whereas financial attitude does not show a significant impact.

Discussion

The findings of this study indicate that financial knowledge, skills, and behavior have a significant influence on investment decisions. Specifically, financial knowledge demonstrates a strong impact on investment decisions, supporting the acceptance of hypothesis H_1. This result aligns with prior research by Rooji et al. (2011), Mandell (2008), and Lusardi and Mitchell (2007), who similarly found that financial literacy significantly affects investment decisions. Additional studies by Balagobei and Prashanthan (2021), Walkumbura (2021), and Alaaraj and Bakri (2020) further confirmed the positive effect of financial knowledge on investment decisions. Financial skills also significantly influence investment decisions, leading to the acceptance of hypothesis H_2. This finding is consistent with the work of Kumari (2020), Walkumbura (2021), and Singh and Raj Kumar (2017), who reported a significant relationship between financial skills and investment decision-making. Similarly, financial behavior significantly affects investment decisions, resulting in the acceptance of hypothesis H_4. This is supported by studies conducted by Alaaraj and Bakri (2020), Balagobei and Prashanthan (2021), and Kristanto et al. (2020). In contrast, financial attitude does not appear to have a significant effect on investment decisions. Consequently, hypothesis H_3 is rejected. This outcome is consistent with the findings of Walkumbura (2021) and Musundi (2014), who also observed no significant influence of financial attitudes on investment decisions.

Conclusion

The results of this research indicated that financial literacy significantly influences investment choices, with financial knowledge, skills, and behavior showing substantial effects. In contrast,

financial attitudes did not significantly affect household investment decisions in the Gampaha district. These findings have important implications for policymakers, investors, financial professionals, and institutions. Research consistently demonstrates that individuals with higher financial literacy tend to make fewer investment mistakes and achieve better returns. This study highlights the need to enhance financial literacy and decision-making capabilities within households. Financial advisors can use these insights to provide more tailored guidance, while financial institutions can identify knowledge gaps and design programs to improve financial literacy, thereby supporting better investment decisions. Local initiatives can also leverage these findings to promote economic security and well-being through targeted financial literacy efforts. Moreover, educators can refine curricula to equip students with the skills necessary to navigate today's complex financial environment effectively. The study faced several limitations as relying on participants' self-reported perceptions raised concerns about accuracy, as respondents might provide biased or incorrect information, potentially affecting the findings. Data collection also took considerable time, as residents had individual schedules and commitments. Although the study provides valuable insights, the sample size was limited, covering only a portion of the 384 households in the Gampaha district. Future research should include a larger and more representative sample from different areas within the district, as financial behaviors and investment preferences may vary across regions. It is also important to examine the influence of cultural factors on financial behavior. Furthermore, given that financial attitudes were not significantly associated with investment decisions, further research is needed to identify other factors that may affect household investment choices.

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Neuroleadership for Human Capital Development: A Mediating Role of Happiness among Casual Workers in Sri Lanka

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Introduction

Human Capital Development (HCD), which enhances employees' skills, knowledge, competencies, and adaptability, is widely recognized as a key driver of organizational performance, sustainability, and competitive advantage in today's knowledge-based economy. Leadership plays a crucial role in shaping HCD, particularly in contexts where employees face job insecurity and limited development opportunities. In this context, Neuroleadership an emerging approach that applies neuroscience to improve decision-making, emotional regulation, collaboration, and change facilitation offers a contemporary framework for understanding how leaders influence employees' cognitive and emotional processes that support learning, engagement, and performance.

Alongside leadership, employee happiness, reflected in well-being, life satisfaction, and positive emotional states, has gained increasing attention as a psychological factor that enhances motivation and leadership effectiveness. These factors are especially relevant for casual workers, who often experience unstable employment, minimal training, and limited career development, particularly in labor-intensive industries such as the cosmetic sector. In Sri Lanka, especially in the cosmetic sector of the Anuradhapura District, casual workers form a significant portion of the workforce, yet their HCD remains constrained due to inadequate leadership support and insufficient emphasis on employee well-being.

Although global institutions such as the World Bank and the Organization for Economic Co-operation and Development emphasize investment in human capital and effective leadership for economic resilience and productivity, empirical evidence on the impact of Neuroleadership on

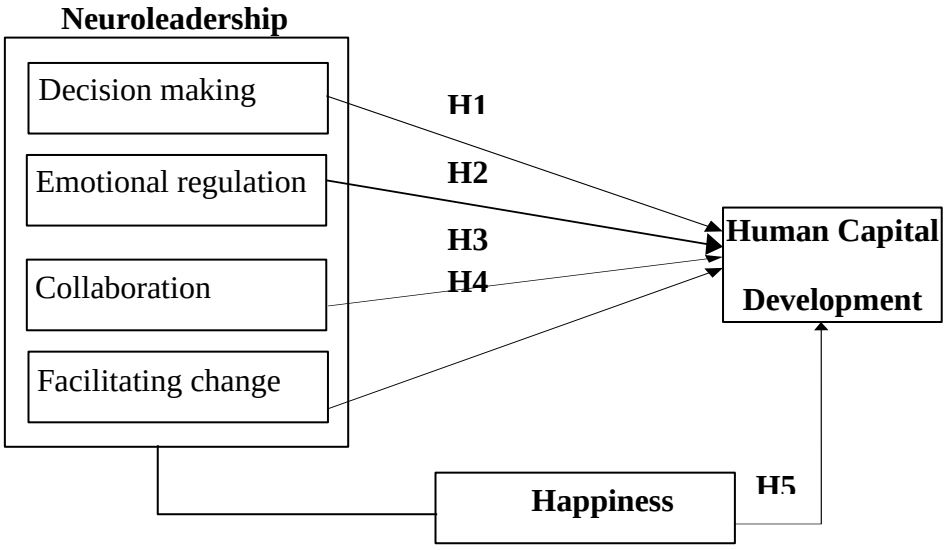
HCD in developing-country contexts is limited. Moreover, the mediating role of happiness in the Neuroleadership–HCD relationship remains largely unexplored, particularly among casual workers. Addressing this gap, the present study examines the impact of Neuroleadership on HCD, with happiness as a mediating variable, among casual workers in the cosmetic sector of the Anuradhapura District, Sri Lanka.

Methodology

This study is quantitative and explanatory and followed the positivistic research philosophy. Study population is 150 casual workers in cosmetic sector in Anuradhapura District and the sample is 108, selected using the cluster sampling method. Primary data is collected using structured questionnaire, and analyzed them using SPSS software. Pearson correlation, multiple regression analyses, and Baron and Kenny mediation test are used test the research hypotheses.

Decision- making was measured using the original scale developed by (French DJ, West RJ, Elander J, 1993) (Ex: *I enjoy making decisions*). Emotional Regulation is measured using the original scale, developed by Preece and Mehta (2023) (Ex: *When I want to feel more positive emotion, I change the way I'm thinking about the situation*). Collaboration was measured using the original scale developed by (Kenaszchuk et al., 2010).(Ex: *I have a good understanding with others about our respective responsibilities*). Facilitating change was measured using the original scale (Ex: I feel that I completely understand the reasons that brought about the changes) (Gagné et al., 2000). Happiness was measured using the original scale developed by Lyubomirsky and Lepper (1999) (Ex: I am intensely interested in other people). HCD is measured using the original scale of Vidotto et al. (2017) (Ex: I constantly do my best).

Conceptual Framework and Hypotheses



H1: Decision-making influences human capital development.

H2: Emotional regulation influences human capital development.

H3: Collaboration influences human capital development.

H4: Facilitating change influences human capital development.

H5: Happiness mediates the relationship between Neuroleadership and human capital development.

Results

Reliability statistics

According to the reliability analysis, the Cronbach's Alpha coefficients of four dimensions of Neuroleadership: Decision making (5 items, $\alpha = 0.761$), Emotional regulation (5 items, $\alpha = 0.805$), Collaboration (5 items, $\alpha = 0.798$), and Facilitating change (5 items, $\alpha = 0.867$), and Human Capital Development comprises 5 items and has a Cronbach's Alpha of 0.847, indicating high levels of internal consistency. Similarly, the mediator variable, Happiness, also consisting of 5 items, demonstrates a Cronbach's Alpha of 0.845.

Pearson Correlation Analysis

Table 1: Pearson Correlation Analysis

Variable Pair	Pearson Correlation Coefficient (r)	Sig. (2-tailed)
Decision Making ↔ HCD	.674**	.000
Emotional Regulation ↔ HCD	.741**	.000
Collaboration ↔ HCD	.759**	.000
Facilitating Change ↔ HCD	.806**	.000

As per the Table 1, the Pearson correlation results show statistically significant positive associations with HCD each with p = .000 (< .01), indicating the relationships are highly unlikely to be due to chance. Specifically, decision making is moderately positively related to HCD (r = .674), emotional regulation also shows a moderate positive relationship (r = .741), and collaboration displays a somewhat stronger moderate-to-strong positive relationship (r = .759). Facilitating change exhibits a strong positive relationship with HCD (r = .806).

Multiple Regression Analysis

Model summary of Multiple Regression Analysis

Table 2: Model summary of Multiple Regression Analysis. Source: Survey Data (2024)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.840[a]	.705	.694	.410

According to the Table 2, R square value is .705 (70%). It means 70% of the variation of the HCD is explained by the neuroleadership.

Coefficients of Multiple Regression Analysis

Table 3: Coefficients of Multiple Regression Analysis. Survey Data (2024)

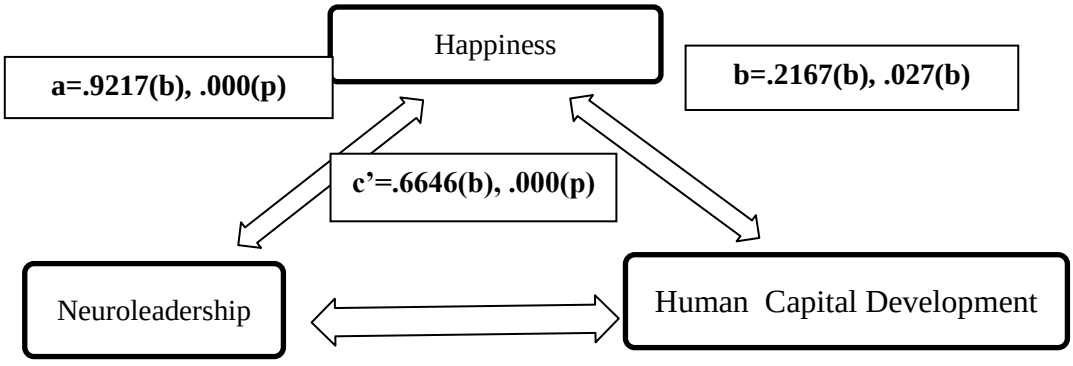
Coefficients[a]						
	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.008	.288		3.499	.001
	Decision Making	-.047	.101	-.045	-.467	.642
	Emotional Regulation	.224	.097	.233	2.322	.022
	Collaboration	.239	.086	.265	2.787	.006
	Facilitating Change	.419	.094	.450	4.454	.000

According to the Table 3, the multiple regression analysis, one-unit change of decision making creates a negative effect (B=-0.047) on HCD, with an error of 0.101 and p = 0.642 (> 0.05). Thus, H2 is rejected. The one-unit change of emotional regulation creates an increase of HCD with a positive effect (B=+0.224, error = 0.097, and p<0.05). Hence, H2 is accepted. Further, when one-unit change of collaboration shows a positive effect (B=+0.239, error = 0.086, and p< 0.05). Thus, H3 is accepted. When facilitating change is changed by one unit, it has the strongest positive effect (B=+0.419, error = 0.094, and p< 0.05). Hence, H4 is accepted.

Mediation Analysis

Table 4: Mediation Analysis

Model Summary							
	R	R-Sq.	MSE	F	df1	df2	p
NL_H_HCD	.8321	.6924	.1724	118.1843	2.0000	105.0000	.0000
Model							
	coeff	se	t	p	LLCI	ULCI	
constant	.7767	.2880	2.6969	.0082	.2057	1.3478	
N_IV	.6646	.1039	6.3984	.0000	.4587	.8706	
H	.2167	.0937	2.3132	.0227	.0310	.4025	



According to Table 4, the model shows an R^2 of 0.6924, meaning 69% of the variation in human capital development is explained by neuroleadership and happiness, while 31% remains unexplained. The coefficient for neuroleadership is 0.6646, indicating a positive and significant effect ($p = 0.000 < 0.05$). The coefficient for happiness is 0.2167, also positive and significant ($p = 0.000 < 0.05$). In both cases, LLCI and ULCI are positive, confirming significance. Following

Baron and Kenny, the path c′ (NL_HCD) and path b (H_HCD) are statistically validated. Hence, H5 is accepted.

Discussion

The findings provide strong empirical support for the role of Neuroleadership in enhancing HCD among casual workers in Sri Lanka's cosmetic sector, with differentiated effects across leadership dimensions. The regression results indicate that H1 was rejected (B = −0.047, Sig = 0.642), confirming that although Decision Making demonstrated a moderate bivariate association, it did not exert a statistically significant influence on HCD when other variables were controlled. This suggests a limited developmental impact of decision-making autonomy in highly structured, low-autonomy work contexts, consistent with Sousa et al. (2019). In contrast, H2, H3, and H4 were accepted, as Emotional Regulation (B = 0.224, Sig = 0.022), Collaboration (B = 0.239, Sig = 0.006), and Facilitating Change (B = 0.419, Sig = 0.000) showed positive and statistically significant effects on HCD. These results emphasize the importance of emotional competence, cooperative work environments, and adaptive capacity in enhancing employee development. Emotional Regulation contributes to resilience and learning (Medury, 2015), while Collaboration facilitates knowledge sharing and capability development (Mishra, 2023). Facilitating Change emerged as the strongest predictor of HCD, highlighting the critical role of communication, innovation, and adaptability in skills acquisition (Hejase, 2023). H5 was accepted based on its significant effect (Sig = 0.022), indicating that Happiness plays a meaningful mediating role. The mediation analysis reveals that Happiness partially strengthens the Neuroleadership–HCD relationship, supporting prior evidence that positive emotional states enhance motivation, engagement, and learning among employees (Lee & Goh, 2023).

Conclusion

The study examined the influence of Neuroleadership on HCD among casual workers in the cosmetic sector in Anuradhapura, incorporating Happiness as a mediating variable. All hypotheses were supported except for Decision Making, which showed no significant effect. The results confirm that Neuroleadership enhances HCD and that Happiness significantly mediates this relationship. Practically, organizations can strengthen decision-making through stress management and communication training, improve Emotional Regulation via workshops and

recognition systems, and enhance Collaboration through team-building and structured communication. Change Facilitation can be advanced through systematic change management and continuous training. Promoting employee Happiness through development opportunities and a positive work culture further amplifies leadership effectiveness. Future research should examine cultural variations in the Neuroleadership–human capital nexus, extend analysis across diverse industries such as technology, healthcare, and education, and explore how emerging technologies, including automation and artificial intelligence, shape these relationships, particularly for temporary workers.

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