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Introducing New Book

Ecology and Empire in Medieval India

Mohd Kamran Khan, *Forest Ecology and Agriculture in Mughal North India*, Manohar, New Delhi, 2026, 241 pages, Rs. 1495/-

Saurav Kumar Rai

It was under the aegis of the Annales School that environmental factors first gained popularity as key determinants influencing the course of human civilization. In this regard, the landmark article of Fernand Braudel titled 'The Role of Environment' (1939) set the groundwork for viewing environmental conditions as fundamental forces shaping human history. Braudel argued that geography and environmental conditions form the most enduring framework of human history. Mountains, rivers, climate, soil, and seas impose long-term constraints and possibilities within which human societies operate. In this context, he emphasized long-term historical structures (*longue durée*) over short-term political events. Environmental factors, because of their relative permanence, shape civilizations over centuries, unlike wars or rulers whose impact may be temporary. However, instead of crude environmental determinism, Braudel proposed that the environment sets limits and offers possibilities. Human agency operates within these structural constraints but cannot entirely escape them.

Following the arguments proposed by the Annales School coupled with growing environmental concerns, a new genre of environmental history gradually emerged in second half of the twentieth century. However, in Indian context, the primary focus of historians remained on environmental destruction unleashed during the colonial rule. While the volume of environmental degradation under the colonial rule was immense, one has to keep in mind that pre-colonial Indian societies were not unresponsive to the limits set by environmental concerns. Rather, in the absence of modern technologies, environmental factors played far greater role in shaping the course of human settlements in ancient and medieval India. There are plenty of works which have now started looking at environmental determinism in pre-colonial India such as while contemplating upon the fall of Indus valley civilization, emergence of *mahajanpadas*, so on and so forth. Lately, historians working on medieval India have also started looking at interaction between environment and society. Some notable works in this regard are that of Shireen Moosvi, Sumit Guha, Meena Bhargava, and Mayank Kumar, among others. The present book by Mohd. Kamran Khan complements and enriches this small but significant coterie of works on medieval environmental history, further expanding our understanding of how ecological factors shaped socio-economic and cultural processes during the medieval period.

The entire book is divided into six chapters including 'Introduction' and 'Conclusion'. The Chapter 1, i.e. 'Introduction', basically provides the cursory review of the extant works on medieval environmental history of India (pp. 18-28). Chapter 2 explores the ways in which rivers and forests were harnessed in medieval north India to extend agricultural land. The great-cultivated expanse of India's plains, valleys, and hill-slopes, argues Khan, has been created in a stubborn struggle against nature, which the Indian peasant has carried on for thousands of years (p. 68). Here, the author highlights the contrasting efforts undertaken in regions marked by stark environmental differences, demonstrating how diverse ecological settings produced varied patterns of adaptation, resource management, and socio-economic organization. The regions chosen by the author for this purpose are submontane region of Punjab, arid tracts of Rajasthan, semi-arid region of Agra, doab of Allahabad, and tropical humid region of Bihar.

In Chapter 3, the author delineates the royal efforts by the Mughals to integrate the flora and fauna of respective regions into the socio-cultural life of the people. Setting up of numerous *baghs* (or gardens) and creation of suitable hunting grounds for *shikar* (game hunt) was part and parcel of this royal effort. Here the author convincingly shows that how the natural environment of the forest cover areas was appropriated and transformed through deforestation and the addition of features such as irrigation not just to enhance agricultural production, but also to form a conducive environment for hunting. In fact, the Mughals viewed the hunting ground as a transitional zone between the cultivated land and uncultivated forest, as it established continuity between hunting practices and agriculture (p. 112). Here, citing Irfan Habib, the author argues that the real purpose of hunting wild animals by the Mughals seems to have been to consolidate their authority over vast stretches of territories or intimidate restive provinces, lead military campaigns, inspect agricultural lands and assess the conditions of their subjects without intermediaries (p. 125).

Chapter 4 offers the microstudy of Awadh region in medieval times so far as environmental history is concerned. Whereas Chapter 5 explores the ecological changes and its impact especially on agriculture in medieval north India. Here the author interestingly connects the climate change in seventeenth century India with the relatively cooler conditions (or, the onset of 'little ice age') across the globe. Various floods, epidemics, famines, and earthquakes that struck the Mughal Empire during this period have been interpreted by the author as significant 'markers' of climate change, indicating broader environmental fluctuations and their impact on society and governance. The author significantly lists a whole range of such calamities in seventeenth century India (pp. 185-194). Simultaneously, he also delves into measures taken by the rulers to mitigate the destruction caused by such natural calamities. In the end, in 'Conclusion', Khan contemplates upon the necessity of exploring India's environmental history during the medieval and early modern periods.

Thus, by juxtaposing environmental history with agricultural studies, this book offers a nuanced understanding of how nature, the state, and ecology interacted in medieval north India. In doing so, it makes a valuable contribution to the growing scholarship on north India's environmental past.

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Child Health and Nutritional Status in Kerala: A Micro-Level Study from Chengalayi Grama Panchayat, Kannur

Alaka M.T· &
Sandhya P.

Kerala is widely recognized for its strong public health infrastructure and positive child health outcomes. However, emerging disparities persist, particularly in rural areas. This study assesses the health and nutritional status of children under five in Chengalayi Grama Panchayath in Kannur district. Using a mixed-methods approach, data were collected from 109 households through structured surveys and caregiver interviews, supplemented by secondary sources such as health records and immunization registers. Anthropometric measurements, including height, weight, and BMI, were analyzed to determine levels of stunting, wasting, and underweight in children. Results revealed both under nutrition and emerging trends of over nutrition, reflecting the dual burden of malnutrition. Socio-economic factors, feeding practices, and access to healthcare were found to significantly influence child health outcomes. The study underlines the need for targeted, community-based interventions and inclusive public health strategies to address nutritional disparities.

Keywords : Nutritional status, child health, anthropometry, Kerala.

1. Introduction

Kerala has long been recognized as a model state in health and human development, and its child nutrition outcomes continue to reflect this strength. According to the National Family Health Survey (NFHS-5, 2019-21), the state reports 23% stunting, 16% wasting, and under 20% underweight prevalence among children under five - figures notably lower than the national averages of 35.5%, 19.3%, and 32.1%, respectively (IIPS & ICF, 2021; SDMIMD, 2023). These achievements highlight Kerala's robust public health infrastructure, high female literacy, and community-based nutrition initiatives that have collectively contributed to improved child well-being. However, despite this progress, anemia remains a significant public health issue, affecting nearly 39% of children aged 6-59 months, according to the state fact sheet (Department of Health Services, Government of Kerala, 2022).

Kerala's nutritional landscape, though commendable in many respects, continues to exhibit persistent inequalities across regions and social groups. Under nutrition remains prevalent among children from marginalized, tribal, and rural communities, where access to balanced diets, quality healthcare, and essential nutrition services is still uneven (NHSRC, 2021; NITI Aayog, 2023). To address these emerging concerns, Kerala must adopt a comprehensive and equity-oriented approach that reinforces preventive healthcare, enhances nutrition and lifestyle education, and integrates community-based support systems.

2. Objectives of the Study

1. To assess the health and nutritional status of children under five in Kerala, with a focus on stunting, wasting, and underweight indicators.
2. To examine how socio-economic factors affect the health and nutrition of children under five in the study area.

3. Methodology

3.1 Data Collection

This study employed a mixed-methods research design to comprehensively assess the health and nutritional status of children under five years of age in Chengalayi Grama Panchayath, situated in the Kannur district of Kerala. The primary data were collected through structured household surveys and semi-structured interviews with mothers or primary caregivers of children under five. Using a random sampling technique, a representative sample of 109 households was selected to ensure diverse socio-economic and demographic representation. The survey instrument gathered detailed information on household characteristics, income levels, sanitation and hygiene practices, infant and young child feeding (IYCF) patterns, and access to healthcare services -all key determinants of child health outcomes (IIPS & ICF, 2021; WHO, 2006).

In addition to the primary data, secondary data sources were utilized to provide contextual and corroborative evidence. These included local health records from Chengalayi Primary Health Centre (PHC), immunization registers maintained by Accredited Social Health Activists (ASHAs), and population data from the Census of India (2011). Supplementary information was also drawn from reports published by the Government of Kerala's Department of Health and Family Welfare (2022) and District Health Action Plan (DHAP), Kannur (2023). These sources offered valuable insights into demographic trends, healthcare utilization patterns, and immunization coverage in the Panchayath, strengthening the reliability and validity of the study findings. The integration of both quantitative and qualitative data ensured a holistic and evidence-based understanding of the health conditions and challenges faced by children under five in Chengalayi.

3.2 Anthropometric Measurement

To objectively evaluate the nutritional status of children under five, anthropometric measurements such as age, height, and weight were collected following standard protocols recommended by the World Health Organization (WHO, 2006). The recorded data were compared with WHO Child Growth Standards to determine the prevalence of stunting (low height-for-age), wasting (low weight-for-height), and underweight (low weight-for-age). Furthermore, the Body Mass Index (BMI)-for-age was computed for each child and classified into nutritional status categories - normal, moderate, or severe - based on WHO-defined percentile cut-offs (WHO, 2007). This methodological approach allowed for the precise identification of malnutrition patterns and provided insights into the nutritional disparities requiring targeted interventions.

The quantitative data were analysed using descriptive statistical techniques, including frequency distributions and percentage analysis, to summarize key demographic characteristics and health indicators (IIPS & ICF, 2021). Meanwhile, qualitative data obtained to explore socio-economic, cultural, and behavioural factors influencing child health and nutrition. By integrating quantitative and qualitative findings, the study ensured a comprehensive, evidence-based assessment of child health outcomes, offering valuable implications for policy formulation and localized public health interventions aimed at improving under-five nutritional status in the study area.

4. Discussion and Results

4.1 Nutritional Status of Children in Kerala

Nutritional status plays a foundational role in determining child health, shaping not only immediate physical well-being but also influencing cognitive development, educational attainment, and future economic productivity. It is also closely linked to disease resistance and overall life expectancy. In this context, Kerala, a state lauded for its high human development indicators, relatively equitable health systems, and high literacy - especially among women - has traditionally been viewed as a model for child health in India. However, recent data suggest emerging challenges that contradict this longstanding narrative of progress.

Table 1: Malnutrition of Children

Indicator	NFHS-4 (2015-16) (%)	NFHS-4 (2019-20) (%)
Stunted	19.7	23.4
Wasted	15.7	15.8
Underweight	16.1	19.7
Overweight	3.4	4.0

Source: National Family Health Survey (2015-16 & 2019-20)

According to the National Family Health Surveys (NFHS-4, 2015-16 and NFHS-5, 2019-21), Kerala has witnessed an unexpected increase in child malnutrition indicators. The proportion of stunted children rose from 19.7% to 23.4%, and the number of underweight children increased from 16.1% to 19.7% over this period. While wasting - a marker of acute under nutrition - remained nearly unchanged (15.7% to 15.8%), these figures point to a growing prevalence of both chronic and acute nutritional deficiencies among young children. The rise in stunting is especially concerning, as it reflects long-term inadequacies in diet and recurrent illness during the critical early years of growth and development.

At the same time, Kerala is beginning to experience the dual burden of malnutrition, with a slight increase in overweight children - from 3.4% to 4.0% - indicating a parallel trend of over nutrition. This reflects the shifting dietary habits, reduced physical activity, and lifestyle transitions often associated with urbanization and rising incomes, even among lower and middle-income families.

4.2 District Wise Analysis of Stunting

The district-wise analysis of stunting in Kerala, as presented in Table 2, reveals significant disparities in the nutritional status of children across the state. Wayanad emerges as the district with the highest prevalence of stunting, recording 31.3% in NFHS-5, which is substantially higher than the state average. It is followed closely by Palakkad (29.5%) and Malappuram (29.4%), both of which also show sharp increases compared to their NFHS-4 figures. Notably, Palakkad experienced a dramatic rise in stunting from 20.2% to 29.5%, indicating a growing public health concern. These figures suggest that children in these districts are more likely to suffer from chronic under nutrition and growth failure, possibly due to a combination of poverty, food insecurity, poor maternal nutrition, and inadequate access to health services.

Table 2: District wise analysis of Stunting in Kerala

District	NFHS-4 (2015-16) (%)	NFHS-5 (2019-20) (%)	Rank
Thiruvananthapuram	19.50	19.50	12
Kollam	14.40	15.50	14
Pathanamthitta	13.30	22.70	7
Alappuzha	14.50	20.10	1
Idukki	15.10	24.30	5
Kottayam	22.05	23.40	5
Ernakulam	12.40	22.00	8
Thrissur	20.80	22.00	8
Palakkad	20.20	29.50	2
Malappuram	26.30	29.40	3

Kozhikode	18.00	21.30	10
Wayanad	27.70	31.30	1
Kannur	25.30	19.40	13
Kasaragod	18.70	25.30	4

Source: National Family Health Survey (2015-16 & 2019-20)

On the other end of the spectrum, Kollam (15.5%), Kannur (19.4%), and Thiruvananthapuram (19.5%) reported the lowest rates of stunting in NFHS-5. These districts have either maintained or improved their performance over time, indicating relatively better outcomes in child nutrition and early childhood care. The stark contrast between districts like Wayanad and Kollam underscores regional disparities that may stem from differences in socio-economic conditions, tribal population concentrations, healthcare accessibility, and the effectiveness of government nutrition programs. The findings highlight the urgent need for district-specific strategies to address stunting, with focused interventions in high-burden areas to ensure equitable child health outcomes across Kerala.

4.3 District Wise Analysis of Underweight

The district-wise analysis of underweight children in Kerala, based on NFHS-4 and NFHS-5 data, reveals a concerning increasing trend in most districts, indicating persistent challenges in child nutrition. Palakkad records the highest prevalence of underweight children at 27.7% in NFHS-5, up significantly from 19.1% in NFHS-4. This sharp rise places Palakkad at the top among all districts, highlighting a serious nutritional crisis. Idukki (23.6%), Wayanad (22.5%), Malappuram (21.4%), and Kasaragod (21.4%) also report high rates, signaling widespread undernutrition in these regions. The causes may include poverty, poor maternal health, low dietary diversity, and limited access to child nutrition services, especially in rural or tribal areas. Notably, Ernakulam and Alappuzha, which are relatively urbanized districts, also show marked increases in underweight prevalence, indicating that even areas with better infrastructure are not immune to nutritional deficiencies.

Table 3: District Wise Analysis of Underweight

District	NFHS-4 (2015-16) (%)	NFHS-5 (2019-20) (%)	Rank
Thiruvananthapuram	21.60	15.20	13
Kollam	14.20	17.00	12
Pathanamthitta	11.40	11.20	14
Alappuzha	17.20	20.40	6
Idukki	14.80	23.60	2
Kottayam	11.30	17.30	10
Ernakulam	12.00	19.40	7
Thrissur	14.00	17.30	10
Palakkad	19.10	27.70	1
Malappuram	17.35	21.40	4
Kozhikode	18.50	18.90	8
Wayanad	27.20	22.50	3
Kannur	10.50	17.90	9
Kasaragod	13.90	21.40	4

Source: National Family Health Survey (2015-16 & 2019-20)

Conversely, a few districts show relatively lower and stable levels of underweight prevalence. Pathanamthitta (11.2%) and Thiruvananthapuram (15.2%) report the lowest figures, both below the state average of 19.7%, suggesting more effective nutritional interventions and possibly better socio-economic conditions. However, the broader pattern across Kerala reveals that most districts have experienced an upward trend in underweight prevalence from NFHS-4 to NFHS-5. This trend challenges Kerala's reputation for strong public health outcomes and highlights the need for urgent, localized interventions.

4.4 District Wise Analysis of Overweight

The district-wise analysis of overweight prevalence among children in Kerala, based on NFHS-4 and NFHS-5 data, highlights the emerging challenge of childhood overweight and obesity, though the overall percentages remain lower compared to undernutrition indicators. Kollam shows the most notable increase, with the overweight rate rising sharply from 3.8% in NFHS-4 to 9.4% in NFHS-5, making it the district with the highest prevalence of childhood overweight. Wayanad (6.5%) and Thrissur (6.1%) follow, indicating that the problem is no longer limited to urban or high-income settings. Interestingly, Wayanad, a district traditionally associated with undernutrition, also reports a significant rise in overweight children, suggesting a dual burden of malnutrition even in rural or tribal areas.

Table 4: District Wise Analysis of Overweight

District	NFHS-4 (2015-16) (%)	NFHS-5 (2019-20) (%)	Rank
Thiruvananthapuram	3.50	2.80	11
Kollam	3.80	9.40	1
Pathanamthitta	3.30	5.00	5
Alappuzha	4.00	4.50	6
Idukki	4.70	2.30	12
Kottayam	3.70	3.20	9
Ernakulam	1.30	5.40	4
Thrissur	3.50	6.10	3
Palakkad	0.80	1.10	14
Malappuram	3.20	3.30	8
Kozhikode	7.40	4.40	7
Wayanad	1.60	6.50	2
Kannur	6.70	3.80	10
Kasaragod	0.40	1.60	13

Source: National Family Health Survey (2015-16 & 2019-20)

Several districts, including Idukki, Kannur, Kozhikode, Kottayam, and Thiruvananthapuram, show a decline or marginal reduction in overweight prevalence, which could be the result of improved awareness or changes in dietary and activity patterns. Kasaragod, which had the lowest rate in NFHS-4 (0.4%), shows a modest increase to 1.6%, pointing to a gradual upward trend statewide. Overall, while overweight among children is still relatively low in Kerala compared to undernutrition, the rising trend in certain districts signals a public health concern. This shift may be attributed to irregular eating habits, reduced physical activity, and increased consumption of processed foods, particularly among urban and middle-income families.

4.5 Nutritional Status of Study Area

The study is conducted within Chengalayi Panchayath in Kannur district and focuses on evaluating the socio-economic conditions and assessing the health status of children among selected households. It emphasizes key health indicators such as the child's age, nutritional status based on Body Mass Index (BMI) classification, weight-for-age, height-for-age, and weight-for-height. These indicators play a crucial role in determining the nutritional well-being and overall health of children.

Table 5: Nutritional Status of Children based on BMI Classification

BMI	Range	No of Respondents	Percent (%)
Underweight	< 18.5	15	13.76
Normal weight	18.5 to 24.9	10	9.17
Overweight or pre-obesity	25.0 to 29.9	24	22.01
Higher obesity	> 30	33	30.27
Total		109	100.00

Source: Primary Data

The data presented in Table 5 reveals a concerning trend in the nutritional status of children within the sampled population of Chengalayi Panchayath. A significant portion of the respondents, 33 out of 109 children (30.27%), fall under the higher obesity category (BMI > 30), indicating a high prevalence of obesity among children in the study area. Additionally, 24 children (22.01%) are classified as overweight or pre-obese. Combined, these figures show that over half (52.28%) of the children are either overweight or obese, suggesting a shift towards unhealthy weight gain patterns. This may be reflective of lifestyle changes, dietary habits, reduced physical activity, or socio-economic factors influencing food choices and health awareness.

Conversely, only 10 children (9.17%) fall within the normal BMI range, which is alarmingly low, and 15 children (13.76%) are classified as underweight. These figures highlight a dual burden of malnutrition, where both undernutrition and overnutrition coexist in the same population. The small proportion of children in the normal BMI range points to a lack of balanced nutritional status among many children. These findings underscore the need for targeted health interventions, nutritional education, and awareness programmes to address both extremes of the malnutrition spectrum in the region. Addressing the root socio-economic determinants influencing dietary and health behaviours will be crucial for improving child health outcomes in Chengalayi Panchayath.

4.6. Weight-for-Age

Table 6 : Weight-for-Age

Age of child (months)	Normal	Moderate	Severe	Total
0-6 months	1 (50%)	1 (50%)	0 (0%)	2
1-2	4 (80%)	1 (20%)	1 (20%)	5
2-3	0 (0%)	3 (75%)	1 (25%)	4
3-4	4 (100%)	0 (0%)	0 (0%)	4
4-5	3 (60%)	2 (40%)	0 (0%)	5
Total	12 (66.7%)	7 (38.9%)	2 (11.1%)	18 (100%)

Source: Primary Data

Table 6 highlights the weight-for-age nutritional status of children across different age groups, shedding light on patterns of undernutrition in the study population. Of the 18 children surveyed, 66.7% (12 children) had a normal weight-for-age, while 38.9% (7 children) were moderately underweight, and 11.1% (2 children) were severely underweight. Nutritional status varied significantly by age. The 3-4-year age group showed the best outcomes, with all children classified as normal. In contrast, the 2-3-year group revealed the most concerning results - none were in the normal category, with 75% moderately underweight and 25% severely underweight. These findings suggest a vulnerability to malnutrition during the transition from infancy to early childhood, possibly linked to inadequate weaning or poor dietary practices. While most children show normal growth, the presence of moderate to severe undernutrition in specific age groups underlines the urgent need for age-specific nutritional interventions and early monitoring to ensure healthy child development.

4.7. Height-for-Age

Table 7 : Height-for-age

Age of Child (months)	Normal	Moderate	Severe	Total
0-6 months	1 (50%)	1 (50%)	0 (0%)	2
1-2	4 (80%)	1 (20%)	1 (20%)	5
2-3	0 (0%)	2 (50%)	2 (50%)	4
3-4	4 (100%)	0 (0%)	0 (0%)	4
4-5	3 (60%)	2 (40%)	2 (40%)	5
Total	12 (66.7%)	6 (33.3%)	3 (16.7%)	18 (100%)

Source: Primary Data

Table 7 presents the height-for-age nutritional status of children, a key indicator of chronic malnutrition or stunting. Out of 18 children, 66.7% (12) had normal height-for-age, while 33.3% (6) were moderately stunted, and 16.7% (3) were severely stunted, indicating that a significant portion suffers from long-term undernutrition. Age-wise analysis shows that the 3-4-year group had the best outcomes, with all children falling within the normal range. In contrast, the 2-3-year group displayed the most concerning results, with no children in the normal category and an equal split between moderate and severe stunting (50% each). The 4-5-year age group also showed high levels of growth faltering, with 40% moderately and 40% severely stunted. These findings emphasize the vulnerability of children in early developmental stages and highlight the urgent need for targeted nutritional interventions to address chronic malnutrition and support healthy growth during critical early years.

4.8. Weight-for-Height

Table 8 : Weight-for-Height

Age of Child (months)	Normal	Moderate	Severe	Total
0-6 months	1 (50%)	1 (50%)	0 (0%)	2
1-2	5 (100%)	0 (0%)	0 (0%)	5
2-3	0 (0%)	2 (50%)	2 (50%)	4
3-4	4 (100%)	0 (0%)	0 (0%)	4
4-5	3 (60%)	2 (40%)	0 (0%)	5
Total	13 (72.2%)	5 (27.8%)	2 (11.1%)	18 (100%)

Source: Primary Data

Table 8 highlights the nutritional status of children based on weight-for-height (WHZ), an important measure of acute malnutrition or wasting. Of the 18 children assessed, 72.2% (13) were found to have a normal weight-for-height ratio, indicating generally healthy short-term nutritional status. However, 27.8% (5) were moderately wasted, and 11.1% (2) were severely wasted, signaling acute undernutrition in a portion of the sample. Age-wise, the 1-2 and 3-4-year groups showed the most favorable outcomes, with all children classified as normal. In contrast, the 2-3-year group showed the highest level of concern, with 50% moderately wasted and 50% severely wasted - none falling into the normal category. This suggests that children in this developmental stage are particularly vulnerable, potentially due to inadequate feeding practices or health issues. The results highlight the need for targeted nutritional support and early interventions to prevent and manage acute malnutrition, especially during the critical early years of growth.

The anthropometric measurements carried out in the study area provide important insights into the nutritional and health status of children in the community. By analyzing key indicators such as height, weight, and Body Mass Index (BMI), the study reveals notable patterns pointing to the presence of both undernutrition and overnutrition among children. These findings highlight the dual burden of malnutrition within the population and emphasize the urgent need for targeted interventions. Efforts should focus on improving dietary diversity, ensuring access to essential nutrients, and strengthening healthcare services to address the underlying causes of poor nutritional outcomes and promote healthier growth and development.

5. Conclusion

In conclusion, advancing child health and nutrition demands a comprehensive, multi-sectoral approach that tackles the wide range of factors influencing early growth and well-being. Strengthening maternal education, expanding access to quality healthcare, and addressing all forms of malnutrition - including undernutrition, micronutrient deficiencies, and emerging childhood obesity - are crucial priorities. Equally important are initiatives that promote exclusive breastfeeding, ensure universal immunization coverage, and improve sanitation, hygiene, and safe water access, which together help prevent avoidable diseases and infections. Moreover, sustained attention to social and environmental determinants such as poverty reduction, food security, and improved living conditions can further enhance child health outcomes. Achieving lasting progress requires coordinated action across sectors - health, education, nutrition, and social welfare - to create an enabling environment for every child. By prioritizing these interconnected areas, policymakers can lay the groundwork for healthy early childhood development, fostering a more resilient, equitable, and inclusive society.

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Macroeconomic Determinants in India and Their Impact on the Indian Steel Industry

Freddy Thomas &
Gerard Rassendren

This study explores the connection between key macroeconomic indicators and finished steel production in India over the period 1990 to 2023. Utilizing time-series econometric techniques such as Granger causality, Johansen cointegration, and the Vector Error Correction Model (VECM), the analysis underscores the significant role of the steel sector in supporting India's economic growth, particularly in relation to GDP expansion, trade liberalization, and fluctuations in the real exchange rate. While openness and GDP positively influence steel production in both short and long terms, exchange rate volatility presents challenges. Macroeconomic variables like inflation, unemployment, and trade volumes show limited direct impact, suggesting the resilience of India's steel industry despite external economic fluctuations. The study underlines the need for targeted policies to enhance the sector's competitiveness and sustainability, focusing on infrastructure investments, export logistics, and currency stability.

Keywords: Indian steel industry, macroeconomic determinants, GDP, trade openness, real exchange rate, steel production trends

Steel Industry in India and Macroeconomic Determinants

India's steel sector holds a crucial position in driving both industrialization and overall economic development, positioning the country as the world's second-largest steel producer. Crude steel production has maintained a compound annual growth rate (CAGR) of approximately 5%, reflecting the industry's resilience in the face of global economic volatility (Economic Times, 2023). Strategic government interventions - such as the National Steel Policy (2017) and the Production Linked Incentive (PLI) scheme - have supported capacity enhancement, while sustainability-driven initiatives have helped align the sector with international environmental benchmarks.

The steel industry's growth is closely linked to macroeconomic variables, including GDP, inflation, real exchange rates, and trade-to-GDP ratios, which influence production and consumption trends. Infrastructure investments, as seen in the Union Budget 2023-24, continue to drive demand, yet challenges persist, such as export restrictions, high logistics costs, and global commodity price volatility. Steel consumption serves as a vital measure of economic development, reflecting its role in advancing industrialization and urbanization (Mukherjee and Roy, 2010). The growth of India's steel sector has been significantly influenced by factors such as deregulation, increased foreign direct investment, and technological innovation, particularly within the private sector. Despite this, there remains a relative lack of empirical research investigating the link between macroeconomic stability and the performance of the steel industry in the Indian context. This study seeks to address that gap by employing a time-series methodology to assess the influence of key macroeconomic variables on the sector. By offering a deeper understanding of economic patterns and their policy implications, the research aims to guide stakeholders in formulating strategies to sustain growth and improve the industry's global competitiveness.

Impact of GDP Growth on the Steel Industry

Several studies have explored the relationship between GDP growth and steel consumption (Gao et al 2019, Palia-Popa et al 2016, Pandia et al 2016, Qian 2021, Ravazzolo and Vespignani 2020, Song et al 2020, Warrel 2014, Warrel and Olsson 2009, Yin and Chen 2013). Economic growth, often driven by infrastructure development, is closely linked to steel demand. For instance, the creation of an infrastructure stock index - incorporating total investment, infrastructure stock, and labor force - has been shown to positively influence a country's economic growth trajectory (Shan 2005). Emphasis on infrastructure development is particularly crucial for emerging economies like India to sustain robust economic growth (Sahoo and Dash 2019). Additionally, natural resource endowments, such as iron and steel, significantly contribute to the economic expansion of nations, as evidenced in countries like Brunei Darussalam (Tahir et al 2022).

Steel production and economic growth exhibit a direct correlation, with bidirectional relationships observed between economic activity and crude steel consumption (Dobrota and Caruntu 2013, Farzana et al 2016). For example, Korea's manufacturing GDP and flat steel product consumption were found to have a two-way long-term causal association (Huh 2011). However, the dynamics may vary across countries; studies from the United Kingdom revealed unpredictable trends between economic activity and steel consumption (Evans 2011). Notably, the relationship between metal utilization intensity and economic growth often follows an inverted U-shaped pattern, where utilization rises, peaks, and eventually declines as per capita income increases (Dulger et al 2014).

The Indian steel industry, as the world's second-largest steel producer, plays a vital role in the nation's economic framework (Pal 2012). Steel demand is intricately tied to key sectors such as infrastructure, real estate, and automobiles. Per capita steel consumption serves as a key indicator of socio-economic progress, reflecting the standard of living (Kavitha and Palanivelu 2014). In India, research using econometric tools like cointegration, VAR, and Granger causality tests has demonstrated a unidirectional causality from GDP growth to steel consumption (Ghosh 2006). Overall, steel production remains a cornerstone for both short- and long-term economic activities, highlighting its critical role in fostering energy-efficient and sustainable growth (Yin and Chen 2013, Xuan and Yue 2016).

Exchange Rate Volatility and Its Effects on the Steel Sector

Fluctuations in exchange rates represent a key macroeconomic variable that can significantly affect international trade flows and productivity across economic sectors.Fluctuating exchange rates affect exports, trade, investments, capital markets, inflation, and employment (Alagidede and Ibrahim 2017, Hatmanu et al 2020, Ioan et al 2020, Jamil et al 2012, Schnabl 2008, Vo and Zhang 2019). Despite its importance, limited research has focused specifically on the steel industry's productivity under varying exchange rate regimes. Theoretical perspectives on exchange rate volatility offer divergent views. Some studies argue that monetary policy uncertainties, nominal interest rate reductions, and currency appreciation negatively affect domestic economies (Obstfeld and Rogoff 1998), while others emphasize the mitigating effects of stable exchange rate regimes (Devereux and Engel 2003).

Empirical studies underscore the complex and context-dependent relationship between exchange rate movements and economic growth.For instance, a 1992 study found a negative relationship between exchange rate volatility and economic growth in 95 developing countries, emphasizing investment's positive role in growth (Dollar 1992). Conversely, countries with flexible exchange rates often absorb shocks more effectively, thereby promoting resilience and growth (Aghion et al 2009, Bleaney and Greenaway 2001). Notably, research on OECD countries (1980-2011) identified a negative correlation between real effective exchange rate volatility and growth, underscoring the benefits of stable exchange rate regimes (Holland et al 2011). A clear empirical link between exchange rate changes and the performance of India's steel industry has not been firmly established.

Exploring the Link Between Trade Openness and Steel Industry Dynamics

Trade openness has transformed India's steel industry, boosting exports and enabling access to advanced technologies. Liberalized policies have enhanced efficiency by allowing imports of essential inputs like high-grade iron ore and metallurgical coal. Export-led growth, leveraging India's resource base and low labor costs, has strengthened its presence in global markets. However, increased competition from cheaper imports during oversupply periods pressures domestic producers. Lessons from Canada highlight the importance of strategic infrastructure investments (Jaworski and Keay 2020). To maximize benefits, India must enhance trade corridors and export logistics while ensuring that liberalization supports competitiveness and resilience globally.

Inflation, Unemployment, and Total Trade

The impacts of inflation, unemployment, and total trade on the steel industry remain underexplored. Inflation affects input costs and profitability, as rising raw material prices can strain production economics, while moderate inflation may boost demand in construction and manufacturing. Unemployment influences steel consumption by affecting income levels and industrial activity, with high joblessness potentially reducing demand in real estate and automotive sectors. Total trade, including imports and exports, shapes domestic production strategies. A surge in imports during global oversupply can depress prices, while strong exports indicate industry competitiveness. Gaining insight into how these factors influence steel production and pricing strategies can better inform decision-making for policymakers and industry stakeholders.

Macro-Economic Determinants of Steel Production in India: Empirical Analysis

Key variables used in the study include GDP, inflation, trade openness, total trade value, real exchange rate, and unemployment. A time series model analyses their impact on finished steel production from 1990-91 to 2022-23. The study relies on secondary data from sources like the CMIE Prowess database, Statista, the Joint Plant Committee (JPC), and government reports, providing insights into the steel sector's growth dynamics and its macroeconomic determinants.

Econometric Framework

The analysis draws on multiple econometric methods to explore the connection between macroeconomic factors and the steel sector in India. It begins with unit root tests - Augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1979), Phillips-Perron (PP) test (Phillips and Perron 1988), and KPSS test (Kwiatkowski et al 1992) - to determine stationarity and the order of integration of the data. If variables share the same integration order, the study applies the Engle-Granger cointegration test (Engle and Granger 1987) and the Error Correction Model (ECM) to examine long-run and short-run dynamics.The study utilizes the Engle-Granger two-step method and the Johansen-Juselius (JJ) (Johansen 1998) maximum likelihood estimator, with Johansen's (Johansen 1998) method preferred for determining the number of cointegrating relationships.Additionally, the study uses variance decomposition and impulse response analysis within the framework of a Vector Autoregressive (VAR) model.

These methodologies provide deeper insights into the interplay between macroeconomic factors and the steel industry's performance, offering valuable guidance for policymakers and industry stakeholders.

The following Table displays general information about the growth of finished steel production and macro-economic variables. The GDP, inflation rate, total trade and steel production show a positive skewness among these variables. Meanwhile, the distributions of openness, real exchange rate, and unemployment rate exhibit negativeskewness.The Jarque-Bera statistics are the test of normal distribution (Jarque and Bera 1980). As shown by their significance level, the GDP, inflation rate, openness index, total trade, and finished steel are normally distributed. However, the real exchange rate and unemployment rate deviate from normality, as indicated by highly significant Jarque-Bera test statistics ($p = 0.000$).

Table 1: Descriptive overview of key variables

	GDP at current prices (Rs crores)	Inflation rate (CPI)	Openness index	Real exchange rate	Total trade (billion dollars)	Unemployment rate	Finished steel production In '000 tons)
Mean	1064635.	7.186970	36.13793	95.92394	556.7390	7.633061	60333.70
Median	771013.2	6.620000	39.90540	99.50000	429.9289	7.850000	57661.00
Maximum	2749846.	13.87000	55.79370	105.9400	1682.005	8.700000	126856.0
Minimum	221486.1	3.330000	15.50630	57.08000	45.88476	4.822000	13566.00
Std. Dev.	808479.9	3.090686	12.72484	10.87917	484.8896	0.832570	37925.88
Skewness	0.606259	0.540841	-0.098312	-2.326107	0.502872	-1.234457	0.272881
Kurtosis	1.988973	2.129053	1.632404	8.064831	2.014743	4.959378	1.571090
Jarque-Bera	3.427015	2.651802	2.624846	65.03146	2.725599	13.66021	3.217006
Probability	0.180233	0.265564	0.269167	0.000000	0.255943	0.001081	0.200187
Sum	35132961	237.1700	1192.552	3165.490	18372.39	251.8910	1991012.
Sum Sq. Dev.	2.09E+13	305.6749	5181.489	3787.405	7523774.	22.18152	4.60E+10
Observations	33	33	33	33	33	33	33

Since the log transformation of variables reduces the lognormality of values, all the selected values are transformed in log forms in the empirical analysis. The table below presents the descriptive statistics for the log-transformed variables used in the analysis. The variables are defined as follows:

LOGGDP = log values of GDP

LOGSTEEL = log values of finished steel production

LOGEXRATE = log values of real exchange rate

LOGINFLATION = log value of inflation rate

LOGOPEN = log values of the index of openness

LOGTRADE = log values of trade

LOGUNEMPL = log values of the unemployment rate

As shown in the Table, the log transformation has drastically reduced the skewness of GDP data. The log values of GDP, steel production, inflation rate, openness index and trade values are normally distributed as shown by the significance values of Jarque-Bera statistics. However, the exchange rate and unemployment values are still not normally distributed.

Table 2: Log-transformed variables: descriptive statistics

	LOGGDP	LOGSTEEL	LOGEXRATE	LOGINFLATION	LOGOPEN	LOGTRADE	LOGUNEMPL
Mean	5.885542	4.677043	1.978554	0.817441	1.528094	2.499978	0.879874
Median	5.887062	4.760882	1.997823	0.820858	1.601032	2.633397	0.894870
Maximum	6.439308	5.103311	2.025060	1.142076	1.746585	3.225827	0.939519
Minimum	5.345346	4.132452	1.756484	0.522444	1.190508	1.661668	0.683227
Std. Dev.	0.370918	0.322843	0.058170	0.187955	0.169511	0.525797	0.051979
Skewness	0.000338	-0.260608	-2.645696	0.077872	-0.446370	-0.238865	-1.736236
Kurtosis	1.471125	1.622046	9.599670	1.692561	1.831446	1.469695	7.171485
Jarque-Bera	3.214007	2.984333	98.38739	2.383771	2.973439	3.533833	40.50659
Probability	0.200487	0.224885	0.000000	0.303648	0.226113	0.170859	0.000000
Sum	194.2229	154.3424	65.29228	26.97555	50.42709	82.49928	29.03585
Sum Sq. Dev.	4.402564	3.335277	0.108279	1.130461	0.919485	8.846812	0.086458
Observations	33	33	33	33	33	33	33

Granger Causality Test Results

The findings show that GDP is not a Granger cause of finished steel production, but the reverse holds true - steel production Granger-causes GDP. No causal link is found between inflation and steel production in either direction.For the real exchange rate, a weak causal relationship is observed, with exchange rate changes Granger-causing steel production at the 10% level. The openness index also Granger-causes steel production, while trade volume shows a similar effect, again at a 10% significance level. Lastly, steel production is found to Granger-cause unemployment, indicating a unidirectional impact on labor dynamics.

Table 3: Bivariate granger causality tests

Pairwise Granger Causality Tests			
Sample: 1990 2022			
Lags: 1			
Null Hypothesis:	Obs	F-Statistic	Prob.
LOGGDP fails to Granger Cause LOGSTEEL	32	0.12873	0.7223
LOGSTEEL fails to Granger Cause LOGGDP		10.9424	0.0025
LOGINFLATION fails to Granger Cause LOGSTEEL	32	0.43354	0.5155
LOGSTEEL fails to Granger Cause LOGINFLATION		0.36820	0.5487
LOGEXRATE fails to Granger Cause LOGSTEEL	32	3.28527	0.0803
LOGSTEEL fails to Granger Cause LOGEXRATE		1.32361	0.2593
LOGOPEN fails to Granger Cause LOGSTEEL	32	4.84372	0.0359
LOGSTEEL fails to Granger Cause LOGOPEN		0.00553	0.9412
LOGTRADE fails to Granger Cause LOGSTEEL	32	3.16737	0.0856
LOGSTEEL fails to Granger Cause LOGTRADE		0.45701	0.5044
LOGUNEMPL fails to Granger Cause LOGSTEEL	32	3.40272	0.0753
LOGSTEEL fails to Granger Cause LOGUNEMPL		4.70798	0.0384

Stationarity and Cointegration in Time Series Data

	Level variables						First difference variables					
	ADF		PP		KPSS		ADF		PP		KPSS	
	t-value	P-value	t-value	P-value	LM test	Critical value at 5%	t-value	P-value	t-value	P-value	LM test	Critical value at 5%
logsteel	-1.378586	0.5802	-1.495425	0.5230	0.644942	0.463000	-5.084703	0.0002	-5.065958	0.0003	0.253118	0.463000
loggdp	0.335486	0.9766	0.331626	0.9764	0.648326	0.463000	-6.267238	0.0000	-6.285805	0.0000	0.205470	0.463000
loginflation	-7.519665	0.0000	-2.354191	0.1622	0.183915	0.463000	-7.218342	0.0000	-7.193344	0.0000	0.071394	0.463000
Logexchage rate	-3.017997	0.0438	-2.757815	0.0757	0.457355	0.463000	-6.406210	0.0000	-7.042724	0.0000	0.500000	0.463000
logopen	-1.946578	0.3078	-1.928216	0.3157	0.550255	0.463000	-4.921684	0.0004	-4.933926	0.0004	0.279890	0.463000
logtrade	-0.672415	0.8397	-0.669237	0.8405	0.639077	0.463000	-4.389711	0.0016	-4.407735	0.0015	0.146145	0.463000
logunemployment	-2.030263	0.2730	0.152869	0.9649	0.201504	0.463000	0.424712	0.9806	-4.432463	0.0014	0.549032	0.463000

The Granger causality and unit root tests assist in identifying macroeconomic variables that share a potential long-run equilibrium relationship with steel production. Based on the results, inflation and total trade do not exhibit Granger causality with steel production, while the unemployment rate fails to achieve stationarity even after first differencing. Consequently, these three variables - inflation, unemployment, and trade volume - are excluded from the final long-run model. The long-run relationship is then estimated using log-transformed steel production as the dependent variable, with GDP, real exchange rate, and trade openness serving as the explanatory variables.

Modelling Long-Term Relationships: Cointegration and VECM

This study identifies a long-run cointegrating relationship among the variables steel production, GDP, real exchange rate, and trade openness. The selection of these variables was informed by preliminary tests of causality and stationarity. Prior to conducting the cointegration analysis, the optimal number of lags was determined using standard model selection criteria, including the Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ). All three measures indicated that a lag length of one was appropriate, supporting the conclusion that the variables are integrated of order one, I(1).

The Johansen test for cointegration (Johansen, 1988; Johansen & Juselius, 1990) was then applied to assess the long-run relationship.In the Johansen cointegration framework, the null hypothesis posits that no cointegrating relationship exists among the variables. This hypothesis is rejected when the trace and maximum eigenvalue statistics exceed their respective 5% critical values. As presented in Table 4, the results for a maximum rank of one lead to the rejection of the null, indicating the presence of a single cointegrating vector. This finding suggests a stable long-term equilibrium relationship between log-transformed steel production and the selected macroeconomic indicators.

Cointegration test result

Table 5: Trace and Maximum Eigenvalue Statistics from Johansen Test

Trace and Maximum Eigen value test of cointegration				
Sample (adjusted): 1992 2022 Included observations: 31 after adjustments Trend assumption: Linear deterministic trend Series: LOGSTEEL LOGGDP LOGEXRATE OPENESS Lags interval (in first differences): 1 to 1				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.673109	55.46466	47.85613	0.0082
At most 1	0.341788	20.80265	29.79707	0.3701
At most 2	0.202514	7.837586	15.49471	0.4829
At most 3	0.026186	0.822577	3.841466	0.3644
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
None *	0.673109	34.66201	27.58434	0.0052
At most 1	0.341788	12.96506	21.13162	0.4554
At most 2	0.202514	7.015008	14.26460	0.4874
At most 3	0.026186	0.822577	3.841466	0.3644
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

Error Correction Mechanism in a Cointegrated System

The Vector Error Correction Model (VECM) represents a cointegrated extension of the Vector Autoregressive (VAR) model, allowing for the analysis of both short-term fluctuations and long-term equilibrium relationships among time series variables.

Before estimating the VECM, it is essential to determine the appropriate lag structure for the underlying VAR model. This is typically done using model selection criteria such as the Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ). The optimal number of lags is evaluated individually for both the dependent and independent variables. As indicated by the results shown in the table below, a lag length of one is optimal for most variables - with the exception of the real exchange rate - and is thus used in the VECM estimation.

Table 6: Lag length selection criteria

Lag length criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
	Endogenous variables: LOGSTEEL					
0	-4.936696	NA	0.086980	0.395780	0.442486	0.410722
1	58.49220	118.4006*	0.001355*	-3.766146*	-3.672733*	-3.736263*
2	58.49419	0.003593	0.001449	-3.699613	-3.559493	-3.654787
3	58.80471	0.538225	0.001519	-3.653647	-3.466821	-3.593880
	Endogenous variables: LOGGDP					
0	-10.57710	NA	0.126686	0.771807	0.818513	0.786749
1	60.95614	133.5287*	0.001150*	-3.930409*	-3.836996*	-3.900526*
2	60.95695	0.001462	0.001230	-3.863797	-3.723677	-3.818971
3	61.35161	0.684070	0.001282	-3.823441	-3.636614	-3.763673
	Endogenous variables: LOGOPEN					
0	15.59724	NA	0.022126	-0.973149	-0.926443	-0.958207
1	56.35664	76.08421*	0.001563*	-3.623776*	-3.530363*	-3.593892*
2	56.40519	0.087391	0.001666	-3.560346	-3.420226	-3.515520
3	56.46921	0.110973	0.001775	-3.497947	-3.311121	-3.438180
	Endogenous variables: LOGEXRATE					
0	75.32945	NA*	0.000413*	-4.955297*	-4.908590*	-4.940355*
1	75.50306	0.324067	0.000436	-4.900204	-4.806791	-4.870320
2	76.25287	1.349672	0.000444	-4.883525	-4.743405	-4.838699
3	76.25297	0.000173	0.000475	-4.816865	-4.630039	-4.757097

* indicates lag order selected by the criterion
LogL: Log likelihood ratio
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The table below presents the results of the Vector Error Correction Model (VECM), from which both the long-run equilibrium relationships and short-run dynamics between steel production and the selected macroeconomic variables are derived.

Table 7: Vector error correction model results

Result of VECM			
Long run relationship		Short run relationship	
Co-integrating Eq:	CointEq1	Error Correction:	D(LOGSTEEL)
LOGSTEEL(-1)	1.000000	CointEq1	-0.057819 (0.03215) [-1.79840]
LOGGDP(-1)	-0.189001 (0.18253) [-1.03547]	D(LOGSTEEL(-1))	0.236144 (0.20888) [1.13052]
LOGEXRATE(-1)	-3.787019 (0.63513) [-5.96258]	D(LOGGDP(-1))	-0.371997 (0.21482) [-1.73168]
LOGOPEN(-1)	-1.677728 (0.37754) [-4.44379]	D(LOGEXRATE(-1))	0.150188 (0.13493) [1.11304]
C	6.504080	D(LOGOPEN(-1))	0.137759 (0.16522) [0.83380]
		C	0.032202 (0.00933) [3.45003]
Included observations: 31 after adjustments Standard errors in ( )& t-statistics in [ ] R-squared- 0.239571, Adj. R-squared- 0.087486, Sum sq. resids- 0.029517, S.E. equation- 0.034361, F-statistic- 1.575239, Prob(F-statistic)-0.053 Log likelihood- 63.84271, Akaike AIC-3.731788, Schwarz SC-3.454242, Durbin-Watson stat- 2.916552			

Long run model

Log steel production (-1) = 0.189 Log GDP (-1) +3.78 Log Real exchange rate (-1) + 1.68 Log openness (-1) - 6.504080

The long-run estimation findings reveal that steel production is positively associated with key macroeconomic indicators, specifically GDP, the real exchange rate, and trade openness. This means that, over time, increases in these variables correspond with a rise in steel production. In other words, as the economy expands, the currency appreciates, and the economy becomes more open to trade, the steel industry in India experiences corresponding growth. These findings underscore the direct and favourable influence of these macroeconomic factors on the long-term development of the steel sector.

Short run relationship

D(LOGSTEEL) = -0.0578 ECt-1 + 0.236 D (LOGSTEEL (-1)) + (-0.371) D (LOGGDP (-1)) + 0.150 D (LOGEXRATE (-1)) + 0.138 D (LOGOPEN (-1)) + 0.032

The short-run model offers valuable insights into the immediate interactions between steel production and selected macroeconomic variables, along with the rate and direction of adjustment toward long-run equilibrium. The negative sign of the error correction term aligns with expectations, indicating a stable long-run relationship among the variables. This coefficient suggests that approximately 5.78 percent of any deviation from equilibrium is corrected annually, reinforcing the model's capacity to capture adjustment dynamics.

In the short run, steel production shows a negative association with GDP, while maintaining positive relationships with both the real exchange rate and the trade openness index.

The robustness of the model is confirmed through diagnostic testing. To validate the specification, tests for serial correlation and normality of residuals were conducted. The Lagrange Multiplier (LM) test reveals no evidence of serial correlation among the error terms. Additionally, the Jarque–Bera test was applied to assess the normality of residuals. As the resulting p-value was not statistically significant at the 5 percent level, the null hypothesis of normally distributed residuals could not be rejected, supporting the model's validity.

Dynamic Analysis: Impulse Responses and Forecast Error Variance Decomposition

Variance decomposition analysis quantifies the proportion of changes in the dependent variable - steel production - that can be attributed to its own innovations versus those arising from external macroeconomic shocks.The results, presented in the following table, are computed over a ten-year forecast horizon.Initially, the variation in steel production is almost entirely driven by its own past values, suggesting that steel production behaves in an exogenous manner in the short run. Over time, a portion of the variation becomes attributable to external influences from the selected macroeconomic indicators. However, their overall contribution remains limited. Even in the later years of the forecast period, macroeconomic variables account for only about 7 percent of the variation in steel production, indicating that the sector's dynamics are largely self-determined.

Table 8: Variance decomposition of LOGSTEEL

Variance Decomposition of LOGSTEEL					
Period	S.E.	LOGSTEEL	LOGGDP	LOGEXRATE	LOGOPEN
1	0.034361	100.0000	0.000000	0.000000	0.000000
2	0.054139	92.44684	1.633254	4.080820	1.839084
3	0.068264	91.65855	1.130618	4.793555	2.417279
4	0.080780	92.14209	0.810016	4.647611	2.400284
5	0.091520	92.33320	0.649623	4.573656	2.443519
6	0.100940	92.51896	0.540829	4.472794	2.467413
7	0.109546	92.68454	0.468743	4.376572	2.470145
8	0.117502	92.79871	0.418072	4.307971	2.475246

Short-Run and Long-Run Effects via Impulse Responses

The impulse response values suggest that in the early periods, shocks to steel production primarily influence its own future values, with little to no immediate impact on the macroeconomic variables. Over time, the shocks originating from steel production start to affect key macroeconomic variables, including GDP, the real exchange rate, and trade openness. Among these, GDP-related shocks exert the most significant influence on steel output. Early-stage innovations in both GDP and trade openness contribute positively to the growth of steel production. However, the impact of real exchange rate shocks shifts over time - becoming negative after the fifth year, suggesting a delayed adverse effect on the sector.

Table 9: Impulse response function results for steel production

Result of Impulse Response Function of Steel production				
Period	LOGSTEEL	LOGGDP	LOGEXRATE	LOGOPEN
	Responses from Steel production			
1	0.034361	0.000000	0.000000	0.000000
2	0.039102	-0.006919	0.010937	0.007342
3	0.039517	0.002194	0.010187	0.007664
4	0.041730	0.000413	0.008939	0.006632
5	0.041486	-0.001247	0.008934	0.006931
6	0.041145	-0.000832	0.008523	0.006836
7	0.041180	-0.001071	0.008335	0.006710
8	0.041110	-0.001213	0.008342	0.006732
9	0.041072	-0.001157	0.008327	0.006729
10	0.041079	-0.001163	0.008324	0.006722
	Responses to Steel production			
1	0.034361	0.013988	0.000924	0.014154
2	0.039102	0.022108	0.002771	0.023007
3	0.039517	0.022397	0.004028	0.027095
4	0.041730	0.023756	7.93E-05	0.026411
5	0.041486	0.024216	-0.001262	0.026146
6	0.041145	0.024011	-0.001479	0.026043
7	0.041180	0.024001	-0.001789	0.025826
8	0.041110	0.023989	-0.001820	0.025769
9	0.041072	0.023954	-0.001779	0.025765
10	0.041079	0.023951	-0.001776	0.025756

Summary and Conclusion

This study examines the macroeconomic factors influencing finished steel production in India from 1990 to 2023, with a focus on key indicators such as GDP, real exchange rate, trade openness, inflation, unemployment rate, and total trade. Using time-series econometric methods - including Granger causality tests, Johansen cointegration analysis, and the Vector Error Correction Model (VECM) - the research identifies both short-term fluctuations and long-term equilibrium relationships between these macroeconomic variables and steel production.

The findings reveal that GDP, the real exchange rate, and the trade openness index exert statistically significant effects on steel production. While GDP and openness show a positive impact, exchange rate shocks exert a negative effect on steel production after a time lag. In contrast, inflation, unemployment, and total trade do not exhibit any notable short-run causal relationship with steel production.

Findings from variance decomposition suggest that steel production is initially influenced by its own past behavior, although the role of macroeconomic variables gradually increases over time. This points to the sector's relative resilience, while also highlighting its exposure to broader economic shifts.

A bidirectional causality between GDP and steel production emphasizes the steel sector's dual role - as both a contributor to and a reflection of economic growth. The study thus underscores the importance of maintaining macroeconomic stability while recommending strategic policy interventions to mitigate external vulnerabilities, boost competitiveness, and ensure sustainable industrial growth. This integrated approach provides valuable insights for policymakers aiming to align India's economic and industrial development agendas.

Policy Recommendations

To support the growth of the Indian steel industry, targeted policy measures are essential. First, promoting infrastructure investments is critical to stimulate domestic steel demand. Public-private partnerships should be encouraged to fund large-scale infrastructure projects, while fiscal incentives can enhance the construction and manufacturing sectors, which are significant consumers of steel. Trade openness policies must focus on improving export logistics and negotiating favorable trade agreements to mitigate global competition and safeguard domestic producers against import surges. Additionally, adopting exchange rate policies that stabilize currency fluctuations will enhance the global competitiveness of Indian steel exports and reduce vulnerability to external shocks.

Second, fostering sustainability and innovation within the steel industry is vital for long-term growth. Policymakers should incentivize the adoption of energy-efficient and low-carbon steel production technologies, aligning with global environmental standards. Addressing macroeconomic risks like inflation and unemployment requires a comprehensive approach, including cost management strategies for raw materials and skill development programmes for labor-intensive downstream industries. By aligning economic growth objectives with industrial policy, India can ensure the resilience and competitiveness of its steel industry in a dynamic global environment.

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Kerala's 2024 Lok Sabha Verdict : A 2019 Redux with a BJP Breakthrough

Josukutty C.A.,
Deepak Krishnakumar &
Subramanian N.

This paper analyzes the 2024 Lok Sabha elections in Kerala, a state marked by high political awareness and a bipolar contest between the UDF and the LDF. The BJP-led NDA, which last won a seat in 2004, made a significant gain by winning Thrissur constituency and secured its highest-ever vote share (19.36%). Employing a convergent mixed methods approach, the paper combines quantitative survey data from 20 Lok Sabha constituencies with qualitative interviews to examine voter behaviour, governance perceptions, and the role of religion and caste. Survey findings indicated widespread dissatisfaction with the Modi government and strong support for the INDIA bloc's stance on democracy and secularism. This paper argues that Kerala's 2024 verdict reflected a continued resistance to majoritarianism and a deep-rooted commitment to secular, democratic values. The UDF's victory primarily reflected the electorate's preference for a non-BJP government at the Centre, with the Congress-led UDF - part of the INDIA bloc - seen as the most viable option to achieve that goal. This was further reinforced by anti-incumbency sentiment against the LDF government in Kerala.

Keywords : Electoral politics in Kerala, Lok Sabha elections 2024, voter behavior analysis, mixed methods research, democratic values and secularism in India.

Introduction

Kerala's electoral landscape has long been characterised by high political awareness, intense ideological engagement, and a unique bipolar contest between the United Democratic Front (UDF) and the Left Democratic Front (LDF). Despite these entrenched dynamics, recent developments - such as the increasing visibility of the Bharatiya Janata Party (BJP)-led National Democratic Alliance (NDA) and the evolving socio-political concerns of the electorate - have added new dimensions to the state's political discourse. The 2024 Lok Sabha election presented a crucial moment to reassess Kerala's electoral patterns amid rising national polarisation, deepening federal tensions, and shifting public expectations around governance, welfare, and democratic values.

The 2024 Lok Sabha verdict in Kerala closely mirrored that of 2019, with the Congress-led UDF securing a decisive landslide victory (ECI, 2024b; Lokniti-CSDS, 2020d). This outcome reaffirmed the UDF's position as the default national choice for a significant segment of the Kerala electorate determined to dislodge the BJP from power at the Centre. The results indicated that a substantial portion of voters - particularly those concerned with secularism, the democratic character of the polity, economic issues such as inflation and unemployment, and the erosion of federal principles - regarded the Rahul Gandhi-led Congress as the most credible national alternative to the BJP. Paradoxically, the BJP achieved a significant breakthrough by winning the Thrissur constituency, marking the culmination of its steady electoral inroads in Kerala over the past decade and a half (ECI, 2024a). At the same time, strong anti-incumbency sentiment against the state government further weakened the LDF, restricting it once again to a solitary seat (ECI, 2024b; Lokniti-CSDS, 2020d).

This study seeks to provide a comprehensive analysis of the 2024 Lok Sabha elections in Kerala by employing a convergent mixed methods approach that integrates both quantitative data from a large-scale voter survey and qualitative insights from in-depth interviews with key stakeholders. The paper is organized into five sections. The first section outlines the methodology, explaining the convergent mixed methods design that integrates quantitative survey data and qualitative interviews to ensure a holistic and triangulated analysis of voter behaviour. The second section reviews the electoral history of Lok Sabha elections in Kerala from 2004 to 2024, tracing shifts in vote shares and seat distributions among the UDF, LDF, and NDA, and highlighting the gradual emergence of a three-cornered contest. The third section examines key voting patterns and public perceptions based on survey findings, focusing on approval ratings of governments, trust in leadership, issue salience, and the role of religion and caste in shaping electoral choices. The fourth section provides a comprehensive discussion of the 2024 election verdict, analyzing the political dynamics behind the UDF's dominant performance, the BJP's symbolic breakthrough in Thrissur, and the LDF's weakened position due to strong anti-incumbency sentiment. The fifth and final section presents the conclusion, reflecting on the implications of the 2024 verdict for Kerala's political future, and emphasizing the electorate's continued commitment to secular-democratic values and its resistance to majoritarian politics.

Methodology

This study adopted a convergent mixed methods design, integrating both quantitative and qualitative approaches for simultaneous data collection and analysis. The quantitative component involved a structured, closed-ended questionnaire administered to respondents selected through systematic random sampling. The initial target was to survey 2,400 respondents across 20 Lok Sabha constituencies, with 20 individuals selected from each of 120 randomly chosen polling booths. However, due to practical challenges such as non-responsiveness, the unavailability of individuals during the survey period, and logistical difficulties in accessing certain areas, the final sample comprised 2,365 respondents.Data collection was carried out through face-to-face interviews conducted by trained investigators, ensuring consistency and reliability in response quality. Informed consent was obtained from all participants, and data confidentiality was strictly maintained throughout the process. The quantitative data were processed and analysed using Microsoft Excel, employing descriptive statistical tools such as percentages and cross-tabulations to identify key voting patterns, preferences, and concerns. The sample was confirmed to be representative of Kerala's demographic profile.

To complement the quantitative insights, a qualitative component was incorporated through in-depth interviews with key stakeholders, including community influencers, journalists, politicians, civil society members, NGO workers, and informed voters. The qualitative data were analysed using thematic analysis, where responses were manually coded and categorized based on predefined thematic areas to ensure coherence and consistency. This process allowed for the identification of recurring patterns and dominant narratives related to voter behaviour.

By integrating both quantitative and qualitative findings, the study was able to triangulate data and validate trends, offering a comprehensive understanding of the socio-political, economic, and demographic factors influencing electoral behaviour. This parallel mixed-methods approach enabled a holistic exploration of voter perceptions, campaign strategies, governance assessments, and underlying community dynamics in the 20 Lok Sabha constituencies.

Electoral History of Lok Sabha Elections in Kerala

The study of electoral history plays a crucial role in election studies, offering a lens to understand long-term political trends, shifts in voter preferences, and the evolving strength of competing parties. In Kerala, where political engagement is high and electoral outcomes often reflect deeper ideological and social undercurrents, historical data provides important insights into the state's dynamic party system. This section examines the Lok Sabha elections from 2004 to 2024, focusing on both seat distribution and vote share trends, with particular emphasis on the enduring competition between the UDF and the LDF, and the slow but steady emergence of the NDAas a third force.

Table 1: Electoral history of Lok Sabha Elections in Kerala since 2004

Election Year	UDF Seats	UDF Vote Share (%)	LDF Seats	LDF Vote Share (%)	NDA Seats	NDA Vote Share (%)
2004	1	38.38	18	46.15	1	12.08
2009	16	47.73	4	41.90	0	6.31
2014	12	41.98	8	40.12	0	10.82
2019	19	47.24	1	34.25	0	14.80
2024	18	45.50	1	33.63	1	19.36

Source: (ECI, 2024a, 2024b; Lokniti-CSDS, 2020a, 2020b, 2020c, 2020d)

Table 1 presents the electoral outcomes of the Lok Sabha elections in Kerala over the past two decades, highlighting a dynamic and evolving political landscape. In the 2004 Lok Sabha elections, the LDF emerged as the dominant alliance, securing 18 out of 20 seats with 46.15% of the vote share, while the UDF managed just 1 seat with 38.38%. The NDA also won 1 seat with 12.08% of the vote, although it was secured by a candidate from one of the Kerala Congress factions (ECI, 2018).This balance shifted significantly in 2009 when the UDF made a major comeback, winning 16 seats and increasing its vote share to 47.73%, while the LDF was reduced to 4 seats with 41.90%, and the NDA failed to win any seat as its vote share dropped to 6.31%.

The 2014 elections witnessed a relatively close contest between the two major fronts, with the UDF securing 12 seats (41.98%) and the LDF improving its performance with 8 seats (40.12%). The NDA, though again without a seat, increased its vote share to 10.82%, indicating a gradual rise in support. In 2019, the UDF swept the polls with 19 seats and a vote share of 47.24%, while the LDF was reduced to a single seat (34.25%), and the NDA, despite registering 14.80% of the votes, remained without representation.

The 2024 verdict was, in many ways, a repeat of 2019. The UDF maintained a strong lead, winning 18 seats with a vote share of 45.5%, while the LDF once again secured only one seat, with its vote share declining slightly to 33.63%. However, in a significant departure from previous patterns, theBJP made a breakthrough by winning a seat and recording its highest-ever vote share in the state - 19.36%. This outcome marks a political milestone for the BJP-led NDA in Kerala, reflecting the steady consolidation of its support base.

Overall, the data underscores that Kerala's parliamentary electoral landscape continues to be largely bipolar between the UDF and LDF, but the NDA's rising vote share and recent electoral success suggest a gradual shift towards a more competitive three-cornered contest in the years to come.

Key Factors and Voting Patterns in Lok Sabha Election

Understanding public perceptions of governance is crucial to analyzing electoral outcomes and political shifts. This section draws on survey-based data to offer a comprehensive view of how voters in Kerala evaluated the Modi government's performance, its leadership appeal, and the credibility of its policy narratives. Key dimensions explored include approval ratings, levels of trust in slogans like "Modi's Guarantee," and concerns over corruption, institutional misuse, and the perceived marginalization of Kerala by the Union government. The analysis also captures critical public opinion regarding the performance of the ruling LDF government in the state, particularly on issues of corruption and fiscal prudence. In addition, the section highlights voter preferences for prime ministerial candidates, assessments of which political formation best protects democracy and secularism, and the perceived beneficiaries of central government policies. Finally, it maps the influence of religion and caste in shaping these attitudes, revealing patterns of minority consolidation behind the UDF and emerging Hindu vote consolidation around the NDA. Together, these insights shed light on voter attitudes and the broader political realignments that shaped Kerala's 2024 Lok Sabha verdict.

Figure 1: Performance of Modi Government

Source: (Survey Research Centre-SRC, 2024)

Public opinion on the performance of the Modi government (Figure 1) revealed a predominantly dissatisfied electorate. While 29.10% of respondents expressed satisfaction with the government's performance, a significantly larger segment - 68.00% - were dissatisfied. Only 2.90% of respondents reported no opinion, indicating that most had a clear stance. The data thus reflected a government under considerable public scrutiny, with more than two-thirds of respondents expressing dissatisfaction with its governance outcomes.

Table 2: Best Prime Ministerial Candidate

Best PM Candidate	Percentage (%)
Narendra Modi	29.06
Rahul Gandhi	41.16
Pinarayi Vijayan	8.15
Mamata Banerjee	2.56
Mallikarjun Kharge	1.76
No opinion	17.30
Grand Total	**100.00**

Source: (SRC, 2024)

The survey results (Table 2) indicated that Rahul Gandhi emerged as the most preferred candidate for the Prime Minister's post, with 41.16% of respondents favouring him. Narendra Modi followed with 29.06%, reflecting sustained but comparatively diminished support. Pinarayi Vijayan ranked third with 8.15%, suggesting notable regional endorsement. Mamata Banerjee and Mallikarjun Kharge received limited backing, with 2.56% and 1.76% respectively. Notably, 17.30% of respondents expressed no opinion, pointing to a considerable segment of undecided or disengaged voters. Overall, the findings reaffirmed Rahul Gandhi's strong appeal among a significant portion of the Kerala electorate, consistent with trends observed in previous electoral cycles in the state.

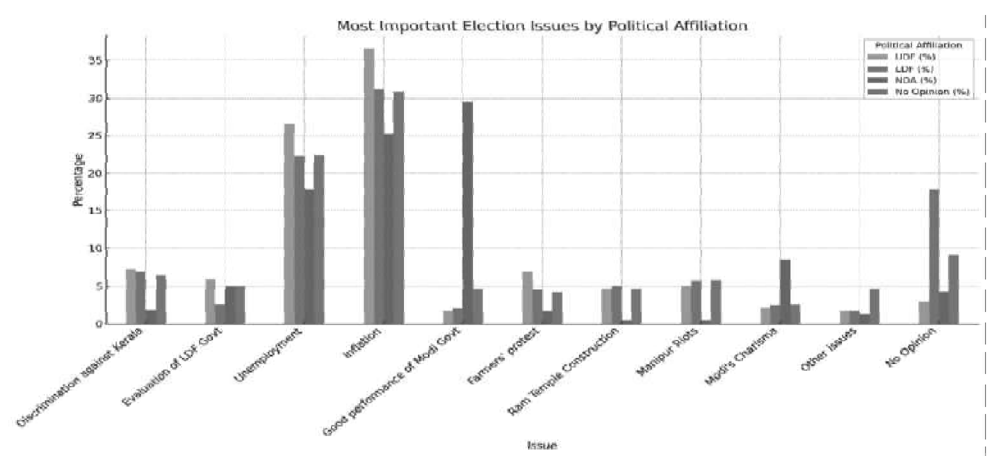
Table 3: Trust in "Modi's Guarantee"

Trust in "Modi's Guarantee"	Percentage (%)
Yes	29.27
No	62.66
Not sure	8.06
Grand Total	**100.00**

Source: (SRC, 2024)

The survey results (Table 3) revealed that a majority of respondents (62.66%) did not trust "Modi's Guarantee," a political slogan used prominently by the Prime Minister and the BJP to assure delivery on promises and policies. This indicated a substantial level of public scepticism towards the credibility or effectiveness of these assurances. Yet, 29.27% of respondents expressed trust in the slogan, suggesting that less than a third were convinced by the central government's narrative of performance and delivery.

Figure 2: Minority Insecurity under Modi Government



Source: (SRC, 2024)

The survey results (Figure 2) indicated that a significant majority, 59.55% of respondents, believed that minorities felt insecure under the Modi government. This perception pointed to widespread concern regarding the treatment and status of minority communities under the Modi government (Biswas, 2024; Tharoor, 2018). In contrast, 31.92% of respondents did not share this view, suggesting that nearly one-third perceived no such insecurity. Additionally, 8.53% of respondents expressed no opinion, reflecting a small but notable segment that either lacked sufficient information or preferred not to comment. Overall, the findings underscored that concerns over minority insecurity were prominent in public discourse, with more than half the respondents acknowledging such sentiments.

Table 4: Failure of Modi Government

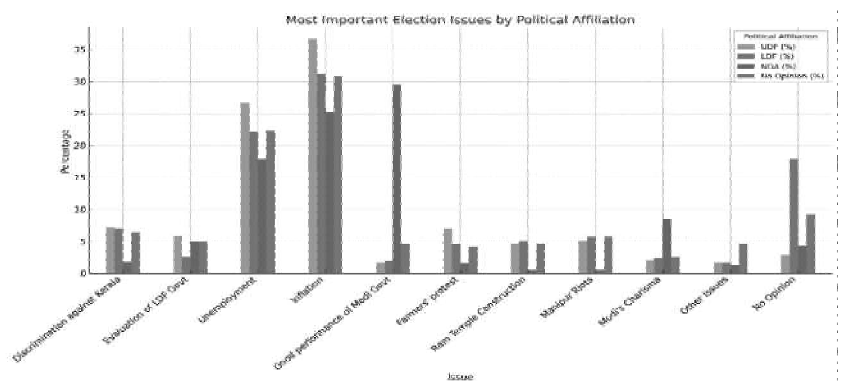
Failure of Modi Government	Percentage (%)
Unemployment / Inflation	35.45
Communalization	24.70
Financial Crisis	8.36
Agrarian Crisis / Agrarian Strike	7.39
Discrimination Against Minorities	7.39

Destruction of Democratic /	
Constitutional Institutions	5.29
No Failure	11.42
Total	**100.00**

Source: (SRC, 2024)

The data on the perceived failures of the Modi government (Table 4) highlighted several key concerns among Kerala voters. Unemployment and inflation emerged as the most pressing issues, with 35.45% of respondents identifying them as major failures. Concerns over communalization followed closely, with 24.70% expressing unease about the growing polarization along religious lines. Together, economic grievances and opposition to communal politics appeared to be the most decisive factors working against the incumbent NDA government. Notably, approximately 11% of voters remained uncritical of the government's performance.

Figure 3: Issue Salience Across Political Affiliations



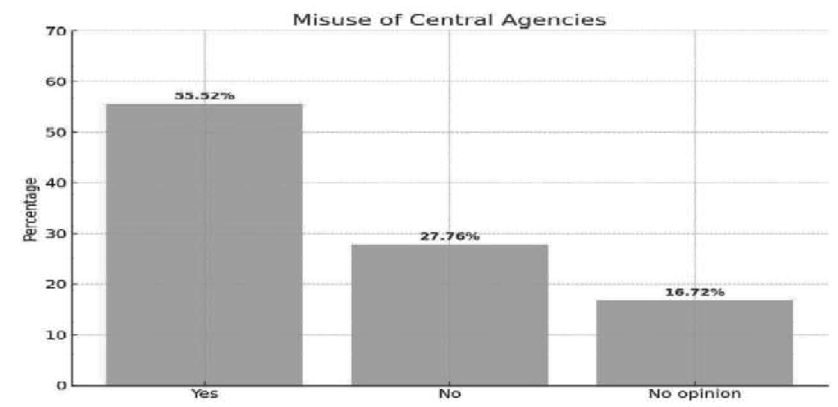
Source: (SRC, 2024)

Figure 3 presents a comparative overview of key electoral issues as perceived by voters in Kerala, disaggregated by political affiliation - namely, the UDF, LDF, NDA, and those without a clear political preference. The findings revealed that economic concerns, particularly inflation and unemployment, dominated voter priorities across the spectrum. Among UDF supporters, 36.57% identified inflation and 26.62% identified unemployment as major failures of the Modi government. LDF voters expressed similar concerns, with 31.16% citing inflation and 22.24% citing unemployment. Even among NDA supporters, who were generally more favorable to the ruling coalition, 25.27% cited inflation and 17.82% cited unemployment - suggesting that economic dissatisfaction cut across partisan lines.

Beyond economic grievances, a significant share of UDF (7.18%) and LDF (6.94%) supporters perceived discrimination against Kerala as a major issue, whereas this concern was marginal among NDA voters (1.80%). Communal issues also featured in the responses, with 5.09% of UDF and 5.67% of LDF voters referencing the Manipur riots, compared to just 0.53% of NDA voters. Cultural themes such as the Ram Temple construction had limited traction, cited by only 4.63% of UDF, 5.10% of LDF, and 0.53% of NDA voters.

In contrast, NDA supporters were more likely to emphasize the positive aspects of the Modi government, with 29.52% citing its good performance and 8.51% highlighting Modi's personal charisma - figures significantly higher than those among UDF, LDF, or politically neutral voters. Notably, 17.85% of LDF supporters and 9.20% of politically neutral respondents expressed no clear opinion, possibly indicating political disengagement or ambivalence. Overall, the data underscored the salience of economic dissatisfaction and resistance to communal politics among opposition voters, while support for the ruling party rested largely on leadership appeal and perceived performance.

Figure 4: Misuse of Central Agencies



Source: (SRC, 2024)

The survey results (Figure 4) indicated that 55.52% of respondents believed that central investigative and enforcement agencies were being misused under the Modi Government. This majority reflected growing public concern over the potential politicisation or selective targeting by institutions such as the CBI, ED, and Income Tax Department. In contrast, 27.76% of respondents did not perceive any misuse, suggesting that over a quarter maintained trust in the impartial functioning of these agencies. Additionally, 16.72% expressed no opinion, indicating either uncertainty or reluctance to comment on the matter. Overall, the data suggested a prevailing perception of institutional misuse among the public.

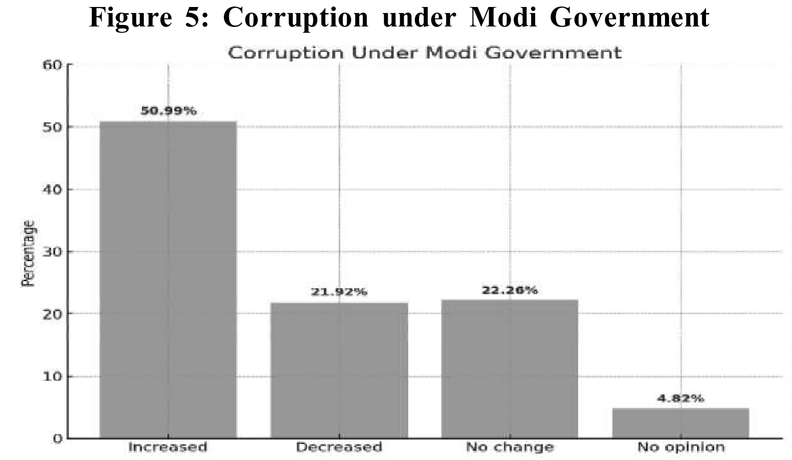
Table 5: Approach of Union Government towards Kerala

Approach of Union Government towards Kerala	Percentage (%)
Positive	28.85
Negative	62.07
No opinion	9.07
Grand Total	**100.00**

Source: (SRC, 2024)

The survey results (Table 5) indicated a broadly negative perception of the Union government's approach toward Kerala. A significant majority of respondents (62.07%) viewed the Centre's stance as negative, citing alleged discrimination in resource allocation that financially constrained the state(Krishna, 2024), along with efforts to destabilise the state government through the Governor's office(The New Indian Express, 2023). In contrast, only 28.85% of respondents viewed the central government's approach positively.

Figure 5: Corruption under Modi Government



Source: (SRC, 2024)

The survey results (Figure 5) showed that 50.99% of respondents believed corruption had increased under the Modi government. This indicated that over half the population perceived a rise in corrupt practices during the administration's tenure. In contrast, 21.92% felt corruption had decreased, while 22.26% reported no noticeable change. A smaller segment, 4.82%, expressed no opinion. These findings suggested that concerns about corruption remained a significant issue for the public, with a clear majority not viewing the government's anti-corruption efforts as effective.

Table 6: Biggest Beneficiary of Modi Government

Biggest Beneficiary of Modi Government	Percentage (%)
Corporates	68.25
Middle class	7.10
Farmers	4.70
Poor People	14.07
No opinion	5.88
Grand Total	**100.00**

Source: (SRC, 2024)

The survey results (Table 6) indicated that a significant majority of respondents believed corporates had been the biggest beneficiaries of the Modi government's policies. An overwhelming 68.25% identified corporates as the primary gainers, suggesting a widespread perception that the administration had prioritised the interests of large businesses. In contrast, only 14.07% felt that poor people had benefited the most, while just 7.10% pointed to the middle class. The farming community was seen as the main beneficiary by only 4.70% of respondents, reflecting dissatisfaction with agricultural policies or a perceived lack of support. Additionally, 5.88% expressed no opinion on the matter. Overall, the findings highlighted a prevailing belief that the Modi government's approach to governance had disproportionately favoured corporates, while offering relatively limited gains to other socioeconomic groups.

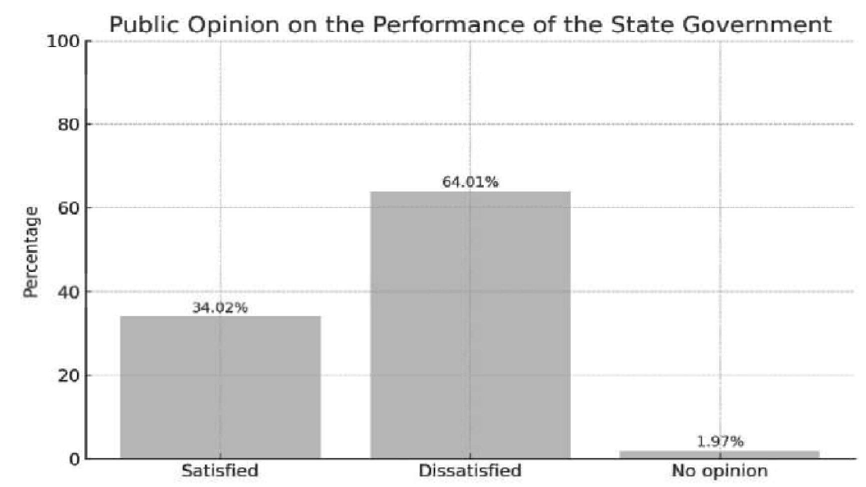
Table 7: Protection of Democracy and Secularism

Protection of Democracy and Secularism	Percentage (%)
INDIA bloc	67.83
BJP/NDA	22.97
No opinion	9.20
Grand Total	**100.00**

Source: (SRC, 2024)

The survey findings (Table 7) revealed that a significant majority of respondents - 67.83% - believed that the INDIA bloc was better positioned to protect democracy and secularism in the country. This strong endorsement reflected a widespread perception that the opposition bloc represented a more inclusive and democratic political vision. In contrast, only 22.97% of respondents expressed confidence in the BJP/NDA to uphold these constitutional values, suggesting a trust deficit among a large section of the electorate regarding the ruling coalition's commitment to democratic and secular principles. Additionally, 9.20% of respondents had no opinion, indicating a limited but present segment that remained undecided or indifferent. Overall, the data pointed to a clear public preference for the INDIA Bloc on matters concerning the preservation of democracy and secularism.

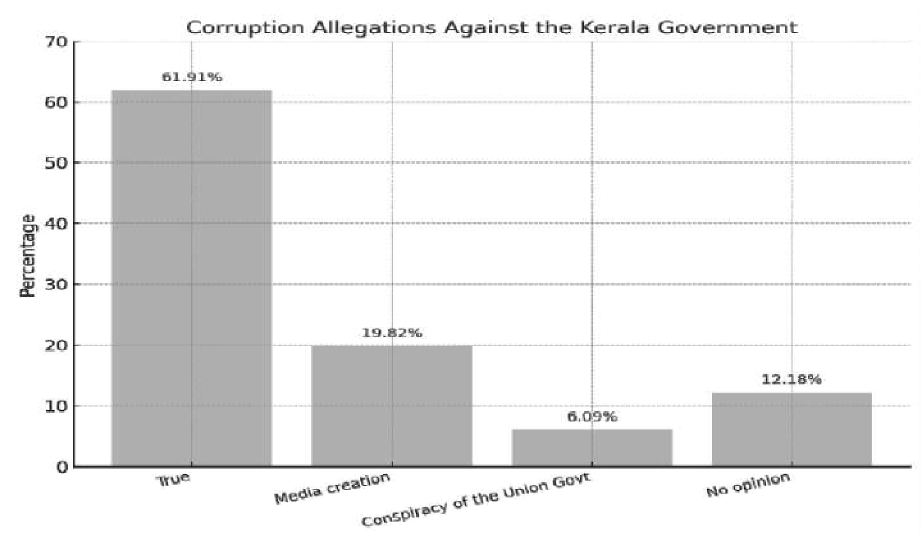
Figure 6: Performance of State Government



Source: (SRC, 2024)

The survey data (Figure 6) on the performance of the state government revealed a majority of respondents (64.01%) were dissatisfied, having rated the government as *bad*, *very bad*, or *average*. In contrast, only 34.02% expressed satisfaction, by rating the performance as *good* or *very good*. A small segment, 1.97%, expressed no opinion, indicating limited disengagement or uncertainty among voters. Overall, the findings pointed to a predominantly critical public mood towards the state government's performance, with nearly two-thirds of respondents registering dissatisfaction.

Figure 7: Corruption Allegations Against the Kerala Government



Source: (SRC, 2024)

The survey findings (Figure 7) indicated that a majority of respondents (61.91%) believed the corruption allegations against the Kerala government to be true, reflecting a significant level of public distrust towards the state administration. Additionally, 19.82% viewed the allegations as a creation of the media, pointing to skepticism regarding how the issue was represented. A smaller segment (6.09%) perceived the allegations as a conspiracy orchestrated by the Union government, highlighting a politically polarized interpretation of the controversy. Meanwhile, 12.18% expressed no opinion, suggesting a degree of uncertainty or disengagement among a portion of the electorate. Overall, the results underscored that corruption remained a prominent concern for voters, with public sentiment largely affirming the credibility of the allegations.

Table 8: Public Opinion on Lavish and Imprudent Spending by the Kerala Government

Public Opinion on Lavish and Imprudent Spending by the Kerala Government	Percentage (%)
Yes	71.31
No	22.43
No opinion	6.26
Grand Total	**100.00**

Source: (SRC,2024)

The survey findings (Table 8) on public opinion regarding the Kerala government's spending practices indicated that a significant majority of respondents (71.31%) believed the government had been engaged in lavish and imprudent spending. This reflected widespread concern among the public about the state's fiscal discipline and expenditure priorities. In contrast, 22.43% of respondents did not share this view, suggesting that a smaller segment found the government's spending justified or reasonable. Additionally, 6.26% expressed no opinion, pointing to a limited portion of the electorate that remained uncertain or disengaged on the issue. Overall, the data highlighted a strong public perception that the Kerala government's financial management had been excessive and poorly aligned with prudent governance expectations.

Table 9: Public Perception of the Effectiveness of UDF MPs as the Opposition in the 17th Lok Sabha

Effectiveness of UDF MPs as the Opposition in the 17th Lok Sabha	Percentage (%)
Effective	33.73
Not Effective	55.94
No opinion	10.33
Grand Total	**100.00**

Source: (SRC, 2024)

The survey findings (Table 9) on the effectiveness of UDF MPs as the opposition in the 17th Lok Sabha revealed that a majority of respondents (55.94%) considered them not effective, indicating widespread public dissatisfaction with their performance in holding the central government accountable. In contrast, 33.73% of respondents viewed the UDF MPs as effective, suggesting that roughly one-third believed the opposition had fulfilled its democratic role to some extent. Additionally, 10.33% expressed no opinion, reflecting a segment of the electorate that remained uncertain or disengaged from parliamentary performance. Overall, the results pointed to a perceived shortfall in the UDF's role as an effective opposition during the 17th Lok Sabha. Thus, any continued support for the UDF in the 2024 election cannot be attributed to the performance of these MPs. Rather, it must be seen as a result of different political dynamics at play.

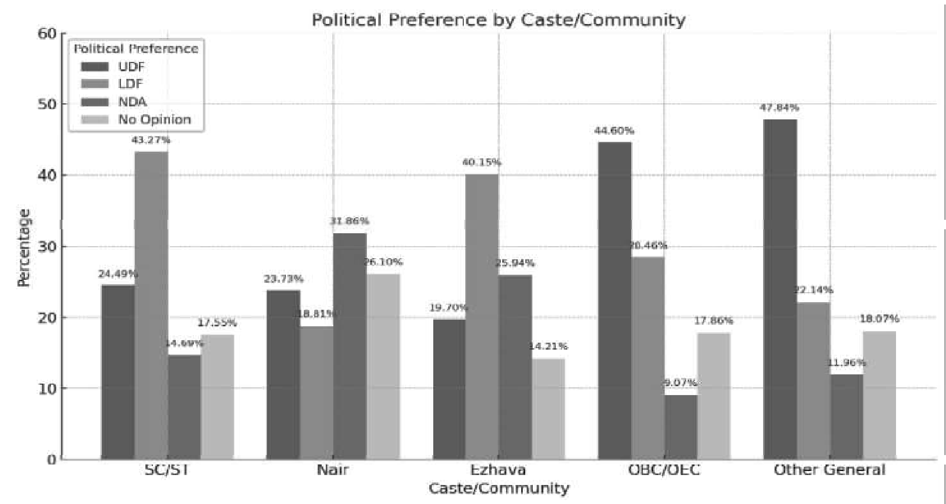
Demographic dynamics

Table 10: Political Preference by Religion

Religion	UDF (%)	LDF (%)	NDA (%)	No Opinion (%)
Hindu	22.83	33.90	24.17	19.10
Muslim	59.07	23.89	1.48	15.56
Christian	53.25	22.17	5.30	s19.28

Source: (SRC, 2024)

Figure 8: Political Preference by Caste/Community



Source: (SRC, 2024)

The survey results highlighted the decisive role of both religious and caste identities in shaping electoral preferences across Kerala. Religion-wise voting patterns (Table 10) revealed that religious minorities strongly favoured the UDF, with 59.07% of Muslim and 53.25% of Christian respondents supporting the alliance. In contrast, the National Democratic Alliance (NDA) secured minimal support among Muslims (1.48%) and limited backing among Christians (5.30%), indicating a significant trust deficit. Among Hindu voters, the Left Democratic Front (LDF) led with 33.90%, followed by the NDA at 24.17% and the UDF at 22.83%. This revealed that the NDA had overtaken the UDF as the second-most preferred political front among Hindus - an advantage that appeared to benefit it in constituencies like Thrissur (SRC, 2024). Thus, a clear minority consolidation worked in UDF's favour, while the NDA made notable gains among the Hindu electorate.

Caste-wise patterns (Figure 8) further revealed underlying social realignments. The LDF retained strongholds among SC/ST (43.27%) and Ezhava (40.15%) communities, in line with its deep organisational networks and pro-welfare orientation. However, the NDA made substantial gains among traditional Congress and Left-leaning caste groups. It emerged as the most preferred alliance among Nair voters (31.86%), displacing the UDF (23.73%) to second place. The NDA also captured 25.94% support among Ezhavas - traditionally a Left-supporting community. Meanwhile, the UDF led among OBC/OEC (44.60%) and Other General categories (47.84%), indicating significant support from socially diverse groups outside the LDF and NDA core bases.

Overall, the combined data suggested a dual trend: a strong religious minority consolidation behind the UDF, and a slow but steady consolidation of Hindu votes around the NDA. This Hindu consolidation signalled emerging caste realignments, as the NDA increasingly encroached upon the traditional vote bases of both the UDF and the LDF, reshaping Kerala's electoral landscape in this election.

Discussion

The electoral trends and survey data from Kerala's 2024 Lok Sabha elections reflected a politically vibrant and ideologically engaged electorate, continuing the state's long-standing tradition of high political consciousness and issue-based voting. Kerala illustrated how the Indian electorate often drew a clear distinction between parliamentary and assembly elections, with voters adopting different preferences based on the nature of the contest and the salience of national versus state-level issues (ETV Bharat, 2025; Shastri et al., 2024). This distinction was particularly evident in 2024, as voters overwhelmingly backed the Congress-led UDF, reaffirming it as the default national alternative to the BJP in the popular imagination.The UDF's landslide victory - securing eighteen out of twenty seats - was ensured by the consolidation of minority votes, who viewed the Congress as the only credible national force capable of removing the BJP from power at the

Centre. This perception had taken root since the sidelining of the Left forces in national parliamentary politics, especially after their decline in West Bengal and Tripura (Sultan, 2024).

The majority of Kerala's electorate - deeply critical of the BJP's anti-minority rhetoric and communal polarisation, suspicious of the Union government's centralising and undemocratic tendencies, disenchanted with the fading charisma of Prime Minister Narendra Modi, and acutely concerned with economic issues such as inflation and unemployment - rallied behind the Congress-led UDF. The perception that the Union government actively discriminated against Kerala further fuelled this support. Notably, this pattern mirrored the dynamics of the 2019 verdict. However, a key departure in 2024 was the BJP's historic entry into Kerala's parliamentary map through its victory in Thrissur - a reward for decades of gradual consolidation among segments of Hindu voters.

In this electoral context, where the principal contest was between voters who sought a national-level alternative to unseat the BJP and those who supported the BJP-led Union government, the LDF was already positioned at a disadvantage. The additional factor of strong anti-incumbency sentiment against the state government further weakened its prospects, leaving it with a tally identical to 2019: one seat out of twenty. The evidence from the election survey substantiated this broader political logic.

The survey data regarding the Modi government's performance, trust in Modi's guarantee, and preference for Prime Ministerial candidates revealed prevailing dissatisfaction with the BJP-led Union government. Overall 68% of respondents expressed dissatisfaction with the Modi government, while only 29.10% viewed it favourably. One civil society activist in Chelakkara observed, "People are disillusioned with slogans and guarantees. They want policy action, not promotional campaigns" (Personal communication, March 2024). Similarly, a majority of respondents expressed distrust in "Modi's Guarantee" and voiced disapproval of the misuse of central agencies, coupled with concerns about corruption and the insecurity faced by minorities. Rahul Gandhi emerged as the most preferred prime ministerial candidate, receiving 41.16% support, significantly ahead of Narendra Modi, who garnered 29.06%.

The public opinion on the Modi government's performance, the perceived insecurity of minorities, and the importance of national issues clearly indicated that voters viewed communalism and undemocratic tendencies as serious electoral concerns. A retired teacher from Palakkad noted, "There's a fear that institutions are no longer neutral - politics seems to have captured even the law" (Personal communication, March 2024). Thus, the Kerala electorate overwhelmingly preferred the Congress-led INDIA bloc over the BJP-led NDA as a means of safeguarding the secular and democratic foundations of the republic. Additionally, the economic difficulties caused by inflation and unemployment further alienated the Modi government from voters: over 68% believed that corporates were the main beneficiaries of the Modi regime, and more than 50% believed corruption had worsened. Rahul Gandhi's sustained focus on the Modi - Adani - Ambani nexus and accusations of crony capitalism resonated with voters (Manoj, 2024). Moreover, the survey revealed that a significant portion of the electorate believed the Union government was discriminating against Kerala and misusing central agencies - campaign narratives prominently advanced by both the UDF and the LDF.

Paradoxically, the NDA's vote share also increased. This gain occurred despite a marginal decline in the NDA's national vote share and setbacks in many of the BJP's traditional strongholds in the Hindi heartland(Anand, 2024; Anshuman, 2024). In Kerala, the NDA's vote share rose from 6.31% in 2009 to 19.36% in 2024 - achieved through the steady consolidation of Hindu voters. The breakthrough in Thrissur, where the BJP secured its first-ever Lok Sabha seat in Kerala, was enabled by controversies surrounding the Thrissur Pooram festival (Sarath & Thomas, 2024), which alienated segments of the Hindu electorate and created an opportunity for the BJP to present itself as a defender of cultural tradition. The survey indicated that around 30% of the electorate maintained a favourable view of the BJP-led Union government across multiple indicators, including government performance, preferred prime minister, and Modi's guarantees. However, this support did not fully translate into votes due to deficiencies in the BJP's state-level leadership, campaign messaging, and candidate strategy. As such, while symbolically significant, the rise in vote share did not necessarily foreshadow similar success in the upcoming assembly elections.

The UDF's victory, as noted earlier, was not a product of enthusiasm for its parliamentary performance. Survey data revealed that most voters were dissatisfied with the performance of Congress MPs from Kerala during the 17th Lok Sabha. Rather, the UDF became the default national alternative due to the political conjuncture of the parliamentary elections and the lack of a viable third front. It was perceived as the only credible force to challenge the BJP at the Centre. Moreover, strong anti-incumbency sentiment against the state government also played a crucial role in reinforcing the UDF's dominance. Survey findings revealed that 64.01% of respondents rated the LDF government's performance as "bad," "very bad," or merely "average." Furthermore, 61.91% believed the corruption allegations against the government were credible, and 71.31% criticised its extravagant spending. This widespread dissatisfaction weakened the LDF's position, indirectly contributing to the consolidation of votes behind the UDF, which was already being viewed as the principal national-level alternative to the BJP.

Therefore, the 2024 verdict reflected Kerala's continued resistance to majoritarian politics and reaffirmation of secular-democratic values, with the UDF emerging as the default national alternative to the BJP due to strong minority consolidation and anti-BJP sentiment. The BJP made a symbolic breakthrough by winning Thrissur and registering its highest-ever vote share in the state, driven by gradual Hindu consolidation and cultural anxieties.The LDF, meanwhile, was weakened by strong anti-incumbency sentiment, resulting in its failure to expand beyond a solitary seat.

Conclusion

The 2024 Lok Sabha election outcome in Kerala reflects a complex interplay of national and state-level dynamics, driven by ideological concerns, anti-incumbency sentiment, and strategic voter calculations. The Congress-led UDF emerged as the principal beneficiary of the electorate's deep-seated aversion to the BJP-led Union government, securing a landslide victory by mobilizing minority support and capitalizing on public dissatisfaction with issues such as inflation, unemployment, institutional erosion, and perceived communal polarization. At the same time, the UDF's gains were reinforced by growing disillusionment with the ruling LDF in the state, which faced significant backlash over corruption allegations, accusations of financial imprudence, and overall governance fatigue after two consecutive terms. Survey data underscored this twin discontent: while the Modi government was rated poorly on multiple governance indicators and perceived as favouring corporates, the LDF too suffered from widespread criticism over its performance and financial management. Notably, the BJP managed a symbolic breakthrough by winning the Thrissur seat and increasing its vote share, marking a significant, though limited, shift in Kerala's political terrain driven by targeted Hindu consolidation. However, this rise did not translate into broader support, hindered by organizational weaknesses and limited state-level leadership. Thus, the UDF's electoral dominance in 2024 cannot be attributed to its prior parliamentary performance but to its strategic positioning as the most viable national-level alternative to the BJP, amplified by the erosion of credibility faced by both the LDF and the NDA in the state.

Looking ahead, the implications of the 2024 Lok Sabha verdict for Kerala's future electoral landscape remain uncertain. Assembly elections in the state represent an entirely different political dynamic, with unique factors at play. The electorate is known to draw a clear distinction between parliamentary and state elections. As a result, the political pendulum in Kerala remains unpredictable. While the BJP may derive some confidence from its performance in the Lok Sabha elections and aim to make inroads in select assembly constituencies, the prospect of achieving state power remains a distant one.

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Indirect Ex-Post Effect of FDI Firms in Manufacturing on India's Current Account of Balance of Payments

Justine George,
Stalin P.C. &
Siby K.M.

The article examines the indirect ex-post effect of Foreign Direct Investment (FDI) firms in the manufacturing sector using the Auto-Regressive Distributed Lag (ARDL) bound test of cointegration and the Todo Yamamottotest of causality. The result shows that the FDI inflow in the manufacturing sector doesn't cause more imports and exports to India. On the other hand, India's exports and imports impact the inflow of FDI in the manufacturing sector. Therefore, the empirical evaluation of the indirect ex-post effect shows that the FDI flows have neither created any worsening effect on the Current Account (CA) of Balance of Payment (BoP) through the negative effect on the increase of merchandise import nor caused any positive effect on the increase in export of India. Given the lack of positive indirect ex-post effect, policy regulations are also needed to improve the linkages between FDI and Non-FDI firms in the economy, which in turn results in a rise in exports and fewer imports in the Balance of Payments (BoP).

Keywords: Balance of payments, foreign direct investment, FDI firms, current account.

Introduction

Foreign Direct Investment (FDI) is regarded as a driving force in developing countries by maintaining sustainable Balance of Payments (BoP) situations, providing technology transfer, job creation, and enhancing competition, efficiency, and productivity in the economy. However, India has pursued a policy of attracting FDI since liberalisation by creating a favourable environment through reducing various norms and regulations, consequently enabling the nation to increase FDI significantly. However, many FDI-related concerns, such as the BoP effect, have not received enough empirical analysis. Nevertheless, the BoP's Current Account (CA) has been continuously in deficit since independence. Therefore, it necessitates the financing of BoP with capital flows, which in turn requires BoP's Capital Account (KA) to be in surplus to balance the deficit in the Current Account. Debt flows such as External Commercial Borrowings (ECB), external loans, Short-term credit, and Non-Resident Indian (NRI) deposits have dominated the composition of capital flows up to liberalisation, which has then gradually shifted to non-debt-creating flows, in particular, Foreign Direct Investment (FDI) and Foreign Portfolio Investment (FPI)during liberalisation period as a means of financing the BoP. The manufacturing sector received significant FDI flows in the post-liberalisation period though financing of the BoP has shifted to Non-debt flows, mainly FDI flows. However, little empirical investigation has been done so far to understand the long-term effects of such financing on the BoP. The long-term impact of FDI on the BoP's Current Account (CA) can be categorised as direct and indirect effects. The ex-post direct impact on the Current Account includes exporting and importing goods and services, repatriating dividends, paying royalties, professional fees, consulting fees, travel expenses, technical fees, and other foreign exchange revenues and expenditures. On the other hand, the indirect effect of FDI on the Current Account (CA) of BoP is the impact of FDI received by companies to enhance the export inclination of the local firm. Additionally, FDI firms might lower the overall import expenditure by producing previously imported items domestically.

However, these long-run indirect effects must be assessed in detail to comment on how far the argument on financing BoP with FDI is beneficial in the long term. The study selects the manufacturing sector to study the indirect ex-post effect, given the large FDI inflows to this sector after the deregulation of the Economy.

Given the issues, the article analyses the indirect ex-post impact of FDI firms and is divided into eight sections. Section II describes the background of the study; Section III describes the Conceptualization of Indirect effect of Foreign Direct Investment (FDI) Companies on the Current Account (CA) of Balance of Payments (BoP); Section IV explains Data and Methodology; Section V discusses the results of the Autoregressive Distributed Lag (ARDL) Bound Co-integration test; Section VI discusses the results of the Todo Yama motto Model and is followed by a summary and conclusion.

Section II. Background of the Study

From 1956 to 1991, India had to deal with several issues with financing the Balance of Payments (Jalan, 1991). However, India experienced a significant BoP issue in 1991 due to the financing Current Account deficit with extremely volatile debt capital flows, worsening the BoP situation. The current Account Deficit has been deteriorating since the 1980s, and the availability of External Commercial Borrowing (ECB) flow was insufficient to finance the same, making it challenging to manage the BoP situation. Due to several uncertainties at the beginning of the 1990s, investors lost faith in the Indian economy, which led to a significant outflow of capital flows and made managing BoP unmanageable. India's foreign exchange reserve had dropped to $1.12 billion in the fourth week of June 1991, which was only enough for three weeks' worth of imports. The adverse situation of the BoP condition pushed the government to pursue economic liberalisation.

As a result, the Indian government established a high-level committee to reform BoP in India. The Committee emphasised the importance of keeping a minimal Current Account deficit. The Committee had further proposed that BoP financing must be changed from debt to non-debt sources. BoP financing through non-debt flows, particularly FDI, may anticipate lower financing costs with more comparative stability than other capital flows. Since then, India has experienced a favourable BoP position, as evidenced by a modest Current Account deficit entirely covered by non-debt capital flows up to the global economic crisis that erupted in 2007 - 2008.

In contrast to previous years of liberalisation, the Current Account Deficit (CAD) increased to 2.3 per cent of GDP in 2008 - 09, primarily caused by the state of the world economy, which caused problems in financing BoP due to the insufficient net capital flows. FDI flows into India decreased in 2009. However, in contrast to other developing nations, FDI flows indicate a fall in 2010 despite the growth rebound occurring before the global recovery (RBI, 2012). In addition, financing the Current Account deficit was again troublesome in 2015 - 16, a year in which India received less non-debt capital flows than required. Therefore, the above evidence indicates that the management of BoP, particularly financing the Current Account deficit, persists even during the liberalisation period.

However, non-debt-producing flows are preferred over debt-creating flows for stability and cost of borrowing. In contrast, non-debt flows must be serviced only once profits are realised, but financing BoP with debt flows would result in a fixed cost of amortisation (Jalan, 1991). The financing of BoP under the liberalisation period has changed in favour of non-debt flows due to the policy change. Therefore, it is expected that these financing methods using non-debt capital flows - which include FDI and FPI - would have decreased the cost of financing BoP in the post-liberalization period. Although foreign investment rose throughout the post-liberalization era, a sizeable amount came from FPI, which lacks the characteristics of FDI.

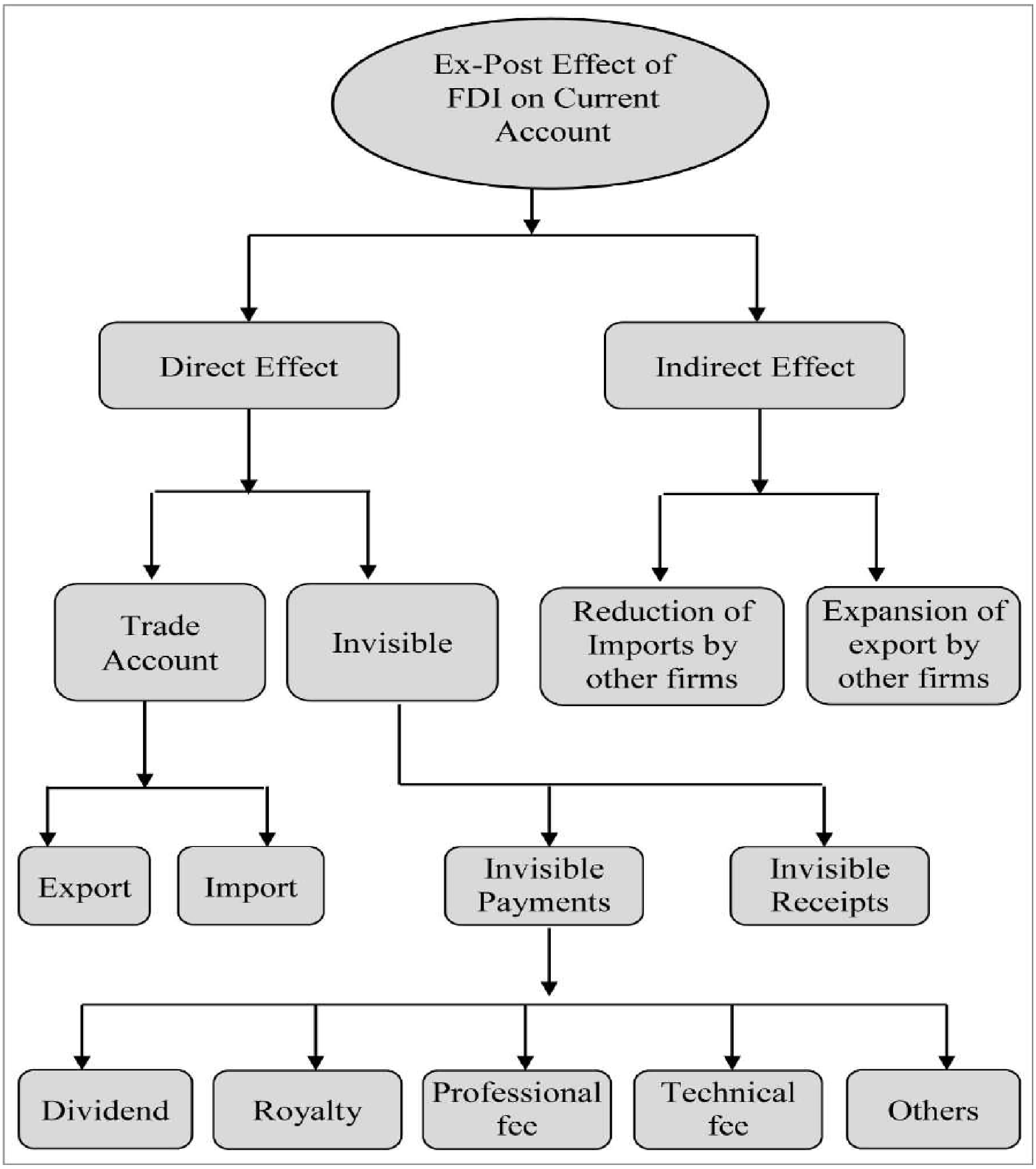
On the other hand, FDI is anticipated to improve the BoP by increasing foreign exchange profits, presumably through exports of products and services from the FDI enterprises, especially on the Current Account. However, during the past ten years, a sizeable portion of FDI has come from private equity and has shifted away from green field investments and towards Brownfield Projects (Reddy, 2008). Therefore, before drawing any conclusions about the advantages of FDI's Impact on the Current Account, the expectation of increased foreign earnings from the firms that got FDI must be assessed in detail. Firms that receive FDI can import products and services or borrow foreign currency spending to stay in the business (Sen, 1995).

The manufacturing industry is one of the key areas in India that received FDI after liberalisation. The manufacturing sector's contribution was 38.23 per cent between 2000 and 2005, but it fell to 24 per cent between 2016 and 2018 and ultimately to 20.56 per cent in 2019–20. The manufacturing industry accounts for a significant portion of all FDI flows during the liberalisation period. After liberalisation, these mergers and acquisitions were associated with about 54% of FDI inflow into the manufacturing sector. Therefore, it may not be connected to other economic capacity expansion (Rao et al., 2014). Additionally, FDI firms in the manufacturing sector have a very high tendency to import compared to their exports (Joseph, 2016; Nagaraj, 2017; Rajakumar, 2005).

Section III: Conceptualization of Indirect Effect of FDI Firms on Current Account of Balance of Payments

Initial and ex-post impacts can be distinguished when FDI has a whole effect on the Current Account (CA) of the Balance of Payments (BoP). The result of FDI flows recorded on the credit side of the Capital Account (KA) of Balance of Payments (BoP), is the first effect. The ex-post effect follows the initial effect, which is the impact of FDI on the BoP's Current Account. More specifically, the firms that received FDI began to impact the Current Account (CA) of the Balance of Payments (BoP) by exporting and importing products and services after receiving FDI on the Capital Account (KA) of the Balance of Payments (BoP). This is known as the long-term ex-post effect of FDI on the Current Account of BoP. The direct ex-post effect on the Current Account includes exporting and importing products and services, repatriating dividends, paying royalties, professional fees, consulting fees, travel expenses, technical fees, and other foreign exchange profits and expenditures. The indirect effect of FDI is the potential for FDI firms to boost the export inclination of the local firm. Additionally, FDI enterprises might lower their overall import expenditure by producing previously imported items domestically (Athreye & Kapur, 2001). The indirect ex-post effect of Foreign Direct Investment (FDI) on the Balance of Payment (BoP) is as essential as the direct effect, if not more important than the direct ex-post effect, given the potential effect it might cause on BoP in the long term. However, the task of estimating the indirect ex-post effect on BoP is challenging due to methodological considerations and the unavailability of appropriate data

Figure 1: Ex-post effect of FDI on the Current Account of BoP



Source: Constructed based onthe Balance of Payments statement in India

Section IV: Data and Methodology

The indirect ex-post effect is an essential effect of Foreign Direct Investment (FDI) firms on the Current Account (CA) of Balance of Payments (BoP). The total indirect ex-post effect can be divided into export and import sides. From the export side, it is expected that the FDI Companies can conceivably increase the export propensity of the domestic firm through spill-over effects (Athreye & Kapur, 2001). FDI companies can reduce the total import bill through domestic production by the FDI firms for previously imported goods from the import side (Athreye & Kapur, 2001). The total of the above effect is called the indirect ex-post effect. Therefore, the analysis is required to understand how the flow of Foreign Direct Investment (FDI) in the manufacturing sector is related to the export and import of non-FDI companies in the Manufacturing sector.

The Department for the Promotion of Industry and Internal Trade (DPIIT) provides data on Foreign Direct Investment (FDI) flow in the manufacturing sector. It is available month and year-wise. The newsletter (erstwhile SIA Newsletter) of DPIIT provides month-wise FDI data. DPIIT uses modified sectoral classification based on the Industries Act 1951 to represent FDI companies by sector. Economic and production activities are classified into 43 categories and 92 sub-categories. However, it is impossible to calculate the aggregate foreign direct investment (FDI) in the manufacturing sector from the DPIIT data. Therefore, DPIIT data was converted to NIC 2008 classification using the NCAR methodology(NCAER, 2009) to calculate the manufacturing sector's aggregate foreign direct investment data.

Estimates of export and import of Non-FDI firms in the manufacturing sector cannot be calculated from the available data source. Given the data unavailability, the study uses India's total export and import as the proxy variables to measure the indirect ex-post effect. The Directorate General of Commercial Intelligence and Statistics (DGCI&S) provides data on merchandise export and import of India. The study used Databases on the Indian Economy (DBIE) of the Reserve Bank of India (RBI) for extracting DGCI&S data. DBIE provides only quarterly exports and imports of India. Since the study period is from 2000 to 2020, the study used quarterly data to increase the number of observations. The study used quarterly data because monthly data is unavailable for export and import in the DBIE. Quarterly data of foreign direct investment (FDI) in the manufacturing sector is computed from the monthly data of DPIIT. Therefore, three variables are used to analyze export and import and FDI investment in the manufacturing sector.

The study examines how the Foreign Direct Investment (FDI)inflows in the manufacturing sector affect merchandise import and export in India to analyze the indirect ex-post effect of Foreign Direct Investment (FDI) firms on the Balance of Payments. The study used the monthly FDI Newsletter (erstwhile SIA Newsletter) data to compile quarterly data for FDI flows to India's manufacturing sector. Quarterly data on manufacturing export and import were collected from DGCI & S. Three variables are used: quarterly FDI flows to the manufacturing sector, quarterly merchandise export, and quarterly merchandise import. To find the relationship among variables, the ARDL Bound test of Cointegration is used to examine the variables' cointegration. The vector error correction model was run to test if the cointegrating variables were in short-term disequilibrium. To identify the direction of causality and check the cointegration results, the study ran for the Todo Yamamoto model of the Ganger non-causality test.

Given the problem, a two-way relationship can be expected among three variables. First, an increase in the flow of foreign direct investment (FDI) in the manufacturing sector can, in turn, cause an expansion of India's import and export volumes. Second, the expansion of exports and imports of India can, in turn, cause an increase in foreign direct investment (FDI) in the manufacturing sector. The study focuses more emphasis on the first relationship than the second. Therefore, the cointegration test can evaluate the relationship mentioned previously.

4.1 Cointegration Analysis

A cointegration test is applied when there is a long-term correlation between several time series. Nobel laureates Robert Engle and Clive Granger introduced the idea of cointegration in 1987. The Engle-Granger Method and the Johansen Cointegration Test are the two primary testing techniques for cointegration in time-series data. The Engle-Granger uses the first regression's residuals to determine whether the time series has unit roots. Engle-Granger uses the Augmented Dickey-Fuller Test (ADF) or Unit Root Test tests to examine the stationarity of time series units. The Engle-Granger test will indicate the residual stationarity if the time series exhibits cointegration. The Engle-Granger method's drawback is that it cannot be applied when there are more than two cointegrating links.

The Johansen test is an essential technique for evaluating cointegrating associations between various non-stationary time series data. Compared to the Engle-Granger test, the Johansen test can measure several cointegrating relationships. Large sample sizes are asymptotic features that affect the Johansen test. As a result, using very little sample data would result in incorrect results from the procedure. The Engle-Granger and Johansen techniques can be utilised only when variables are integrated in the same order.

Pesaran et al. (2001) created the ARDL bound testing as a cointegration technique to assess the long-term interaction among the variables. The ARDL bound test is a newly developed, advantageous way to examine cointegration. The Johansen and the Engle-Granger cointegration tests demand that all of the series be integrated of order 1 (i.e., I(1)). The Bounds cointegration test, in contrast, supports the combination of I(0) and I(1) and may be applied when a fractionally integrated series exists. There are short-run and long-run dynamics in this model. The empirical findings of the ARDL bound test methodology are significantly better than those of other cointegration techniques, which is one of its key benefits. The conventional F-test is used in this work to examine a co-integrated connection using the ARDL bound technique.

4.2 Causality Analysis

The study used the Todo Yamamoto model in the VAR framework to detect causality. The Toda and Yamamoto (1995) test involves the estimation of a vector autoregressive (VAR) model in levels, a method that minimizes the risks associated with incorrect identification of the order of integration of the respective time series and co-integration among the variables

Section V: ARDL Co-integration Test

The ARDL cointegration approach was developed by Pesaran and Shin (1999) and Pesaran et al. (2001). Three primary benefits of the ARDL model include: First, not every variable needs to be integrated in the same sequence. Second, the ARDL test is substantially more effective for small and finite sample data sizes. Third, the long-run model's unbiased estimates would be derived using the ARDL approach.

There are three variables in the Autoregressive Distributive Lag (ARDL) Bound test model: quarterly data of FDI flows in the manufacturing sector and quarterly data of exports and imports of India. Since the above three variables are a different order of integration, export and import are integrated into order one, and FDI investment in the manufacturing sector is integrated into zero (See Table 1). The ARDL bound test was employed in this study to examine the co-integration of the three variables mentioned above.

Table 1: ADF and PP unit root test on the log levels of variables

Variables	ADF test			PP test	
	SIC lag	T-stat	Critical Value at 5%	T-stat	Critical value at 5%
Ln(Export)	0	-1.166766 b	-3.467703	-0.707880	-3.467703
Ln(Import)	3	-0.269801 b	-3.470032	-0.131672	-3.467703
Ln(FDIM)	0	-3.956038 c	-2.898623	-4.006394	-2.898623

Source: Computed from DIIPT and DBIE using E Views Software Version 12

Table 2 : ADF and PP unit root test on the first differences of log levels of variables

Variables	ADF test			PP test	
	SIC lag	T-stat	Critical Value at 5%	T-Stat	Critical value at 5%
Ln(Export)	0	-10.30890 b	-3.468459	-11.74766	-3.468459
Ln(Import)	2	-7.320318 b	-3.470032	-11.39219	-3.468459
Ln(FDIM)					

Source: Computed from DIIPT and DBIE using E Views Software Version 12

The ARDL model used in this study is expressed as follows

$$D(\ln(Export_t)) = a_{01} + b_{11}\ln(Export_{t-1}) + b_{21}\ln(Import_{t-1}) + b_{31}\ln(FDIM_{t-1}) + \sum_{i=1}^{p} a_{1i}\ D\,(\ln(Export_{t-1})) + \sum_{i=1}^{q} a_{2i}\ D\,(\ln(Import_{t-1})) + \sum_{i=1}^{q} a_{3i}\ D\,(\ln(FDIM_{t-1})) + \varepsilon_{1i} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$D(\ln(Import_t)) = a_{02} + b_{12}\ln(import_{t-1}) + b_{22}\ln(Export_{t-1}) + b_{32}\ln(FDIM_{t-1}) + \sum_{i=1}^{p} a_{1i}\ D\,(\ln(Import_{t-1})) + \sum_{i=1}^{q} a_{2i}\ D\,(\ln(Export_{t-1})) + \sum_{i=1}^{q} a_{3i}\ D\,(\ln(FDIM_{t-1})) + \varepsilon_{2i} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$D(\ln(FDIM_t)) = a_{03} + b_{13}\ln(FDIM_{t-1}) + b_{23}\ln(Export_{t-1}) + b_{33}\ln(Import_{t-1}) + \sum_{i=1}^{p} a_{1i}\ D\,(\ln(FDIM_{t-1})) + \sum_{i=1}^{q} a_{2i}\ D\,(\ln(Export_{t-1})) + \sum_{i=1}^{q} a_{3i}\ D\,(\ln(Import_{t-1})) + \varepsilon_{3i} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The F-statistic, which under the null hypothesis of no cointegration follows an asymptotic distribution, is the basis of the bound test. Ordinary least squares (OLS) estimation of the three equations (1, 2, and 3) is the first stage in the ARDL technique. By conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, the estimation of the three equations compares the null hypothesis, H0: b1i = b2i = b3i = 0, to the alternative hypothesis, H1: b1i "" b2i ""b3i"" 0 for i = 1, 2 and 3.

Two sets of critical values for a given significance level can be determined (Pesaran et al., 2001). The first is the upper and the second is the lower bound. The ARDL model's first level is specified on the assumption that all of the model's variables are integrated in a sequence of zero.

The second one, however, is calculated assuming the variables are integrated into order one. When the test statistic result exceeds the upper critical boundaries value, the null hypothesis of no cointegration is rejected. In addition, it is permissible if the F-statistic is less than the value of the lower limits. The cointegration test is inconclusive if the estimated F statistic is between the lower and upper bound.

Using the Akaike information criterion (AIC), the study selects the highest lag order of 2 for the conditional ARDL vector error correction model. When each variable is considered a dependent (normalised) variable in the ARDL-OLS regressions, the derived F-statistics are shown in Table 3. They are as follows for equation (1), = 9.490083; for equation (2),= 4.283853; for equation (3), =7.816053.Since the F-statistics for the first equation (9.490083) and the third equation (7.816053) are higher than the upper-bound critical value (6.36) at the 1% level, it is obvious from these results that there is a long-term association among the variables when export and FDI are the dependent variables. However, because the estimated F statistic for the second equation (4.28) is less than the crucial value (5.1.5), the null hypothesis that there is no cointegration among the variables in equation (2) is accepted at a 1% level. For the other equations (1) and (3), the null hypothesis of no cointegration is rejected.

Table 3 : Results from bound tests

Dependent variable	AIC	F-statistics	Decision
F_{Export} *(Import, FDIM)*	2	9.490083	Cointegration
F_{Import} *(export, FDIM)*	2	4.283853	Not Cointegrated
F_{FDIM} *(export, Import)*	2	7.816053	Cointegration
Lower–bound critical value at 5 %		3.79	
Upper-bound critical value at 5 %		4.85	
Lower–bound critical value at 1%		5.15	
Upper-bound critical value at 1%		6.36	

Source: Computed from DIIPT and DBIE using E Views Software Version 12

As per the ARDL test, three equations are created out of three variables in which each variable acts as the dependent variable. Cointegration is identified when FDI in manufacturing and export is the dependent variable, and no cointegration is found when Import is the dependent variable. An error correction model was also run to know the short-term equilibrating relationship among cointegrating variables. However, cointegration is found in the first equation, where export is dependent. However, the expected independent variable FDI is insignificant in the ARDL model. This is because import is found significant in the first ARDL model equation and, thereby, the cointegration - results of the first equation show that the relationship between import and export is positive and significant. Still, an increase in FDI in manufacturing doesn't, in turn, cause an increase in exports. The second equation, where import is a dependent variable, shows that the equation is not cointegrated at 1 % level. The result is inconclusive at the 5 % level because the value of F statistics is 4.28, which lies between the lower and upper bound values.

But in the third equation, where foreign direct investment as a dependent variable shows that the equation is cointegrated at a 1 % level, both independent variables, such as export and import, are significant. The result of the third equation indicates that an increase in exports, in turn, causes an increase in FDI, but on the other hand, a rise in imports causes a decrease in the flow of FDI. Because of the above reasons, the error correction model is run only for the third equation, where FDI is a dependent variable. The model found the anticipated negative sign of the regression coefficient of the model. Therefore, the above cointegration model shows that the flow of FDI in manufacturing does not affect exports or imports. Export and import of India impact the flow of foreign direct investment (FDI) in the manufacturing sector.

The model is significant at a 1% level, and the regression for the basic ARDL equation (3) suits quite nicely. It also passes all the diagnostic tests against serial correlation (Durbin Watson test and Breusch-Godfrey test), heteroscedasticity (White Heteroskedasticity Test), and normality of errors (Jarque-Bera test). The short-run dynamics test the stability of the long-run coefficients. To evaluate the parameter stability, the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests are also computed (See Appendix) (Pesaran and Pesaran, 1997). The plot of the CUSUM is within acceptable bounds, which suggests that there is not much lack of any coefficient instability. However, the CUSUMSQ plot barely crosses the 5% probability range of parameter stability's significant bands.

Section VI: Todo Yamamotto Causality Analysis

Several tests have been created to determine a causal relationship. Quantifying causal effects from time series using the Granger causality test is standard practice. Traditionally, VAR model estimation is used to assess causality in the Granger sense. The non-stationary issue is still present in this model, though. When the Granger causality test is run at the first difference VAR framework, it will give false results, particularly in cointegration. It has been emphasised that eliminating biases while testing for unit roots and cointegration among the variables is a need for the validity of the causality test. Unfortunately, these tests are unreliable for ordinary time-series sample sizes because they are sensitive to the trend and constant term values in limited samples. Additionally, the traditional F-statistic employed to check Granger causality may be invalid. The test does not have a standard distribution when the time series data are integrated or cointegrated.

Toda and Yamamoto (1995) were created to examine Granger causality (1961) due to the above mentioned issue. They developed a technique based on the estimate of an enhanced VAR model (, where k is the optimal time lag for the initial VAR model, and dmax is the highest integrated order on the system's variables (VAR model). The Toda-Yamamoto causality test's primary goal is to solve the issue of incorrect asymptotic critical values that arise when causality tests are conducted when nonstationary are present. It facilitates the Granger Causality test, which is one benefit.

This section explains the Toda and Yamamoto process before going into detail about the empirical model used in this study. The Todo Yamamoto model employs a Modified Wald (MWALD) test to impose constraints on the parameters of the VAR (p) model. When a VAR [p + dmax] is estimated, this test has an asymptotic chi-squared distribution with p degrees of freedom in the limit. The technique is implemented in three parts. Test each time series in the first step to ascertain the system's variables' highest order of integration or dmax. The research obtains the most significant value (d_max) if the integration order varies. If the null hypothesis is non-stationary, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests can be employed to determine this.

On the other hand, the stationarity of the null hypothesis may be examined using the Kwiatkowski, Phillips, Schmidt, and Shin test (KPSS). In the second stage, a VAR model is built on series levels independent of the integration order, and the ideal lag length (k) is then determined. There is no way to predict the lag duration (p). As a result, it needs to be obtained using various lag length criteria, including the Akaike's information criterion (AIC), Schwarz information criterion (SC), final prediction error (FPE), and Hannan Quinn (HQ), information criterion in the process of the VAR at levels among the variables in the system. The third stage uses the modified Wald procedure to test the VAR (k) model for causality (Bakar, 2015).

The following bivariate VAR (k) Model is estimated in the study to test for Granger causation between three variables:

$$LEXPORT_t = \alpha + \sum_{i=1}^{k+d} \beta_1 \, LEXPORT_{t-i} + \sum_{i=1}^{k+d} \beta_2 \, LIMPORT_{t-i} + \sum_{i=1}^{k+d} \beta_3 \, LFDIM_{t-i} + \varepsilon_{t1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$LIMPORT_t = \alpha + \sum_{i=1}^{k+d} \beta_1 LIMPORT_{t-i} + \sum_{i=1}^{k+d} \beta_2 LEXPORT_{t-i} + \sum_{i=1}^{k+d} \beta_3 LFDIM_{t-i} + \varepsilon_{t2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$LFDIM_t = \alpha + \sum_{i=1}^{k+d} \beta_1 LFDIM_{t-i} + \sum_{i=1}^{k+d} \beta_2 LIMPORT_{t-i} + \sum_{i=1}^{k+d} \beta_3 LEXPORT_{t-i} + \varepsilon_{t3} \quad \ldots\ldots\ldots\ldots\ldots (6)$$

Table 4

VAR Granger Causality/Block Exogeneity Wald Tests

Date: 06/25/21 Time: 08:47

Sample: 2001Q1 2020q4

Included observations: 77

Dependent variable: LEXPORT			
Excluded	Chi-sq	df	Prob.
LIMPORT	4.099361	2	0.1288
LFDIM	2.311248	2	0.3149
All	7.068227	4	0.1323
Dependant variable: LIMPORT			
Excluded	Chi-sq	df	Prob.
LEXPORT	21.81448	2	0.0000
LFDIM	1.286357	2	0.5256
All	24.97470	4	0.0001
Dependent Variable: LFDIM			
Excluded	Chi-sq	df	Prob.
LEXPORT	6.377808	2	0.0412
LIMPORT	8.069071	2	0.0177
All	8.794512	4	0.0664

Source: Computed from DIIPT and DBIE using E Views Software Version

The Todo Yamamotto model confirms the evidence of cointegration in the ARDL Bound test. The above table indicates that the flow of FDI in the manufacturing sector doesn't cause imports and exports. However, the flow of imports and exports does cause the flow of foreign direct investment (FDI) in the manufacturing sector. The cointegration identified in ARDL bound test confirms the results in the causality check of the Todo and Yamamotto model. Therefore the empirical evaluation of the indirect ex-post effect shows that foreign direct investment (FDI) inflows into the manufacturing sector don't create additional strain on the Current Account(CA) of Balance of Payment (BoP) through its adverse effect on merchandise import. On the other hand, FDI flows into the manufacturing sector do not cause an increase in Export of India

Summary of Findings and Conclusion

The article examined the indirect ex-post effect of foreign direct investment (FDI) firms in the manufacturing sector using the ARDL bound cointegration test and the Todo Yamamotto model to causality. As per the ARDL test, three equations are created out of three variables in which each variable acts as the dependent variable. Cointegration is identified when FDI in manufacturing and export is the dependent variable, and no cointegration is found when Import is the dependent variable. An error correction model was also run to know the short-term equilibrating relation among cointegrating variables. However, cointegration is found in the first equation, where export is the dependent variable. However, the expected independent variable FDI is insignificant in the ARDL model. This is because import is found significant in the first ARDL model equation, thereby the reason for the cointegration - results of the first equation show that the relation between import and export is positive and statistically significant. But an increase in FDI in manufacturing doesn't, in turn, cause an increase in exports. The second equation, where import is a dependent variable, shows that the equation is not cointegrated at 1 % level. The result is inconclusive at the 5 % level because the value of F statistics is 4.28, which stands between the lower and upper bound limit.

But in the third equation, where FDI as a dependent variable shows that the equation is cointegrated at a 1 % level, both independent variables, such as export and import, are significant. The result of the third equation indicates that an increase in exports, in turn, causes an increase in FDI, but on the other hand, a rise in imports causes a decrease in the flow of FDI. Because of the above reasons, the error correction model is run only for the third equation, where FDI is a dependent variable. The model found the expected negative sign of the regression coefficient of the error correction model. Therefore, the above cointegration model shows that the flow of FDI in manufacturing does not affect exports or imports. Export and import of India impact the flow of Foreign direct investment (FDI) in the manufacturing sector.

The Todo Yamamotto model confirms the evidence of cointegration. It can be seen that the flow of foreign direct investment (FDI) in the manufacturing sector doesn't cause imports and exports. However, the flow of imports and exports does cause the flow of FDI in the manufacturing sector. The cointegration found in ARDL bound test confirms the results in the causality check of the Todo and Yamamotto model. Therefore, the empirical direct ex-post effect shows that foreign direct investment (FDI) inflows into the manufacturing sector create additional strain on the Current Account (CA) of Balance of Payments (BoP) through its negative effect on merchandise import. On the other hand, FDI flows into the manufacturing sector does not cause an increase in export to India.

To conclude, FDI flows in the manufacturing sector doesn't cause more imports and export to India. However, India's exports and imports impact the in-flow of Foreign direct investment (FDI) in the manufacturing sector. Therefore, the empirical evaluation of the indirect ex-post effect shows that FDI flows neither worsened the Current Account (CA) of Balance of Payment(BoP) through the negative effect on merchandise import nor caused any positive effect on any export increase in India. Given the lack of positive indirect ex-post effect, policy regulations are also needed to improve the linkages between FDI and Non-FDI firms in the economy, leading to increased exports and fewer imports in the Balance of Payments.

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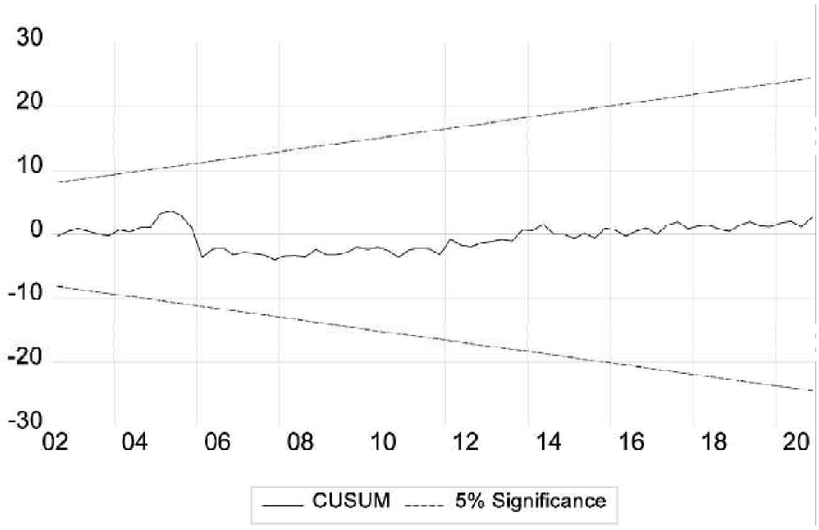
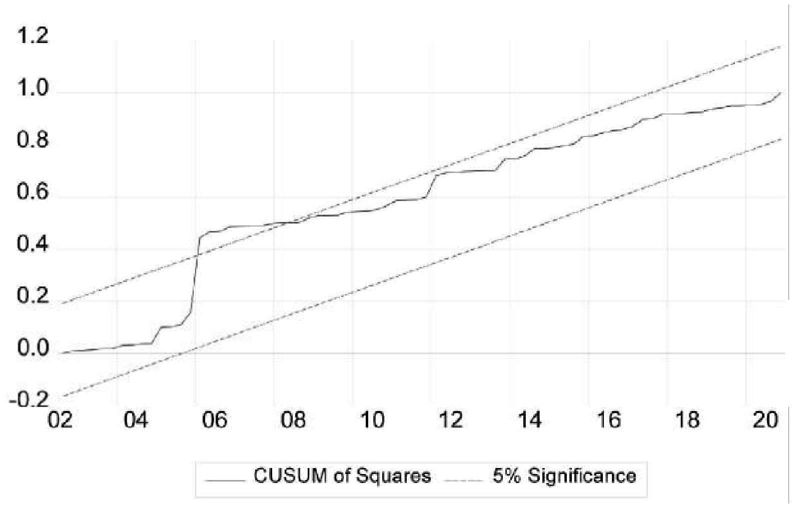
Appendix

1. CUSUM Plot (For Third equation of ARDL where lfdim as dependent variable)



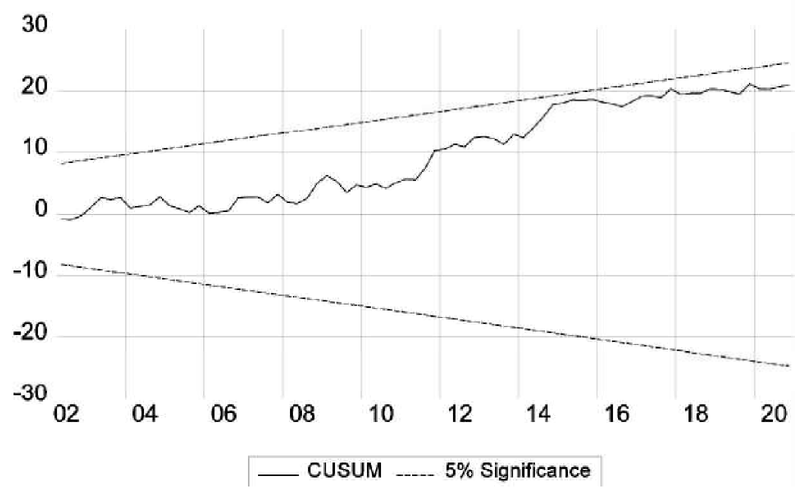
Source: Computed from DIIPT and DBIE using E Views software Version 12

2. CUSUM Square (For Third equation of ARDL where lfdim as dependent variable)



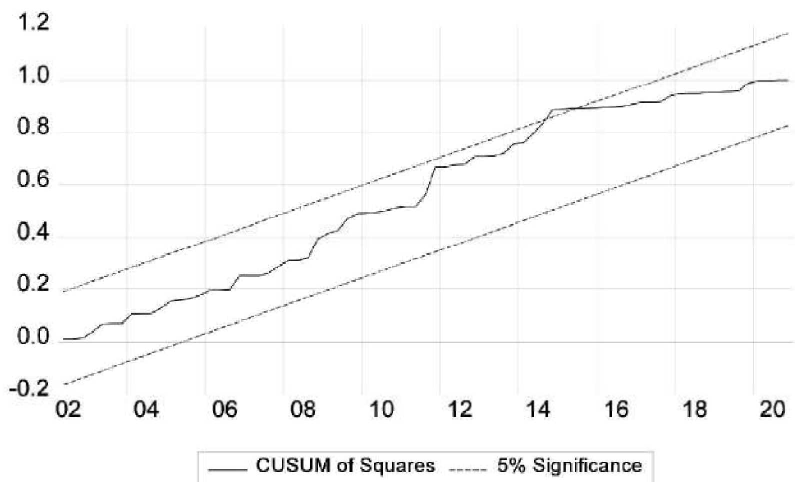
Source: Computed from DIIPT and DBIE using E Views software Version 12

3. CUSUM Plot (For first equation of ARDL where lexport as dependent variable)



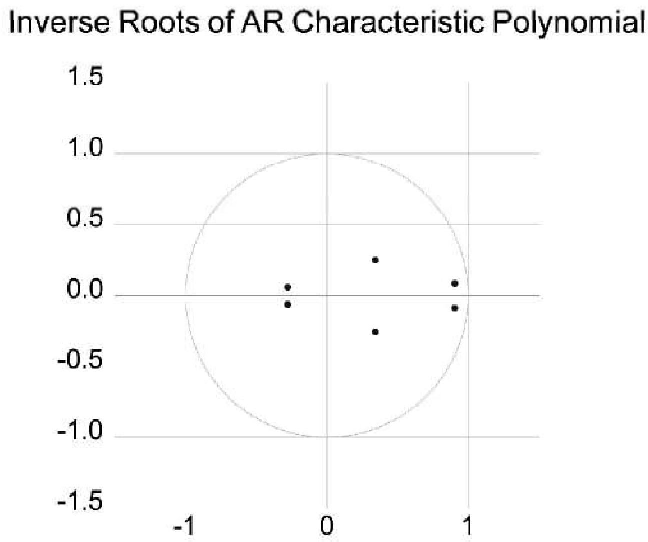
Source: Computed from DIIPT and DBIE using E Views software Version 12

4. CUSUM Square (For first equation of ARDL where lexport as dependent variable)



Source: Computed from DIIPT and DBIE using E Views software Version 12

5. Inverse Root of AR Characteristic Polynomial



Source: Computed from DIIPT and DBIE using E Views software Version 12

Climate Change and Energy Resilience: An Analytical Study of The Power Sector in Kerala

Shanimol Emerson
& Sindhu S. Nair

Kerala has been experiencing severe climate changes, mirroring a global challenge that affects multiple sectors, including energy. The state's energy infrastructure is particularly vulnerable to rising temperatures, shifting precipitation patterns, and the increasing frequency of extreme weather events. The power sector in Kerala not only contributes to climate change but also bears its most severe consequences. This paper aims to examine the long run effects of climate change in Kerala and its impact on the power sector and identify the associated risks and challenges. Forecasting tools like ARIMA models or climate-sensitive energy models are used to predict future energy demand and supply gaps under various climate scenarios, helping policymakers prepare for potential challenges. The widening gap between demand and supply highlights potential risks of energy shortages and underscores the need for improved local energy generation and diversification to ensure future energy security.

Keywords: Climate change, electricity demand, electricity supply, Kerala, power crisis, energy efficiency, adaptation strategies.

1. Introduction

Land use, climate change, and energy choices are linked, and understanding their interactions can impact ecological patterns and processes(Dale et al., 2011). Climate change is real, and its effects are increasingly evident across sectors, including India's power sector.The Co2 emission rates in India are high, despite the country having relatively low per capita emissions. As the population becomes more affluent and energy consumption rises, the power sector, which currently depends heavily on coal, is expected to expand. Consequently, unless significant changes are made to the electricity production sector, greenhouse gas emissions and other forms of air pollution are likely to increase as well (Sengupta et al., 2022).

Kerala, the southern state of Indian peninsula is no exception to this. Once renowned as "Gods own Country" for its temperate climate is now grappling with profound environmental crisis. Hydropower constitutes the primary basis of the state's energy infrastructure, contributing 72% of its electricity generation, with thermal power plants representing the next most significant source. Kerala, which was a power surplus state until 1987 and capable of supplying electricity to neighbouring states, now experiences power shortages of varying magnitudes, largely dependent on the intensity and variability of the monsoons (Indian Economic Review, 1997). The state's power industry, which is vital to its economic expansion, is facing more difficulties as a result of temperature rise, altered rainfall patterns, and extreme weather occurrences. Given its distinct geographic and climatic characteristics, Kerala is particularly susceptible to the adverse impacts of climate change. Long-term trends of climatic variables in Kerala shows rising air temperature, relative humidity, sea level pressure, and sea surface temperature, with varying precipitation rates, indicating climate change impacts (Krishnan et al., 2024) (Rajendran et al., 2022).

On the demand side, Kerala exhibits a notable pattern of continuous growth in electricity consumption, with household usage surpassing commercial needs. This trend emphasizes the importance of addressing and meeting the energy demands of the state. The power sector in Kerala is highly dependent on rainfall for electricity generation. However, the state's own power production is both inconsistent and insufficient to meet the growing demand. With 76% of its electricity imported from other states, Kerala may encounter difficulties as these states shift towards cleaner energy, complicating electricity imports(Pohit et al., 2023). Achieving sustainable power generation in the state is increasingly critical as the state faces growing energy demands and the challenges of climate change.

With the change in intensity and patterns of extreme weather conditions, it is imperative to look into the energy profile of Kerala. Studying the relationship between climate change and electricity consumption is crucial for understanding the environmental and socio-economic impacts of rising temperatures. Assessing the impact of climate change on the electricity sector is vital for the development of future electricity markets and system models. A thorough understanding of current climatic trends is essential for fostering sustainable growth in the power sector, as climate change can reduce power plant efficiency and lead to higher peak demand due to increased cooling needs during hotter summers (Chandrasekhar & Reddy, 2022) and (Císcar & Dowling, 2014). Studying climate change is essential in the context of achieving sustainable power generation because it directly influences both the supply and demand sides of energy. This paper seeks to explore the long-term effects of climate change in Kerala and its implications for the power sector, identifying the associated risks and challenges. It also provides an overview of Kerala's current electricity landscape and examines the state's potential for renewable energy development.

Numerous studies have examined climate change in India and Kerala, with a focus on variables such as rainfall and temperature, as well as on the power sector independently(Bhattacharjee et al., 2023) (Krishnakumar et al., 2009) (Ajithkumar & Riya, 2022). Furthermore, there exists a body of research dedicated to analysing the effects of climate change on the power sector (Mideksa & Kallbekken, 2010) (Cox et al., 2017) highlighting how climate change will influence the demand and supply dynamics of the power sector.

Although extensive research exists on the effects of climate change on the power sector at a global or national level, there is a noticeable lack of studies focusing on specific regions, such as Kerala. This absence is particularly important because localized research is crucial for understanding the distinct ways in which climate change impacts regional power systems. Kerala, with its unique climatic conditions and energy needs, represents a key area where focused studies could shed light on specific challenges and potential solutions for enhancing energy resilience. Filling this research gap could lead to more effective, region-specific strategies and policies, improving climate adaptation efforts within the power sector.

Objectives of this study are:

1. Analyse the energy profile of Kerala to understand key trends in capacity, generation, and consumption.
2. Evaluate the impact of climatic factors like temperature and rainfall on the state's electricity demand.
3. Forecast the demand-supply gap to support better planning for Kerala's energy sector.

2. Literature Review

2.1 Climate Change and Electricity Consumption

The relationship between climate change and electricity consumption is increasingly important due to rising global temperatures and shifting weather patterns, which significantly affect energy demand for heating and cooling. Research shows that a 1°C rise in summer temperatures can lead to a 0.015% increase in per capita electricity consumption, while a decrease in winter temperatures have a smaller impact (0.002%) (Zhang et al., 2019). Studies from regions like Serbia and tropical areas further confirm that both extreme cold and heat drive electricity demand, particularly for heating and air conditioning. Notably, Singapore and Hong Kong experience a 3-5% increase in annual electricity consumption with a 1°C temperature rise (Ang et al., 2017). The relationship between temperature and electricity usage is complex, with specific thresholds indicating where demand surges (Valor et al., 2001). In China, extreme heat days are projected to increase residential electricity consumption significantly, driven mainly by air conditioning (Zhang et al., 2022). Additionally, geographical disparities exist; northern Europe may see reduced heating costs due to warmer winters, while southern Europe faces higher cooling demands (Pilli-Sihvola et al., 2010). Overall, climate change not only raises electricity demand but also exacerbates air pollution and economic costs, particularly in areas dependent on thermal power generation (Huang et al., 2024).So, fluctuations in temperature directly influence electricity consumption, with increased demand for heating in colder periods and cooling in warmer ones. As temperatures rise, especially in regions reliant on-air conditioning, electricity demand can surge significantly, often outpacing supply capabilities. Studies have demonstrated that a 1°C increase in summer temperatures can lead to a marked rise in electricity usage, particularly in tropical and subtropical areas where cooling systems are heavily utilized. Conversely, extreme cold spells during winter months also drive-up electricity consumption for heating, further complicating the supply-demand balance. This dual pressure can strain electrical grids, particularly in regions that may not be equipped to handle such spikes in demand, leading to outages or shortfalls. Moreover, the relationship between temperature and electricity consumption is complex and nonlinear; it varies based on factors like geographical location, infrastructure, and socioeconomic conditions.

The demand-supply gap is further exacerbated by the limitations of existing energy systems, which may not be designed to accommodate sudden shifts in consumption patterns. As a result, there is a critical need for proactive measures, including investments in energy-efficient technologies, upgrades to grid infrastructure, and the integration of renewable energy sources.

Kerala, with its distinct monsoon climate and tropical temperatures, has seen a sharp increase in electricity consumption in recent years. Studies on Kerala's energy sector indicate that temperature -induced changes in electricity consumption are likely to exacerbate the existing demand-supply gap (Chandrasekhar & Reddy, 2022). As temperatures continue to rise, particularly during the summer months, the demand for cooling increases, putting pressure on the electricity grid. This has led to significant supply constraints, especially during peak demand periods (Nair et al. 2019). Kerala's dependency on hydropower- exacerbates the situation, as climate change has also affected rainfall patterns, leading to variability in hydropower generation. With less rainfall during critical periods, the state oftenfaces electricity shortages, which are worsened by increased temperature-driven demand.

2.2 Theoretical Framework: Temperature-Electricity Nexus

The theoretical framework that emerges from the reviewed literature is based on the temperature-electricity nexus, which posits that electricity consumption is highly sensitive to fluctuations in temperature. As global temperatures rise, electricity demand for cooling increases, particularly in warmer regions, while colder regions experience a moderate rise in electricity use for heating. This relationship is moderated by socioeconomic factors, such as income levels, and is influenced by the availability of alternative energy sources for heating and cooling.

Several theoretical frameworks have been developed to analyze the relationship between climate change and energy demand. One of the most prominent models is the energy-climate nexus, which posits that climate conditions, including temperature, precipitation, and humidity, directly influence energy consumption patterns. This framework helps explain how rising temperatures drive energy demand, particularly for cooling. The "Environmental Kuznets Curve" (EKC) is another theoretical framework frequently referenced in studies on energy consumption and climate change. This framework suggests that energy consumption rises with economic development until it reaches a tipping point, after which technological advancements and energy-efficient practices help reduce consumption. However, in developing regions like Kerala, where energy efficiency measures are still in the early stages of implementation, the rise in energy demand due to climate change has not yet plateaued.

Another key theoretical model is the "degree-day" concept, which measures the deviation of temperatures from a baseline "comfort" temperature (typically 18°C) to estimate energy demand for heating (heating degree-days) or cooling (cooling degree-days) (Valor et al., 2001). This model has been used extensively in forecasting electricity consumption in the context of climate change, providing policymakers with insights into future energy demand under different climate scenarios.

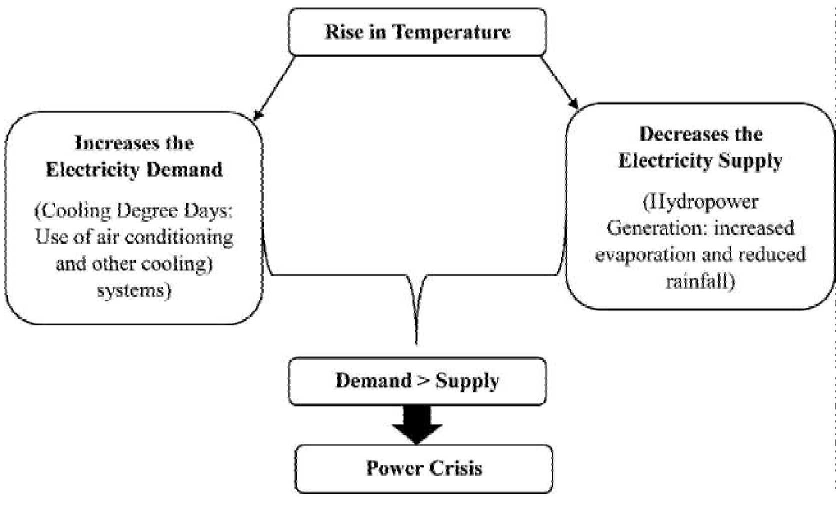
The "degree-day" concept is particularly important for Kerala as it provides a systematic approach to understanding and predicting electricity demand in response to temperature fluctuations due to climate change. By measuring deviations from a baseline "comfort" temperature (typically around 18°C), this model helps to estimate the energy requirements for both heating and cooling in residential and commercial sectors. In a region like Kerala, where temperatures can significantly influence the use of air conditioning and other cooling systems, the degree-day model enables policymakers to forecast future electricity demand accurately under various climate scenarios.

3. Conceptual Framework

The relationship between increased temperatures and electricity consumption in Kerala is pivotal, especially as climate change continues to influence weather patterns. Rising average and peak temperatures result in a greater demand for cooling systems, particularly air conditioning, which is essential in the hot and humid climate of the region. This increased electricity demand can be effectively measured using the degree-day model, which quantifies the demand for cooling (Cooling Degree Days, or CDD). As temperatures surpass a baseline comfort level, typically around 25°C, the demand for cooling rises, leading to an increase in electricity consumption. Each additional CDD correlates with a specific percentage increase in electricity demand, placing significant stress on the existing electricity supply infrastructure.

Simultaneously, rising temperatures can negatively impact electricity supply in Kerala, primarily due to the state's reliance on hydropower for electricity generation. Higher temperatures contribute to increased evaporation rates from reservoirs and alter rainfall patterns, which can result in reduced water levels and diminished hydropower generation capacity. This decrease in available water directly affects the electricity supply, making it increasingly challenging to meet the surging demand. The interplay between increased demand and decreased supply creates a critical gap, leading to an imbalance in the energy system. As electricity consumption peaks, particularly during hot weather, this situation culminates in a significant power crisis.

The combined effect of increased electricity demand from higher temperatures and decreased supply due to reduced hydropower capacity creates a scenario where demand consistently outstrips supply. This imbalance results in power shortages and load shedding, posing substantial challenges for both residential and commercial consumers. Such crises are particularly pronounced during peak consumption periods, when the demand for cooling is at its highest. Thus, understanding this dynamic is essential for managing energy resources and ensuring a stable power supply.



Independent Variable:

Temperature Changes: Measured Cooling Degree Days (CDD), indicating the demand for cooling based on deviations from a baseline comfort temperature (typically 35°C).

Dependent Variable:

Electricity Demand: The total electricity consumption by residential, commercial, and industrial sectors in Kerala.

In the context of Kerala, a suitable degree-day model to assess the impact of temperature changes on electricity demand could be a Modified Degree-Day Model. This model can be adapted to the specific climatic conditions and energy consumption patterns observed in Kerala. Below are key components and considerations for implementing this model:

Cooling Degree Days (CDD): Measures the number of degrees that a day's average temperature is above a baseline (typically 25°C) and indicates the demand for cooling.

$$CDD = \sum_{i=1}^{n} \max(0, T_{avg,i} - T_{base})$$

Where Ti is the daily maximum temperature, Tbase is the baseline comfort temperature (typically set at 35°C), and n represents the total number of days in the analysis period.

4. Data & Methodology

4.1 Data Source

This study utilized secondary time series data to analyse the relationship between temperature changes and electricity consumption in Kerala. The dataset comprised two primary components: electricity consumption data and temperature data. The electricity consumption data, which includes unrestricted electricity demand, was sourced from the Power System Statistics by Kerala State Electricity Board (KSEB). This data spans from 1988 to 2023, enabling a comprehensive examination of consumption patterns and trends over time. For temperature data, daily maximum and minimum temperatures were obtained from the NASA website (gridded data) from the year 1990 to 2022. Rainfall data was taken from the India Meteorological Department (IMD) gridded database for the same period.

4.2 Methodology

The time series data for both electricity consumption and temperature was cleaned and pre-processed to handle any missing values or outliers. This involved normalizing the data to ensure comparability across different time periods. To quantify the relationship between temperature and electricity consumption, the study employed the degree-day model. Cooling Degree Days (CDD) were calculated using the formula that considers daily maximum temperatures relative to a baseline comfort temperature, typically set at 35°C. This calculation enabled the quantification of the additional energy demand required for cooling as temperatures rise.

Statistical Analysis: To explore the relationship between temperature and electricity consumption, various statistical methods were applied:

- Regression Analysis: simple regression analysis was used to examine the impact of temperature (measured in degree-days) on electricity consumption. This method allowed for the assessment of the strength and direction of the relationship while controlling for other variables, such as seasonal effects.

Demand Side:

$$Ln\ (Per\ Capita\ Electricity\ Consumption) = \beta 0 + \beta 1\ .Ln\ (CDD\ or Annual\ Number\ of\ Days\ with\ Heat\ Index > 35°C) + \in$$

Supply Side:

$$Ln\ (Own\ Power\ Generation) = \beta 0 + \beta 1\ .Ln\ (Rain\ Fall\ in\ mm) + \in$$

Power Crisis:

$$Ln\ (Purchased\ Power) = \beta 0 + \beta 1\ .Ln\ (Rain\ Fall\ in\ mm) ++ \beta 2\ .Ln\ (CDD\ or Annual\ Number\ of\ Days\ with\ Heat\ Index > 35°C) + \in$$

- Time Series Analysis: Time series analysis techniques, including Autoregressive Integrated Moving Average (ARIMA) models, were employed to forecast electricity demand (Unrestricted) and supply based on historical data trends and temperature variations. This analysis accounted for autocorrelation and seasonality within the data.
- Correlation Analysis: Pearson correlation coefficients were calculated to measure the strength of the relationship between temperature and electricity consumption, providing a preliminary understanding of the degree of association between the two variables.

To determine the demand-supply gap by subtracting the estimated electricity supply from the projected demand for corresponding time periods (daily, monthly, or annually):

$$Gap = Demand - Supply$$

To analyze the demand-supply gap in electricity consumption in relation to temperature change, we represented this relationship with the following regression model

Model Specification: Let Gt denote the demand-supply gap for electricity at time t. The model was expressed as:

$$Gt = f\ (Tt) + \in t$$
$$Gt = \beta 0 + \beta 1\ Tt\ + \in t$$

Where:

Gt: The demand-supply gap at time t (calculated as demand minus supply).

Tt: The average temperature at time t (°C), which represented the temperature change influencing electricity demand.

∈t: The error term, capturing unobserved factors that may have affected the demand-supply gap.

- Mann-Kendall test: In the current study, the Mann-Kendall test was utilized to analyze trends in temperature and precipitation data over time. This non-parametric statistical method was selected for its ability to identify significant trends in climatic variables without assuming a specific distribution, making it particularly suitable for environmental data.By applying the Mann-Kendall test to the temperature and precipitation data, the study aimed to identify significant trends that could inform our understanding of how climate change affects electricity demand and supply dynamics in Kerala.

In the current study, restricted electricity demand was utilized to analyze the impact of temperature changes on the supply-demand gap in Kerala, as this approach captures the total electricity consumption that could occur with limitations, reflecting peak load conditions during hotter months when air conditioning usage significantly increases. This perspective is particularly relevant given the ongoing effects of climate change, which are expected to escalate electricity consumption patterns, especially as temperatures rise above a baseline "comfort" temperature of 35 degrees Celsius. This threshold is significant because it indicates when consumers typically seek additional cooling solutions, thereby impacting overall demand. By focusing on unrestricted demand with a baseline of 35 degrees Celsius.

5. Results and Discussion

5.1 Temperature Variation in Kerala

Temperature variation in Kerala has become a significant concern, with studies showing a consistent warming trend across the state. Kerala's tropical climate and geographical features lead to notable seasonal temperature fluctuations. "Average temperatures typically range between 28°C and 32°C, with an annual rainfall of around 3000 mm. Over the past 40 years, temperature trends reveal a clear seasonal pattern: temperatures start rising in January, peak during March and April, and cool down with the onset of the monsoon in June, making July and August the coolest months. The winter season, with relatively lower temperatures, runs from November to January (Mohan, 2023). A study covering from 1980 to 2020 reveals that Kerala has experienced a temperature increase of 0.03ºC per year, aligning with global warming trends. Future projections under different Representative Concentration Pathways (RCPs) suggest continued warming, with temperatures rising at a rate of 0.03ºC per year under RCP 4.5, and more rapidly under RCP 8.5-0.05ºC per year by mid-century and 0.06ºC per year by the end of the century (Ajithkumar and Riya, 2022).

Table 1 : Climate Change in Kerala from 2016-2022

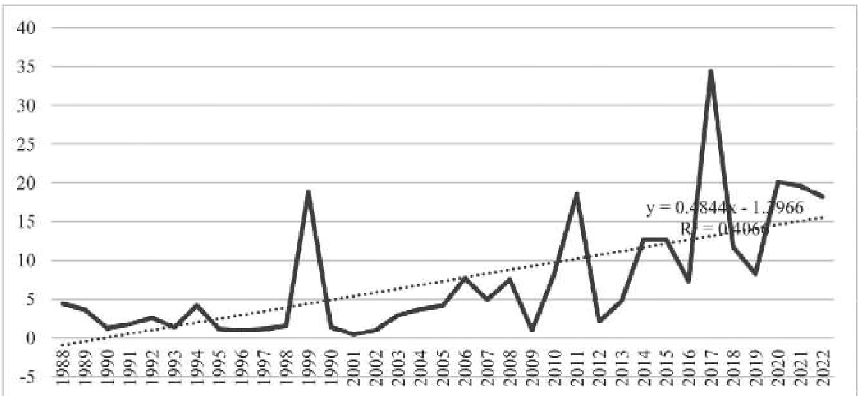
Climate Change Parameter	Year	Average	SD	CV
Temperature (^{0}C)	2016	11.144	2.738	24.569
	2017	10.285	3.151	30.637
	2018	10.504	2.740	26.084
	2019	10.332	3.073	29.743
	2020	10.116	2.648	26.177
	2021	9.677	3.100	32.040
	2022	9.988	2.319	23.221
	ALL(2016-2022)	10.292	2.767	26.884
Maximum Temperature (^{0}C)	2016	32.477	2.746	8.456
	2017	31.705	2.684	8.464
	2018	31.648	2.378	7.513
	2019	32.340	3.002	9.282
	2020	31.921	2.870	8.992
	2021	31.033	2.538	8.178
	2022	31.162	2.205	7.075
	ALL(2016-2022)	31.755	2.597	8.178
Minimum Temperature (^{0}C)	2016	21.334	2.018	9.460
	2017	21.420	1.935	9.032
	2018	21.143	1.767	8.356
	2019	22.009	1.798	8.169
	2020	21.805	1.706	7.824
	2021	21.356	1.882	8.812
	2022	21.174	1.377	6.502
	ALL(2016-2022)	21.463	1.754	8.171

Actual Rainfall (mm)	2016	131.463	149.656	113.839
	2017	115.156	100.287	87.088
	2018	212.996	242.610	113.904
	2019	231.826	264.768	114.210
	2020	207.236	199.479	96.257
	2021	262.322	185.606	70.755
	2022	228.276	199.638	87.455
	ALL(2016-2022)	198.468	197.704	99.615

Source : Authors Computation

Table.1 The data from 2016 to 2022 reveals notable climate variation in Kerala, suggesting potential signs of climate change over the years. The average temperature fluctuated throughout the period, starting at 11.144°C in 2016, dropping to 9.677°C in 2021, and slightly increasing to 9.988°C in 2022. This variability indicates shifts in the region's temperature patterns. The maximum temperature remained fairly stable but varied year by year, with the highest recorded in 2016 at 32.477°C and the lowest in 2021 at 31.033°C. Minimum temperatures also showed fluctuations, reflecting changes in both daily highs and lows, which may signify alterations in the region's overall weather conditions. Additionally, rainfall exhibited significant variability, with extreme levels recorded in 2018 and 2019. The coefficient of variation for rainfall was high at 99.615%, indicating substantial unpredictability in precipitation patterns. These variations in temperature and rainfall align with broader global trends linked to climate change, suggesting that Kerala is experiencing shifts in its climate over the years, particularly in the frequency of extreme weather events and deviations from traditional weather patterns.

Figure 1: Annual Number of Days with Heat Index > 35°C



Source: Climate Knowledge Portal, World Bank

Figure 1 on the annual number of days with a heat index greater than 35°C from 1988 to 2022 shows significant variation and a general upward trend in recent years, suggesting increasing instances of extreme heat in Kerala. In the earlier years (1988-1997), the number of days with a heat index above 35°C remained relatively low, fluctuating between 0.96 and 4.43 days annually. However, there was a noticeable spike in 1999, with 18.85 days, followed by a decrease in the early 2000s. After 2006, the frequency of extremely hot days started to increase more consistently, with notable peaks in 2010 (8.27 days), 2011 (18.55 days), and a dramatic surge in 2017 with 34.49 days. The trend continued, with years like 2020 and 2021 seeing over 18 days, reflecting the growing impact of rising temperatures and heat stress. This pattern indicates that Kerala has been experiencing more frequent and sustained periods of extreme heat, which could have significant implications for public health, agriculture, and electricity demand in the region.

Table 2 : Mann-Kendall Test Results for Temperature and Rainfall Trends in Kerala

Variable	Tau Value	p-Value	Significance
Maximum Surface Temperature	0.268	0.023	Statistically significant ($p < 0.05$)
Minimum Surface Temperature	0.557	0.000	Statistically significant ($p < 0.05$)
Rainfall	0.111	0.347	Not statistically significant ($p > 0.05$)

Source: Authors Computation

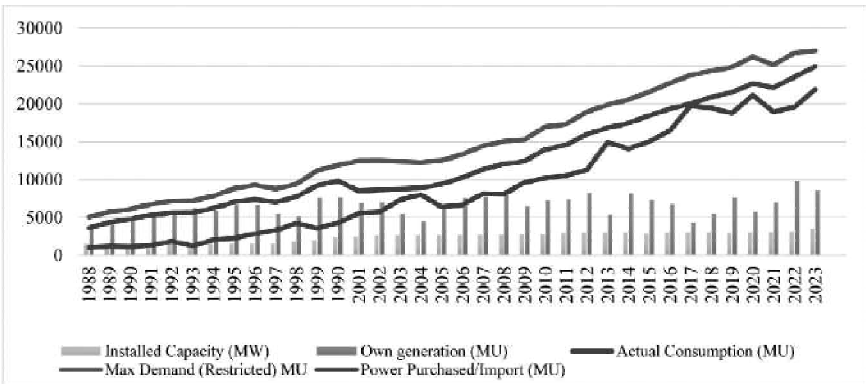
Table.2 The Mann-Kendall test revealed a significant increasing trend in the annual average maximum surface temperature ($\tau = 0.268$, $p = 0.0228$). The positive tau (τ) value suggests a moderate upward trend in maximum temperatures over the past 35 years. This indicates that the region has experienced warming at the maximum temperature level, and the trend is statistically significant at the 5% level. This finding is consistent with global warming patterns observed in various regions, which may have implications for the local energy demand.

A strong, statistically significant increasing trend was observed for the annual average minimum surface temperature ($\tau = 0.557$, $p < 0.00001$). The high positive tau value indicates that minimum temperatures have increased substantially over the years. The significance of this trend suggests that the region is experiencing warmer nights and reduced temperature variation between day and night.

The analysis of rainfall data did not reveal a significant trend ($\tau = 0.111$, $p = 0.3473$). Although the tau value was positive, indicating a slight upward trend, the result was not statistically significant at the 5% level. This suggests that while there may be some variation in annual rainfall, there is no clear evidence of a long-term increase or decrease in rainfall amounts during the study period. This could imply that rainfall patterns have remained relatively stable, although other factors such as the intensity and seasonality of precipitation events were not examined in this analysis.

5.2 Power Sector in Kerala

Figure 2 : Profile of Power Sector in Kerala



Source: Source: Power System Statistics, KSEB

Figure. 2 Kerala's electricity supply is largely dependent on hydropower, which accounts for a significant portion of the state's energy production. However, in recent years, the state has diversified its energy sources, incorporating thermal power, wind energy, and solar energy into its grid. The state's electricity consumption pattern shows the trend of demand peaking during the summer months due to increased usage of cooling appliances, especially in urban areas. At the same time, the state faces challenges in power generation during these periods, as rising temperatures reduce water levels in reservoirs, negatively affecting hydropower generation. This creates a demand-supply gap, leading to increased reliance on electricity imports from neighbouring states or on thermal power plants, which are more expensive and contribute to carbon emissions.

In response to these challenges, Kerala has been investing in renewable energy projects, particularly solar power, through initiatives like the Soura project, aiming to reduce dependency on hydropower and non-renewable energy sources. The state's power sector also faces issues related to transmission losses, aging infrastructure, and the need for grid modernization. However, Kerala has made significant strides in providing near-universal electricity access, with high levels of household electrification and efforts towards sustainability. The state continues to balance its energy demand with renewable energy goals while addressing the vulnerabilities posed by climate change to its power generation capacity.

The power sector in Kerala has undergone significant changes in terms of installed capacity, electricity generation, and consumption over the years. From 1988 to 2023, the installed capacity increased from 1,476.5 MW to 3,514.81 MW, reflecting efforts to expand the state's energy infrastructure. However, despite this increase in capacity, the state's own generation of electricity has fluctuated, showing periods of growth and decline, influenced by factors such as hydroelectric generation dependency and climatic variations. In 2022, Kerala generated 9,742.28 million units (MU) of electricity, a notable increase from 4,325.08 MU in 2017, but still below the growing consumption demand.

Kerala's electricity consumption has steadily risen, driven by factors such as population growth, urbanization, and the increasing use of electrical appliances. In 1988, the actual consumption stood at 3,626 MU, but by 2023, this figure had increased to 24,923.51 MU. This rise in demand has outpaced the state's own generation, leading to a growing reliance on power imports and purchases from neighbouring states and central grids. In 2023, Kerala imported 21,876.93 MU, highlighting the state's reliance on external sources to meet its energy needs.

The demand for electricity also reached a peak restricted maximum of 27,009.74 MU in 2023, indicating the strain on supply infrastructure due to increased consumption. This imbalance between demand and supply has prompted Kerala to invest in alternative sources such as solar and wind energy, but challenges remain in aligning supply with demand effectively. Additionally, Kerala's number of electricity consumers has grown substantially, from 2.76 million in 1988 to over 13.6 million by 2023, reflecting the state's extensive electrification efforts.

Per capita electricity consumption has also seen a sharp rise from 172 kWh in 1988 to 682 kWh in 2023, as living standards have improved and electricity usage has become more widespread. However, the significant coefficient of variation (CV) values across several parameters such as power purchases (75.17%) and electricity consumption (51.26%) indicate volatility in the sector, driven by factors such as fluctuating hydroelectric generation, seasonal demand shifts, and the changing energy landscape in Kerala.

5.3 Impact of Climate Change on Electricity Demand in Kerala

The impact of climate change on electricity consumption in Kerala is significant, driven primarily by the rise in average and peak temperatures. As temperatures increase, particularly due to the state's hot and humid climate, the demand for cooling systems such as air conditioning rises sharply. This increased demand is closely associated with the Cooling Degree Days (CDD) model, which measures the demand for cooling when temperatures exceed a baseline comfort level, typically around 30°C. As the number of CDDs increases, so does the electricity consumption, straining the region's electricity infrastructure. This growing demand for electricity during hotter periods is exacerbated by a simultaneous reduction in electricity supply, particularly from Kerala's hydropower sources. Climate change-induced alterations in rainfall patterns and increased evaporation rates from reservoirs lower water levels, thus reducing the hydropower generation capacity, which Kerala heavily depends on. The resulting supply-demand gap creates an imbalance in the energy system, leading to power shortages, load shedding, and significant challenges for both residential and commercial consumers. This dynamic of rising electricity demand alongside dwindling supply highlights the critical need for better energy management and adaptation strategies to ensure a stable and sustainable power supply in the face of ongoing climate change.

Table 3 Correlation Analysis of Climate Variables and Electricity Consumption in Kerala

Variables		Per Capita Consumption (kWh)	Own generation (MU)	Power Purchased/ Import (MU)
Per Capita Consumption (kWh)	Pearson Correlation	1	.445**	.987**
	Sig. (2-tailed)		.007	.000
	N	36	36	36
Annual Average Maximum Surface temperature	Pearson Correlation	.362*	-.133	.364*
	Sig. (2-tailed)	.030	.438	.029
	N	36	36	36
Annual Average Minimum Surface temperature	Pearson Correlation	.3707**	.075	.754**
	Sig. (2-tailed)	.000	.662	.000
	N	36	36	36
ACTUAL Rainfall (mm)	Pearson Correlation	.134	.654**	.044
	Sig. (2-tailed)	.437	.000	.799
	N	36	36	36
Annual Number of Days with Heat Index & gt; 35^0C	Pearson Correlation	.708**	.186	.713**
	Sig. (2-tailed)	.000	.276	.000
	N	36	36	36
Own generation (MU)	Pearson Correlation	.445**	1	.341*
	Sig. (2-tailed)	.007		.042
	N	36	36	36
Power Purchased/ Import (MU)	Pearson Correlation	.987**	.341*	1
	Sig. (2-tailed)	.000	.042	
	N	36	36	36

*Note: *. Correlation is significant at the 0.05 level (2-tailed).,*
***. Correlation is significant at the 0.01 level (2-tailed).*
Source: Authors Computation

Table.3 reveals the intricate relationships between demand-side factors, specifically changes in temperature and heat, and supply-side factors, including rainfall, own electricity generation, and power purchases/ imports in Kerala. On the demand side, the Annual Number of Days with Heat Index > 35°C serves as a critical indicator of electricity demand, particularly for cooling purposes. The high correlation with Per Capita Consumption (kWh) ($r = .708$, $p < .01$) signifies that as the frequency of extremely hot days increases, per capita electricity consumption also rises. This trend is largely attributed to the heightened use of air conditioning and other cooling systems, reflecting an immediate demand response to rising temperatures. Furthermore, the correlation between Annual Average Minimum Surface Temperature and Per Capita Consumption ($r = .707$, $p < .01$) suggests that both minimum and maximum temperatures influence electricity demand. As temperatures rise, individuals are likely to utilize more electricity for heating and cooling, leading to a significant increase in overall consumption.

On the supply side, the relationship between Own Generation (MU) and Per Capita Consumption ($r = .445$, $p < .01$) indicates that as electricity consumption increases, the demand for local generation capacity also rises. However, the relatively weaker correlation suggests that local generation may not fully meet the increased demand during peak temperature periods, resulting in greater reliance on external sources. This dependence is further highlighted by the robust positive correlation between Power Purchased/Import (MU) and Per Capita Consumption ($r = .987$, $p < .01$), underscoring that when local demand spikes due to high temperatures, there is a corresponding increase in electricity imports to meet this demand. This relationship illustrates the need for external electricity sources to bridge the gap created by local generation limitations, especially during extreme heat events.

In terms of rainfall, the correlation with Actual Rainfall (mm) shows a weaker relationship with both demand and supply variables. While rainfall can influence hydropower generation capacity-an essential source of electricity in Kerala-it does not strongly correlate with either per capita consumption or power imports. This suggests that while rainfall affects the availability of hydropower, it may not directly relate to immediate electricity demand fluctuations driven by temperature.

Table 4 : Model Result- Demand Side

Model 1 (Demand Side)				
Dependent Variable: First difference of Log(Per Capita Consumption (kWh)#				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.025648	0.013830	1.854568	0.0726
Log (Annual Number of Days with Heat Index > 35°C)	0.009285	0.002706	3.431263	0.0017
R-squared	0.466127	Mean dependent var		0.000000
Adjusted R-squared	0.449444	S.D. dependent var		24.09200
S.E. of regression	17.87613	Akaike info criterion		8.661832
Sum squared resid	10225.79	Schwarz criterion		8.751618
Log likelihood	-145.2511	Hannan-Quinn criter.		8.692452
F-statistic	27.93940	Durbin-Watson stat		2.012868
Prob(F-statistic)	0.000009			

#Augmented Dickey-Fuller test statistics at First Difference -5.285773 (0.0001),
Source: Estimated by Author, 2024

Table.4 presents the results of a regression model analyzing the demand side factors influencing per capita electricity consumption in Kerala, specifically focusing on the impact of the annual number of days with a heat index greater than 35°C. The dependent variable in this model is the first difference of the logarithm of per capita consumption (kWh), which allows for a clearer understanding of the percentage change in electricity consumption over time. The model coefficient for the constant term (C) is 0.025648, with a standard error of 0.013830 and a t-statistic of 1.854568. This indicates that while the constant term is not statistically significant at the conventional levels (with a p-value of 0.0726), it suggests a positive baseline level of per capita consumption.

More critically, the variable representing the log of the annual number of days with a heat index greater than 35°C has a coefficient of 0.009285. This statistically significant result ($p = 0.0017$) indicates that as the number of hot days increases, there is a corresponding rise in per capita electricity consumption. Specifically, a one-percent increase in the number of days exceeding this heat index is associated with an increase of approximately 0.0093 percent in per capita electricity consumption. The model demonstrates a relatively moderate fit, with an R-squared value of 0.466127, indicating that approximately 46.6% of the variability in per capita consumption can be explained by the model. The adjusted R-squared value of 0.449444 suggests that the inclusion of additional variables may improve the model fit. The standard error of the regression is 17.87613, providing insight into the accuracy of the model's predictions.

The F-statistic value of 27.93940, along with a corresponding p-value of 0.000009, indicates that the overall model is statistically significant, implying that the independent variables included have a meaningful effect on the dependent variable. Finally, the Durbin-Watson statistic of 2.012868 suggests that there is no significant autocorrelation in the residuals of the model, supporting the robustness of the regression analysis. These results highlight the importance of temperature and heat index as critical factors influencing electricity consumption in Kerala, emphasizing the demand-side responses to climate change and its implications for energy management in the region.

Table 5 : Model Result- Supply Side

Dependent Variable: Own generation (MU))				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.358295	1.080596	3.107816	0.0038
Log (ACTUAL Rainfall (mm))	0.696263	0.139197	5.001984	0.0000
R-squared	0.423923	Mean dependent var		8.761679
Adjusted R-squared	0.406979	S.D. dependent var		0.213765
S.E. of regression	0.164616	Akaike info criterion		-0.716455
Sum squared resid	0.921341	Schwarz criterion		-0.628482
Log likelihood	14.89620	Hannan-Quinn criter.		-0.685750
F-statistic	25.01984	Durbin-Watson stat		1.331517
Prob(F-statistic)	0.000017			

Source: Estimated by Author, 2024

Table 5 provides the results of a regression analysis examining the supply side factors that influence electricity generation in Kerala, with the dependent variable being the own electricity generation measured in million units (MU). This model aims to quantify the impact of actual rainfall on electricity generation, particularly given the region's reliance on hydropower. The constant term (C) has a coefficient of 3.358295, accompanied by a standard error of 1.080596 and a t-statistic of 3.107816. This indicates that the constant term is statistically significant ($p = 0.0038$), suggesting a positive baseline level of electricity generation that is not accounted for by rainfall. The key independent variable, representing the log of actual rainfall (mm), has a coefficient of 0.696263. This result is statistically significant ($p = 0.0000$) and indicates a strong positive relationship between rainfall and electricity generation. Specifically, an increase in rainfall is associated with a nearly proportional increase in own electricity generation. For each percentage increase in actual rainfall, the model predicts an approximate 0.696 percent increase in electricity generation. The model's fit is moderate, with an R-squared value of 0.423923, signifying that around 42.4% of the variability in own generation can be explained by rainfall. The adjusted R-squared value of 0.406979 suggests that the model could benefit from the inclusion of additional explanatory variables to enhance its predictive power. The standard error of the regression is 0.164616, indicating the level of accuracy in the model's predictions. The F-statistic value of 25.01984, alongside a p-value of 0.000017, indicates that the overall model is statistically significant, confirming that the independent variable has a substantial impact on the dependent variable. The Durbin-Watson statistic of 1.331517 raises some concern about potential autocorrelation in the residuals, as values significantly below 2 may indicate positive autocorrelation., The results from Table 5 underscore the significant role of rainfall in determining electricity generation in Kerala, particularly in the context of hydropower dependence. As climate change influences rainfall patterns, understanding this relationship becomes critical for energy management and planning in the region.

Table 6 : Model Result- Power Crisis and Climate Change

Dependent Variable: Ln (Power Purchased/Import (MU))				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.224609	5.149999	1.208662	0.2354
Log (Annual Number of Days with Heat Index > 35°C)	0.532306	0.117263	4.539437	0.0001
Log (ACTUAL Rainfall (mm))	0.223000	0.663481	0.336105	0.7389
R-squared	0.386512	Mean dependent var		8.741370
Adjusted R-squared	0.349331	S.D. dependent var		0.972517
S.E. of regression	0.784471	Akaike info criterion		2.432042
Sum squared resid	20.30804	Schwarz criterion		2.564002
Log likelihood	-40.77675	Hannan-Quinn criter.		2.478099
F-statistic	10.39540	Durbin-Watson stat		2.048670
Prob(F-statistic)	0.000315			

Source: Estimated by Author, 2024

Table.6 presents the results of a regression analysis exploring the relationship between climate change factors and the power crisis in Kerala, with the dependent variable being the natural logarithm of power purchased/imported (MU). This model is designed to assess how increased temperatures and rainfall impact the reliance on power imports, particularly in the context of climate variability. The constant term (C) has a coefficient of 6.224609, with a standard error of 5.149999 and a t-statistic of 1.208662. The probability value ($p = 0.2354$) indicates that the constant term is not statistically significant, suggesting that the baseline level of power purchases/imports does not differ significantly from zero. The variable representing the log of the annual number of days with a heat index greater than 35°C has a coefficient of 0.532306. This coefficient is statistically significant ($p = 0.0001$), demonstrating a strong positive correlation between extreme heat days and the volume of power purchased/imported. This suggests that as the number of excessively hot days increases, the demand for electricity, particularly for cooling purposes, also rises, leading to greater reliance on power imports. Conversely, the variable for log actual rainfall (mm) exhibits a coefficient of 0.223000 but has a standard error of 0.663481 and a non-significant t-statistic of 0.336105 ($p = 0.7389$). This result implies that actual rainfall does not significantly contribute to the variation in power purchases/imports in the model, indicating that rainfall alone may not mitigate the need for imported electricity, especially given the dependence on hydropower generation.

The model's fit, as indicated by an R-squared value of 0.386512, suggests that approximately 38.6% of the variability in power purchases/imports can be explained by the independent variables included in the model. The adjusted R-squared value of 0.349331 indicates that the model could benefit from additional explanatory factors to improve its predictive capacity. The standard error of the regression is 0.784471, reflecting the accuracy of the predictions made by the model. The F-statistic of 10.39540, along with a p-value of 0.000315, confirms that the overall model is statistically significant, indicating that the independent variables together have a meaningful impact on the dependent variable. The Durbin-Watson statistic of 2.048670 suggests that there is no significant autocorrelation in the residuals. So, the findings from Table 6 highlight the critical relationship between climate change, specifically extreme temperature events, and the power crisis in Kerala.

The significant correlation between the number of hot days and increased power imports underscores the need for effective energy management strategies to address the rising electricity demand driven by climate-induced temperature changes. Meanwhile, the limited role of rainfall in this context suggests that additional measures are necessary to enhance the resilience of the energy supply system in the face of climate variability.

The analysis of the impact of climate change on electricity demand in Kerala reveals a critical interplay between rising temperatures, extreme weather conditions, and the region's energy consumption patterns. The findings indicate that as average and peak temperatures increase, there is a corresponding rise in electricity demand, particularly for cooling systems. The significant correlation between the number of days with a heat index exceeding 35°C and per capita electricity consumption emphasizes the growing reliance on air conditioning, thereby amplifying the pressure on the state's electricity supply.

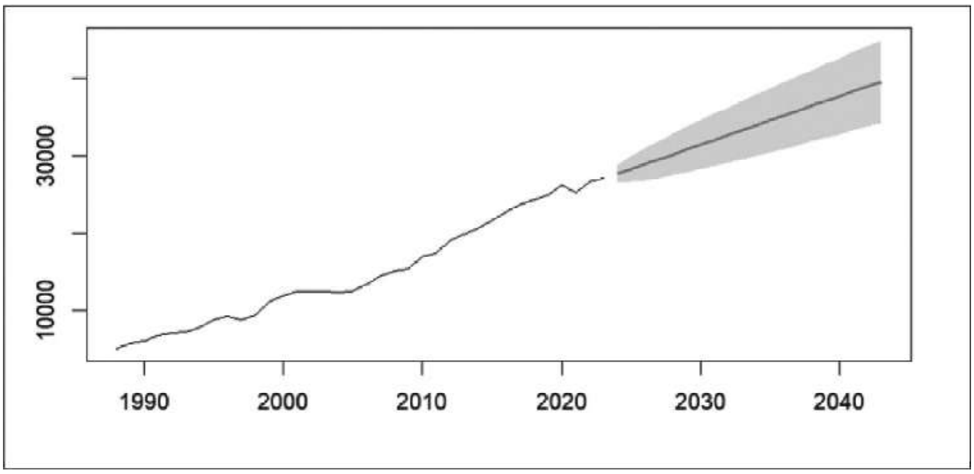
Furthermore, the examination of the supply side highlights the vulnerabilities of Kerala's hydropower-dependent energy system. Changes in rainfall patterns and increased evaporation rates due to climate change threaten the availability of water resources, which are crucial for electricity generation. The negative correlation observed between actual rainfall and electricity generation reinforces the notion that climate variability can significantly affect the state's ability to meet rising electricity demand.

This dual challenge of increased electricity consumption and decreased hydropower capacity sets the stage for potential power crises, especially during peak demand periods. The results underscore the urgency of implementing adaptive strategies to address both demand-side and supply-side issues. Enhancing energy efficiency, diversifying energy sources, and developing robust policies are essential for managing the effects of climate change on electricity demand in Kerala.

5.4 Demand and Supply Gap

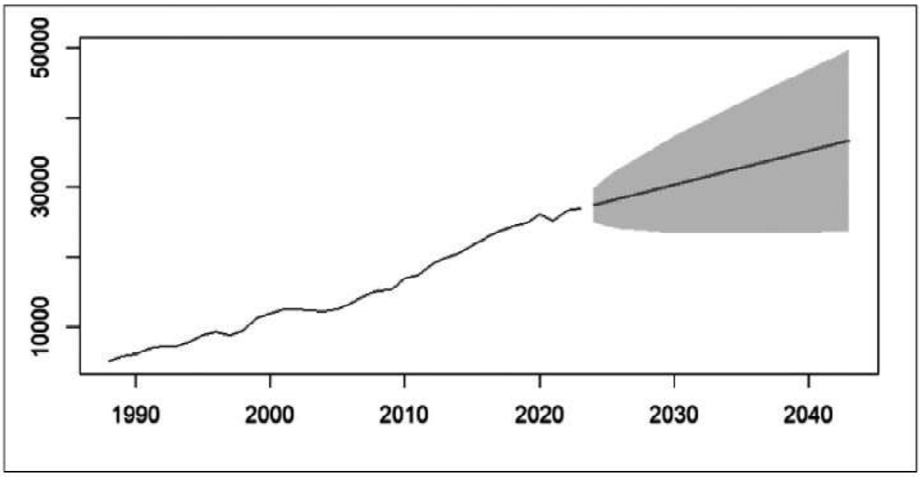
The demand and supply gap of electricity in Kerala is a pressing challenge exacerbated by rising consumption due to economic growth, urbanization, and climate change. As the state increasingly relies on hydropower for its electricity generation, altered rainfall patterns and higher temperatures strain this single-source dependency, leading to supply fluctuations during peak demand periods, particularly in hot and humid months. The correlation between increased temperatures and electricity demand highlights the urgency of addressing this imbalance, as the state faces frequent power shortages and load shedding that disrupt daily life and hinder industrial productivity. To mitigate these challenges, Kerala must enhance energy efficiency, diversify its energy generation mix by incorporating renewable sources like solar and wind, and implement sustainable energy policies that ensure reliable power supply while adapting to the impacts of climate change.

Figure 3 : Forecast on Max. Electricity demand (restricted) in Kerala Forecast from ARIMA (0,1,0) with drift



Source: Estimated by Author, 2024

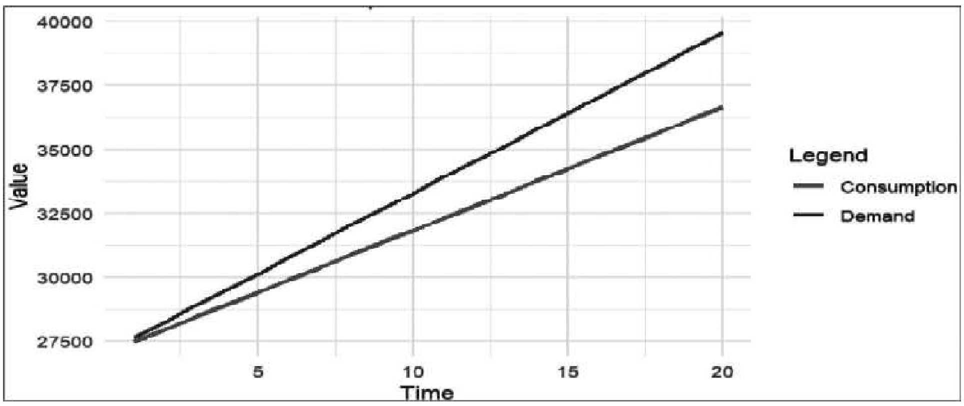
Figure 4 : Forecast on Supply of Electricity in Kerala - Forecast from ARIMA (0,1,0) with drift



Source: Estimated by Author, 2024

Figure.3 and Figure.4 explains the ARIMA model (0,1,0) with drift provides forecasts for the peak electricity demand and supply in Kerala from 2024 to 2043. The ARIMA model forecasts increasing peak demand for power in the coming decades, with uncertainty rising the further we project into the future. The lower and upper bounds indicate the potential range within which the actual demand could fall. The forecast shows a steady increase in the peak demand for power over the years, starting from 27,491.89 MW in 2024 to 36,652.41 MW by 2043. The difference between the lower and upper bounds (confidence interval) increases over time. The forecasted peak electricity demand for Kerala begins at 27,636.78 MW in 2024 and gradually increases to 37,669.43 MW by 2040. Over the 20-year period, the demand is projected to increase steadily at a nearly linear rate, suggesting growing pressure on Kerala's energy infrastructure. The forecasted electricity supply starts at 27,491.89 MW in 2024 and increases to 35,206.01 MW by 2040. While the supply also exhibits steady growth, the rate of increase is slightly lower than that of demand, highlighting the potential for an increasing supply-demand gap.

Figure 5 : Forecast on demand supply gap of Electricity in Kerala



Source: Estimated by Author, 2024

Figure 5 shows a persistent increase in demand without a commensurate rise in supply, leading to a growing gap between the two by 2040. This raises significant concerns about the adequacy of Kerala's current energy generation and distribution infrastructure. The widening demand-supply gap indicates potential risks of energy shortages and frequent power outages, especially during peak demand periods. This is particularly worrisome given Kerala's reliance on hydropower, which can be unreliable due to seasonal variations in rainfall, especially in the context of climate change.

Using the selected ARIMA model, we forecasted the demand for the next 20 years (2024-2043).

Table 7 : Forecast Values of Gap on Electricity demand & Supply using ARIMA

Year	Point Forecast on Max. demand (restricted)	Point Forecast on Actual Consumption (Supply)	Gap (Demand-Supply)
2024	27636.78	27491.89	144.89
2025	28263.82	27974.02	289.8
2026	28890.86	28456.16	434.7
2027	29517.9	28938.29	579.61
2028	30144.94	29420.42	724.52
2029	30771.99	29902.55	869.44
2030	31399.03	30384.68	1014.35
2031	32026.07	30866.82	1159.25
2032	32653.11	31348.95	1304.16
2033	33280.15	31831.08	1449.07
2034	33907.19	32313.21	1593.98
2035	34534.23	32795.35	1738.88
2036	35161.27	33277.48	1883.79
2037	35788.31	33759.61	2028.7
2038	36415.35	34241.74	2173.61
2039	37042.39	34723.88	2318.51
2040	37669.43	35206.01	2463.42

Source: Estimated by Author, 2024

Table 7 presents the forecasted values of the gap between electricity demand and supply in Kerala from 2024 to 2040, based on an ARIMA model. The forecasted maximum demand shows a steady increase from 27,636.78 MU in 2024 to 37,669.43 MU by 2040. In contrast, the projected actual consumption (supply) also rises, but at a slower rate, starting at 27,491.89 MU in 2024 and reaching only 35,206.01 MU by 2040. This disparity leads to an increasing gap between demand and supply over the years. For instance, the gap is 144.89 MU in 2024, but it escalates significantly to 2,463.42 MU by 2040. The growing gap indicates that while both demand and supply are expected to increase, the demand growth outpaces the supply, leading to a critical energy shortfall in the future. This trend underscores the need for strategic planning and investment in energy infrastructure to bridge the widening gap, ensuring that Kerala can meet its electricity needs effectively in the coming years.

The analysis of the regression results and the demand-supply gap reveals critical insights into the power crisis in Kerala, exacerbated by climate change and increasing electricity consumption. The regression analysis indicates a significant relationship between temperature fluctuations-particularly the number of days with a heat index above 35°C-and electricity demand, highlighting the growing need for cooling systems in response to rising temperatures. As climate change continues to escalate, the demand for electricity is projected to increase significantly, placing immense pressure on Kerala's already strained power infrastructure. Simultaneously, the supply side faces challenges due to its heavy reliance on hydropower generation, which is vulnerable to altered rainfall patterns and increased evaporation rates caused by rising temperatures. The regression results demonstrate that actual rainfall plays a crucial role in the state's electricity generation capacity. With diminishing water resources due to climate variability, the state's ability to meet the escalating demand becomes increasingly compromised, leading to a widening gap between electricity demand and supply.

Table.7 shows the forecast values from the ARIMA model further underscore this crisis, predicting a persistent demand-supply gap over the coming years. As the demand for electricity continues to outstrip supply, Kerala is likely to face more frequent power shortages and load shedding, posing significant challenges for both residential and commercial consumers. This imbalance not only disrupts daily life but also hampers economic activities, making it imperative for policymakers to devise effective strategies to enhance energy security and sustainability in the face of climate change. Addressing these challenges will require a multifaceted approach, including diversifying energy sources, improving energy efficiency, and investing in renewable energy solutions to bridge the gap and ensure a stable power supply for the future.

6. Suggestions

Diversifying energy portfolio can be an efficient solution for the diverging demand supply gap in Kerala. To diversify the generation portfolio effectively, consider incorporating renewable energy sources such as solar and wind power, and enhancing small-scale hydropower projects. Promote energy storage solutions by investing in large-scale batteries and pumped hydro storage to manage fluctuations in renewable energy production. Enhance grid flexibility with smart grid technology and demand response programmes to optimize energy distribution and consumption. Additionally, explore emerging technologies such as hydrogen fuel cells and geothermal energy for a stable and sustainable power supply.

To accelerate renewable energy development in Kerala, the state should focus on expanding solar and wind energy capacity. Investing in solar photovoltaic (PV) systems is particularly promising due to Kerala's high solar irradiance year-round. Promoting rooftop solar installations across urban and rural areas can alleviate pressure on the central grid and enable households to generate their own electricity. Additionally, exploring offshore wind energy along Kerala's extensive coastline could further enhance the state's renewable energy portfolio and complement existing onshore wind projects.

Also, the demand side management can effectively address peak energy demands by implementing peak time control strategies. By incentivizing consumers to shift their energy usage to off-peak hours, utilities can reduce strain on the grid during high-demand periods. This can be achieved through time-of-use pricing, demand response programmes, and smart appliances that automatically adjust consumption based on real-time energy availability. These measures not only help balance supply and demand but also contribute to overall grid stability and efficiency.

7. Conclusion

In conclusion, climate change has emerged as a significant force reshaping the environmental and socio-economic conditions of Kerala, particularly within the power sector. The state has witnessed pronounced alterations in temperature, rainfall patterns, and humidity levels due to climate variability, directly impacting electricity demand. As temperatures rise, the demand for cooling systems and energy consumption has surged, creating substantial pressure on Kerala's power infrastructure.

The analysis indicates that as average and peak temperatures increase, there is a corresponding rise in electricity demand, particularly for cooling systems. The significant correlation between the number of days with a heat index exceeding 35°C and per capita electricity consumption underscores the growing reliance on air conditioning, amplifying the pressure on the state's electricity supply. On the supply side, Kerala's hydropower-dependent energy system faces vulnerabilities due to changing rainfall patterns and increased evaporation rates, which threaten the availability of water resources crucial for electricity generation. The observed negative correlation between actual rainfall and electricity generation highlights how climate variability can significantly impair the state's ability to meet rising electricity demand.

This dual challenge of increased electricity consumption coupled with decreased hydropower capacity sets the stage for potential power crises, especially during peak demand periods. The findings emphasize the urgency of implementing adaptive strategies to address both demand-side and supply-side issues. Enhancing energy efficiency, diversifying energy sources, and developing robust policies are essential for effectively managing the effects of climate change on electricity demand in Kerala. By prioritizing these strategies, Kerala can work towards ensuring energy security, mitigating the impacts of climate variability, and fostering sustainable economic growth for its population in the face of an uncertain climate future.

The analysis also reveals a critical demand-supply gap, driven largely by increased electricity consumption in the face of dwindling hydropower resources. The state's reliance on hydropower generation makes it particularly vulnerable to climate-induced changes, such as altered rainfall and higher evaporation rates, which further diminish the capacity to meet rising electricity demands. Consequently, the growing gap between electricity demand and supply poses significant challenges, leading to frequent power shortages and load shedding that disrupt daily life and economic activities.

To address these challenges, it is essential for policymakers and energy planners to adopt a multifaceted approach that includes diversifying energy sources, enhancing energy efficiency, and investing in renewable energy solutions. Such strategies will not only help bridge the demand-supply gap but also ensure the long-term sustainability and resilience of Kerala's power sector in the face of ongoing climate change. As Kerala navigates these pressing issues, a comprehensive understanding of the interplay between climate dynamics and energy consumption patterns will be crucial in formulating effective policies aimed at securing the state's energy future and safeguarding the well-being of its citizens.

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Specificities of financial inclusion: A Study of Savings and Credit Accounts of Financially Included Households in Kerala

Sreejith A. &
Manju S. Nair

Financial inclusion is considered to be a leading factor and a prerequisite condition for inclusive growth and thereby social inclusion. Among the States, Kerala is considered to be fully financial included State though it lacks inclusive growth. This paradoxical situation necessitates an in-depth analysis of specificities of financial inclusion in Kerala. The specific objective of the study is to analyse the utilisation pattern of savings and credit accounts of financially included households and to examine the factors which hinder household's inaccessibility to these accounts. The study found that there is a tendency of less utilisation of savings accounts and unproductive use of credits by financially included households. Factor analysis by principal component method shows that due to various socio-economic factors, households are voluntary excluded from accessing formal financial services. Therefore, financial inclusion policies should focus to improve the utilisation of formal banking services and to tackle voluntary exclusion.

Keywords : Financial inclusion, savings inclusion, credit inclusion.

I. Introduction

Financial inclusion may be defined as the process of ensuring access to financial services and timely and adequate credit needed by vulnerable groups such as weaker sections and low income groups at an affordable cost (GoI, 2008). It ensures accessibility of financial services like savings and credit at an affordable cost to all sections of population in a country. Access to institutional sources of credit to all segments of the population, especially socially and economically deprived sections, is reckoned as one of the prerequisites for achieving inclusive growth (Mohan, 2006; Thorat, 2006). Inclusive growth necessitates people's participation in economic growth and sharing benefits from economic growth. It focuses on creation of more productive employment opportunities as a means of increasing incomes for the excluded groups. Therefore, accessibility savings and credits from formal financial institutions is necessary condition for inclusive growth (Kelkar, 2010)

Even the concept of financial inclusion is of recent origin; India has adopted various policy initiatives since independence for improving the accessibility of formal financial services and intended to bring about financial inclusion. Establishment of vast network of cooperative banks, nationalisation of commercial banks, setting up of regional rural banks and various social and development banking initiatives are aimed to improve the access to finance for the rural poor. As a result of these initiatives, access to formal financial services of the rural poor has somewhat improved. However, with the onset of economic reforms in the early nineties there was a distinct shift in the banking policy (Chavan, 2007). The focus of the banks during the reform periods has been on enhancing the efficiency and profitability of the banks. As a result, many of the regulations that were applied on the banking system during the pre-reform period have been relaxed in order to allow a market-based and more liberalised operation of the banking system. This has led to exclusion of most of the rural households from the formal financial system (Rao, 2007).

Kerala is considered to be the first state to attain 100 per cent financial inclusion in the country based on no-frills accounts (SLBC, 2007). The wide spread number of rural and semi-urban branches and various financial inclusion initiatives helped to attain this claim. Financial literacy of the people of Kerala is also high and hence the services provided by the banks are more widely used. However, studies pointed out that some sections of the population still face difficulties in the accessibility of formal financial services (Chavan, 2007). Inclusive growth is lagging behind in Kerala and poverty and inequality are still prevalent in some parts of rural Kerala (Subramanian and Prasad, 2008). This contrasting view necessitates an in-depth understanding of the specificities of financial inclusion in the state of Kerala. It also raises the question of methodology and indicators used in the measurement of financial inclusion. Merely having an unused policy driven no-frills account is not a good measure of financial inclusion. Many of the basic savings bank deposit accounts opened as part of financial inclusion drive are dormant or inoperative (Tripati, Saurabh et al., 2015). The role of financial inclusion for inclusive growth depends on the proper utilisation of savings and credit accounts. Financial inclusion leads to inclusive growth if savings and credit accounts are used for productive purposes. Based on this, the objective of the study is to examine the utilisation pattern of savings and credit accounts of financially included households in Kerala. The study also tries to analyse the factors which led to household's inaccessibility of savings and credit.

II. Data and Methodology

Accessibility and usage of savings and credit accounts depend on various region specific and socio-economic factors of people. Region specific characteristics like physical connectivity to financial institutions and other infrastructure developments are influencing factors for accessibility of savings and credit accounts by households. Socioeconomic characteristics like level of income, education, occupation, etc., have a determining factor for accessibility and usage of savings and credit accounts. In order to get a better understanding of specificities of financial inclusion in a comparative manner, it is necessary to collect samples from regions where banking and other infrastructure facilities (in terms of number of banks and branches) are developed and regions where banking and other infrastructure facilities are less developed. Therefore the researcher has first identified two Districts, one with a developed banking infrastructure and another with less developed banking infrastructure. For developed banking infrastructure, Ernakulum District was selected and Wayanad District was selected for less developed banking infrastructure. From each District the same rationale is adopted to select the relevant Block Panchayat and Grama Panchayat. Borda Ranking methodology is used for the selection of Districts, Block Panchayats and Grama Panchayats. Multistage sampling framework is used in the survey design. Based on Borda Ranking Methodology, Nenmeni and Pozhuthana Panchayath in Waynad District, and Kumbalangy and Pallipuram Panchayath in Ernakulam District are selected for primary survey. Using Kukeran Formula, the study considers 384 households as sample, selecting 110 households from Pallipuram Panchayat, 122 households from Kumbalangy Panchayat, 68 households from Pozhuthana Panchayat and 84 households from Nenmeni Panchayat. The identified sample from each ward is selected randomly (using random number table) from the house list of each ward. Factor analysis by Principal Component Method is used to examine the factors responsible savings and credit exclusion.

III. Discussion

3.1Financial inclusion status of households

The financial sphere of Kerala is characterised by the existence of three prominent financial institutions viz., rural co-operatives, scheduled commercial banks (SCBs) and regional rural banks (RRBs). With wide network of rural and semi urban branches, scheduled commercial banks have a greater role for promoting financial inclusion in Kerala. Since banks are considered as the gateway to the most basic form of financial services, the present study used banking inclusion/exclusion as analogous to financial inclusion/exclusion. The study defined financial inclusion as a situation where at least one member in a household has savings or credit account or avails any other financial services from scheduled commercial banks. Such households are treated as financially/banking included otherwise the household is financially/banking excluded. The extent of financial/ banking inclusion shows the financial inclusion status of households in the study areas (See Table 1).

Table 1 : Extent of banking/financial inclusion and exclusion

Panchayat	Banking Inclusion		Banking Exclusion		Total	
	n	Per cent	n	Per cent	n	Per cent
Kumbalangy	96	78.68	26	21.32	122	100
Pallipuram	67	60.9	43	39.1	110	100
Nenmeni	60	71.42	24	28.58	84	100
Pozhuthana	28	41.17	40	58.83	68	100
Total	**251**	**65.36**	**133**	**34.64**	**384**	**100**

Note: n-Number *Source: Primary Data*

The status of banking inclusion and exclusion shows that, out of total 384 sample households 251 (65.36 per cent) are financially included and remaining 133 (34.64 per cent) are financially excluded. Among the Panchayats, banking inclusion is high in Kumbalangy Panchayat and low in Pozhuthana Panchayat. It tends to show that financial exclusion is high in Pozhuthana and low in Kumbalangy Panchayat. Comparatively ST population is high in Pozhuthana Panchayat and only one bank is working in Pozhuthana Panchayat. Compared to Nenmeni Panchayat, Pozhuthana Panchayat is a hilly area, road and other transportation facilities are less developed in this Panchayat. These may be the factors leading to high financial exclusion in Pozhuthana Panchayat.

IV. Specificities of financial Inclusion: Savings Inclusion/Credit Inclusion

4.1 Accessibility of savings accounts: Savings inclusion/exclusion

Accessibility of basic savings accounts by the low income households is considered as the initial step to financial inclusion. Accessibility of savings accounts enables households for getting various financial services like savings, credits and other benefits. Savings accounts provide the opportunity to store money in safe and it enables the households to meet unforeseen financial emergencies and future financial needs. It not only provides to store money in safe, but it also provides interest income on savings to enhance financial wealth of households. Another benefit of holding savings accounts is that it provides liquidity i.e., we have full access to money whenever required with no fine and no limitation. Thus accessibility of savings accounts has a greater role for financial inclusion by providing financial independence and liquidity and thereby reducing household's dependence on informal money lenders. The crucial factor of financial inclusion for inclusive growth depends on the proper use of the savings accounts. Accessibility of savings accounts leads to inclusive growth if the savings accounts used for productive purposes rather than unproductive purposes. In this context, this section analyses the utilisation of savings accounts of financially included households. Purpose of savings accounts, utilisation pattern and amount of transactions in savings accounts are analysed in detail. The factors which lead to the household's inaccessibility of savings accounts are also examined.

4.1.a Purpose of savings accounts

Purpose of opening savings accounts is the determining factor for the proper use of savings accounts. If the account is opened for savings and for obtaining credit, it may be properly used. Savings habits and regular savings of people will improve, if the account is opened for savings purpose. No-frills savings accounts opened only for receiving government benefits may tend to remain accounts unused and keep it as dormant account for long time. Thus properly used savings accounts increase financial well being of households, and in turn it may reduce the household's dependence on money lenders.

Table 2 : Distribution of financially included households with savings account by purpose of savings account

Purpose of savings accounts	Number	Per cent
Savings	124	61.69
Receive Loan	3	1.49
Receive Gas Subsidy	28	13.93
Receive Govt Pension	20	9.95
Savings & Loan	21	10.45
Others	5	2.49
Total	**201**	**100**

Source: Primary Data

The purpose of opening the savings accounts among the financially included households shows that majority of households opened their account for savings purpose (See Table, 2). Twenty eight bank accounts were for receiving gas subsidy. Twenty households opened their account for receiving government pension like old age pension, and other pensions and twenty one households used it for savings and receiving loan.

4.1.b Usage pattern of savings accounts

Since majority of financially included households opened their account for savings purpose, it may tend to argue that the accounts are properly used. Usage pattern of these basic savings accounts are essential for financial inclusion. Mere opening a savings account and not using it is not a good indicator of financial inclusion.

Table 3 :Distribution of financially included households with savings account by savings account usage pattern

Savings account usage pattern	Number	Per cent
More than once in a month	41	20.40
More than once in six months	93	46.27
More than once in one year	67	33.33
Total	**201**	**100**

Source: Primary Data

Table 3 shows savings account usage pattern among financially included households. It shows that Ninety three households (46.27 per cent) used their savings accounts more than once in the last six months. Forty one households (20.40 per cent) use their savings accounts more than once in a month and 67 households (33.33 per cent) use their account for more than once in a year. Thus the analysis shows that financially included households are likely to open savings accounts and have a tendency of not to operate these accounts. The following Table 4 shows the amount of money kept in these savings accounts.

Table 4 : Distribution of financially included households with savings account by savings amount

Savings	Number	Per cent
Less than 500	30	14.93
500-999	56	27.86
1000-4999	51	25.37
5000 and above	25	12.44
Not responded	39	19.40
Total	**201**	**100**

Source: Primary Data

The amount of money in savings accounts shows that, 30 households are keeping an amount less than Rs 500 in their account, 56 households are keeping an amount between Rs 500 and Rs 999 and 51 households are keeping amount in their savings accounts ranging between Rs 1000 and Rs 4999. Amount above Rs 5000 are kept in basic savings account only by 25 households. Thirty nine households have not responded to the question. Analysis shows that even the accounts are opened for savings purpose, majority of the financially included households are not using the accounts for its designed purpose. Usage pattern and amount of transaction through savings accounts are very less.

4.2 Savings exclusion

Savings exclusion refers to households' inability for accessing basic savings accounts from the scheduled commercial banks. The reasons for savings exclusion can be classified into voluntary exclusion and institutional exclusion. Voluntary exclusion refers to a situation in which people voluntarily do not open a basic savings account in scheduled commercial banks. Institutional exclusion refers to a situation in which people approach the scheduled commercial banks but have been denied services from the institution.

Table 5 : Distribution of households by status of savings exclusion

Status	Number	Per cent
Institution exclusion	6	4.51
Voluntary exclusion	127	95.49
Total	**133**	**100.00**

Source: Primary Data

Table 5 shows that out of 133 financially excluded households, majority of them, 127 (95.49 per cent) did not approach scheduled commercial banks for opening a basic savings account. So it is argued that they are voluntarily excluded. Six of the savings excluded households approached the scheduled commercial banks for opening basic savings account, but the bank rejected their application for opening the account. This is due to the fact that four applications were incomplete and two applications were rejected due to other reasons.

4.2 a Factor analysis of reasons for savings exclusion

Factor analysis by Principal Component Method is used to examine the factors responsible for savings exclusion. Kaiser-Meyer-Olkin Measure of Sampling Adequacy is found to be 0.529 which indicates that proportion of variance in the variables is reasonably caused by the underlying factors (See Table 6). High values generally indicate that a factor analysis may be useful to explain the factors causing savings exclusion.

Table 6 : KMO and Bartlett's test for factors responsible for savings exclusion

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.529
Bartlett's Test of Sphericity	Approx. Chi-Square	1666.217
	df	210.000
	Sig.	0.000

The significance level of Bartlett's Test of Sphericity is less than 0.05 which indicates that the variables are related and hence factor analysis is useful to examine the factors for savings exclusion. Factor analysis by Principal Component Method using Varimax Rotation extracted seven factors which is capable of explaining 75.938 percentage of variance of all the 21 variables related to savings exclusion. For clarity in the explanation of results small coefficients with absolute value 0.5 were suppressed and the results are given in Table 7.

Table 7 : Factors of savings exclusion extracted by principal component analysis

Factors	Variables	Factor Loading	Per cent of Variance
Factor. 1	Illiteracy/language problem	0.778	14.015
	Fear of bank	0.859	
	Cultural barrier	0.879	
	Attitude of bank staffs	0.510	
Factor. 2	high minimum balance	0.926	13.292
	takes too much time	0.735	
	Don't have the basic documentation	0.813	
Factor. 3	No need of savings	0.552	13.204
	Don't trust in banks	0.766	
	bank is so far	0.711	
	high fees	0.533	
	Bank hours inconvenient	0.716	
Factor. 4	Dependence on other means of savings	-0.730	10.772
	dont know how to open bank account	0.758	
Factor. 5	unsuitable products	0.650	9.677
	low income	0.747	
	unknown bank and its services	0.580	
Factor. 6	low interest rate	0.773	7.861
	high transaction cost	0.756	
Factor. 7	procedural hazards	-0.602	7.118
	bad services	0.805	

Source: Primary Data

Table 7 shows that Factor one comprises variables like illiteracy/language problem, fear of banks, cultural barriers, and attitude of bank staff and these variables explain 14.015 per cent of the variance. Among the variables, cultural barriers (0.879 factor loading) are important for self exclusion among the households. Fear of banks and illiteracy and language problem are also very influencing variables for self exclusion of households. Second factor explains 13.292 per cent of influence of the variables for self exclusion. High minimum balance, takes too much time, do not have the basic documentation are the variables in the second factor. All these three variables are very influencing factors for self exclusion of households. High minimum balance (0.926 factor loading), takes too much time (0.735 factor loading) and do not have the basic documentation (0.813 factor loading) are very influencing factors for self exclusion. Factor three includes the variables no need of savings, do not trust banks, bank is so far, high fees and inconvenient bank hours. Factor three explains 13.204 per cent of the variance in savings exclusion. Among the variables in factor three, lack of trust in banks (0.766 factor loading) is the most influencing factor for savings exclusion. Variables like depends on other means of savings and do not know how to open bank accounts comprises factor four. Factor four explains 10.772 per cent of variance of savings exclusion. Both these factors, dependence on other means of savings (0.730 factor loading) do not know how to open bank accounts (0.758 factor loading) are influencing factors for savings exclusion. Variables like low income (0.747 factor loading), unsuitable products (0.650 factor loading), unknown bank and its services (0.580 factor loading) together comprises factor five. Factor five explains 9.677 per cent of variance in savings exclusion. Among the variables in factor five, low income with factor loading 0.747 is influencing variable for savings exclusion. Low interest rate and high transaction cost together constitute factor six. Factor six explains 7.861 per cent of variance in savings exclusion. In factor six, the variable low interest rate (0.773 factor loading) is the influencing factor for savings exclusion. Procedural hassles and bad services comprise factor seven and explains 7.118 per cent of variance in savings exclusion. Bad services (0.805 factor loading) are the influencing variable among the variables in factor seven.

4.3 Accessibility of credit accounts: Credit inclusion/exclusion

Ensuring accessibility of credit accounts and affordable credit by all sections of household is considered to be the pre-requisite for inclusive growth and poverty reduction (Mohan, 2007). By ensuring accessibility of formal credit accounts and credit, the productive use of the credits is also very important and determining factor for inclusive growth (Thorat, 2007). Credit needs and credit amount are the influential factor to the households for choosing sources of credits. For large volume of credit and for productive use, people generally prefer institutional/formal sources of credit. People prefer non-institutional/informal sources of credit for unproductive purposes and smaller amount of loan. Based on this, this section try to analyse the credit account details of financial included households in Kerala. Purpose of taking credit, collateral used for taking credit and factors for credit exclusion are analysed in detail.

Table 8 : Distribution of financially included households with credit account by purpose of taking loan

Purpose of loan	Number	Per cent
Agriculture Purpose	12	25.00
Small business	2	4.17
Education	2	4.17
Buying/building house	15	31.25
Buying consumer durables	1	2.08
Marriage expenses	7	14.58
Multiple purpose	3	6.25
Consumption expenses	2	4.17
House maintenance	4	8.33
Total	**48**	**100**

Source: Primary Data

Table 8 shows that out of total 48 households, who have credit from scheduled commercial banks, twelve households used their credit for agriculture purposes and only two households used their credit for small business. Two households used it for education and fifteen households used it for building or buying houses. Seven households used their credit for marriage purposes. Two households used their credit for consumption expenses and four consumers used it for house maintenance. Analysis shows that the productive use of the credit is very low among the financially included households.

4.3a. Time taken for sanctioning the loan

Time taken for sanctioning the loan is another influencing factor to the households for choosing sources of credit. Generally people depend on those sources where there is immediate credit delivery. It is seen that there is immediate credit delivery from informal sources of credit, whereas there is lagging of credit delivery from formal sources of credit. The lagging of credit delivery from the formal sector may be due to the responsibility of banks to strictly follow the RBI guidelines for loan sanctioning. However, informal sectors like money lenders need not follow any type of regulations.

Table 9 : Distribution of financially included households with credit account alone by time taken for sanctioning loan

Time taken for sanctioning of loan	Credit	Per cent
Within Week	5	10.42
Within Two Weeks	11	22.92
Within a Month	28	58.33
More than One Month	4	8.33
Total	**48**	**100**

Source: Primary Data

Time taken for sanction of credit shows that out of total credit account holders, 28 households (58.33 per cent) got loan within one month. For four loan seekers sanctioning of loan took more than one month and five loan seekers, got loan within one week. Eleven households received their credit within two weeks (See Table 9.)

For accessing the bank credit, collateral security plays a determining factor for lenders as well as borrowers. Collateral security acts as a safety net for lenders and enables the households for accessing the credit. Regarding the collateral security used for taking loan shows that majority of financially included households (32 households) used land as their loan security (See Table 10). Twelve households used gold as security for getting loan and two households used their house and other buildings as loan security. Only one household each used other means and personal security or salary as collateral for availing credit from scheduled commercial banks.

Table 10 : Distribution of financially included households with credit account by loan security

Loan security	Number	Per cent
House/other buildings	2	4.17
Land	32	66.67
Gold	12	25.00
Personal security/ salary	1	2.08
Others	1	2.08
Total	**48**	**100**

Source: Primary Data

4.4 Credit exclusion

Credit exclusion refers to the situation where people do not have access to credit from scheduled commercial banks. Like savings exclusion, reasons for credit exclusion can be classified into institutional exclusion and voluntary exclusion. Voluntary exclusion refers to a situation in which people voluntarily do not approach scheduled commercial banks for credits. Institutional exclusion refers to a situation in which people approach the scheduled commercial banks for credits but have been denied services from the institution.

Table 11 : Distribution of households by status of credit exclusion

Status of credit exclusion	Number	Per cent
Institution exclusion	12	4.00
Voluntary exclusion	235	78.30
Had loan four years back but now closed	53	17.70
Total	**300**	**100.00**

Source: Primary Data

Table 11 shows that, twelve households approached scheduled commercial banks for credit but was refused due to lack of security and bad credit history. Two hundred and thirty five households did not approach scheduled commercial banks for credit needs. These households are referred to as self excluded or voluntary excluded from accessing credit facilities. Self exclusion/voluntary exclusion is a policy issue from the point of view of financial inclusion. It raises the question of whether these self excluded households depend on other sources of credit agencies and what are the factors hindering self exclusion of households for accessing credit from scheduled commercial banks. Based on this, the following section analyses the reasons for self exclusion for accessing the bank credit from commercial banks.

4.4 a.Factor analysis of reasons for credit exclusion

Factor analysis by Principal Component Method is used to examine the factors responsible for credit exclusion. Following Table 12 presents KMO and Bartlett's Test for factors responsible for credit exclusion. Kaiser-Meyer-Olkin Measure of Sampling Adequacy is found to be 0.710 which indicates the proportion of variance in the variables reasonably caused by the underlying factors. High values (close to 1.0) generally indicate that a factor analysis may be useful to explain the factors causing credit exclusion.

Table 12 : KMO and Bartlett's test for factors responsible for credit exclusion

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.710
Bartlett's Test of Sphericity	Approx. Chi-Square	1373.602
	df	136.000
	Sig.	0.000

The significance level of Bartlett's Test of Sphericity is less than 0.05 which indicates that the variables are related and hence the factor analysis is useful to examine the factors for credit exclusion. Factor analysis by Principal Component Method using Varimax Rotation extracted six factors which are capable of explaining 68.78 percentage of variance of all the 17 variables related to credit exclusion. For clarity in the explanation of results small coefficients with absolute value below 0.5 were suppressed (see Table 13)

Table 13 : Factors of credit exclusion extracted by principal component analysis

Factors	Variables	Factor Loading	Per cent of Variance
Factor. 1	Fear of banks	0.872	18.254
	Cultural barriers	0.827	
	Illiteracy and language problem	0.820	
	Attitude of bank staff	0.717	
Factor. 2	Lack of Repaying Capacity	0.861	12.558
	Lack of adequate collateral	0.854	
Factor. 3	No need of bank credit	0.770	11.944
	Availability of informal loans	0.635	
	Inconvenient bank working Hours	0.598	
	Banks are too far	0.584	
Factor. 4	Too much formalities/requirements	0.825	10.248
	Delay for getting bank credits	0.807	
Factor. 5	Terms of repayment	0.847	8.349
	Fear of penalty for nonpayment of installments	0.680	
Factor. 6	High interest rates for bank loan	0.674	7.434
	Bad credit history	0.629	

Factor one consists of four variables viz., fear of banks, cultural barriers, illiteracy/language problem and attitude of bank staff. Factor one represents distracting factors which act as barriers to enter into the banking scenario. These variables explain 18.254 per cent of variance. Among the variables in Factor one, the variable fear of banks (0.872 factor loading) is the most influential variable for households voluntarily not approaching a scheduled commercial bank for credit. Variables like lack of repaying capacity (0.861 factor loading) and lack of adequate collateral (0.854 factor loading) comprises factor two and this factor explains 12.56 per cent of variance in credit exclusion. Both the variables in factor two are influencing factors for credit exclusion of households. Factor three comprises the variables of no need of bank credit, availability of informal loans, inconvenient bank working hours, banks are too far etc. Factor three could explain 11.944 per cent of variance in credit exclusion. Among the variables in factor three, the variable no need of credit (with factor loading 0.770) is the most influential variable for credit exclusion of households. Factor four includes two variables viz., too much formalities or requirements and delay for getting bank credit. Factor four explains 10.248 per cent of variance in credit exclusion. Both the variables in factor four, too much formalities or requirement (0.825 factor loading) and delay for getting bank credit (0.807 factor loading), are very influential variables for credit exclusion of households. Factor five includes the variables like terms of repayment (0.847 factor loading) and fear of penalty for non-payment of installments (0.680 factor loading). Factor five could explain 8.349 per cent of variance in credit exclusion and among the variables terms of repayment is the influential variable for credit exclusion. High interest rate for bank loan and bad credit history are variables comprising factor six. Factor six explains 7.434 per cent of variance in credit exclusion and the variable high interest rates for bank loan (0.674 factor loading) is the influential variable for credit exclusion of households.

5. Conclusion

The paradoxical situation of co-existence of high level of financial inclusion and non- inclusive growth necessitates an in-depth analysis of specificities of financial inclusion in Kerala. It necessitated the detailed analysis of savings and credit accounts of financial included households in Kerala. The study found that there is a tendency of less utilisation of savings accounts and unproductive use of bank credits by financially included households. Less utilisation of savings accounts and unproductive use of bank credit may be the reason for the coexistence of financial inclusion and non-inclusive growth in Kerala. Factor analysis by principal component method shows that due to various socio-economic factors households are voluntary/self excluded from accessing formal financial services. So, financial inclusion policies formulated in order to improve the utilisation of formal banking services and to tackle self/voluntary exclusion issues needs more attention.

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