ON THE ROAD TO ACHIEVING FULL ELECTRIFICATION IN SRI LANKA

APRIL 2023

ASIAN DEVELOPMENT BANK

ADB

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ISBN 978-92-9270-053-9 (print); 978-92-9270-054-6 (electronic); 978-92-9270-055-3 (ebook)
Publication Stock No. TCS230011-2
DOI: http://dx.doi.org/10.22617/TCS230011-2

Notes:
In this publication, "$" refers to United States dollars and "SLRs" as Sri Lanka rupees.
ADB recognizes "Ceylon" as Sri Lanka and "China" as the People's Republic of China.

Cover design by Josef Ilumin.
On the cover: Electrification has paved the way for strengthening children's education in Sri Lanka (photo by Keshan Samarasinghe).

About the Serendipity Knowledge Program

The Serendipity Knowledge Program is an ADB platform dedicated to identifying knowledge solutions for Sri Lanka's development challenges. *Serendib* is one of Sri Lanka's ancient names and serendipity refers to a fortunate finding, which is a common occurrence throughout the history of product invention and scientific discovery. ADB established this new knowledge program in 2021 in line with its vision as a knowledge solutions bank.

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Foreword by the Ministry of Power and Energy of Sri Lanka

Sri Lanka takes pride in having become, in 2016, the first country in South Asia to have achieved full electrification. In doing so, the country fulfilled a key policy element set forth in the National Energy Policy and Strategies of Sri Lanka identified back in 2008 and reaffirmed in the updated Energy Policy of 2019. However, the foundation to achieving full electrification was laid in 1980 with the establishment of the rural electrification division within the Ceylon Electricity Board. Thereafter, the launch of several programs in 2011 designed to achieve the last-mile service connection was crucial in reaching the full electrification target. Several stakeholders, from the Government of Sri Lanka to the Ceylon Electricity Board and multilateral and bilateral development partners, came together in assisting various components of several related projects.

I am pleased to introduce this new publication, *Achieving Full Electrification in Sri Lanka*, jointly published by the Ministry of Power and Energy and the Asian Development Bank Development. The publication collates the many initiatives taken in achieving this goal and evaluates the socioeconomic impact of electrification. This documents the development and evolution of Sri Lanka's electricity sector and sets the stage for the country in achieving its new goal of generating 70% of electricity through renewable energy by 2030. More importantly, this publication showcases the success of Sri Lanka's power sector despite the country's long periods of social unrest. I hope it will be an inspiration not only for all stakeholders involved but also for other countries in the region aspiring to achieve full electrification.

I am especially thankful to the authors and the Asian Development Bank for this publication, and I hope that our collective efforts will contribute toward a better tomorrow for Sri Lanka.

Mapa Pathirana
Secretary
Ministry of Power and Energy
Government of Sri Lanka

Foreword by the Asian Development Bank

Sri Lanka is a founding member of the Asian Development Bank (ADB), having joined in 1966. Today, ADB is one of the country's largest multilateral development partners. Sri Lanka has experienced a gradual structural transformation from an agriculture-based economy to a manufacturing and services-based economy. ADB has been working closely with the Government of Sri Lanka, approving a cumulative total of over $11.3 billion, financed by regular and concessional ordinary capital resources, the Asian Development Fund, and other special funds.

In the energy sector, ADB has been supporting Sri Lanka across all the subsectors—generation, transmission, and distribution—and in developing institutional capability of the power sector over the years. ADB has supported 18 projects with about $1.5 billion in grants, loans, and technical assistance. It played a vital role in providing support to expand energy access in Sri Lanka through interventions such as rehabilitating local power distribution networks and modernizing the distribution infrastructure, thereby extending the benefits of electrification to as many villages as possible in rural areas. This publication, initiated by the Ministry of Power and Energy with the support of ADB, showcases the pathway and achievements of Sri Lanka over the past years in attaining 100% electrification.

Sri Lanka's relatively rapid electrification has laid the foundations for the country's economic growth and accelerated rural development. ADB was the first multilateral lending agency to provide a loan solely dedicated for rural electrification to Sri Lanka and approved three loans to support rural electrification between 1980 and 1996. These loans stimulated the extension of the distribution network to many rural areas, making the total electrification level of Sri Lanka grow from 12% in 1980 to 63% in 2000 and paving the way to achieve full electrification in 2016. This publication takes a closer look at how the expansion of the electricity industry and rural electrification has impacted Sri Lanka's socioeconomic development during the last few decades. The publication reports on macroeconomic modeling results, which confirm the strong long-term relationship between electricity use and good economic outcomes. These results show that the growing electrification rate correlates with Sri Lanka's declining unemployment rate. A 1% increase in electricity demand has led to a 0.63% increase in per capita gross domestic product. Statistics show an increased number of small and medium-sized enterprises and a shift from purely agricultural activities to a mixed economy with commercial and industrial activities. This publication describes how consistent national policies, national funding, and appropriate credit mechanisms led to 100% household connectivity by 2016.

ADB will continue to support Sri Lanka's economic recovery from the coronavirus disease pandemic and its sustainable and inclusive development in the long term with affordable and sustainable energy for all. The bank's financial investments and knowledge work will seek to strengthen the drivers of growth by promoting diversification of economic activities, supporting human capital development, and driving productivity enhancements, and will seek to improve the quality of growth by fostering inclusiveness.

Kenichi Yokoyama
Director General
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Acknowledgments:

For assisting in the field survey,

- Swetha Perera, Manager (projects), Resource Management Associates (Pvt) Limited (RMA)
- Ruwani Wijesinghe, Chief Engineer, Ceylon Electricity Board
- Research Assistants, Department of Sociology, University of Kelaniya, Sri Lanka

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Abbreviations

ADB	–	Asian Development Bank
ARDL	–	autoregressive distributed lag
CEB	–	Ceylon Electricity Board
CFS	–	Consumer Finance Survey
DGEU	–	Department of Government Electrical Undertaking
GDP	–	gross domestic product
GWh	–	gigawatt-hour
kV	–	kilovolt
kWh/person	–	kilowatt-hour per person
LECO	–	Lanka Electric Company
MW	–	megawatt
NCRE	–	nonconventional renewable energy
PUCSL	–	Public Utilities Commission of Sri Lanka

Executive Summary

Sri Lanka achieved 100% electricity supply coverage for the entire country in 2016. The benefits of electrification had a direct impact in raising living standards in the country. In addition, the availability of grid electricity supply triggered rapid development in rural areas and at the national level, creating new opportunities for investment. This study initiated by the Ministry of Power and Energy, Sri Lanka with support from the Asian Development Bank (ADB) examines various initiatives taken for countrywide electrification and attempts to assess the socioeconomic impact of electrification.

Socioeconomic development. The Sri Lankan economy experienced a gradual structural transformation from an agriculture-based economy to a manufacturing and services-based economy. The agriculture sector, which accounted for 37.8% of gross domestic product (GDP) in 1960, dropped to 7.9% in 2018, and the industry sector and service sector grew from 16.8% to 27.0% and 45.4% to 56.8%, respectively, during the same period. The per capita GDP was $4,102 in 2018 and Sri Lanka is now categorized as an upper middle-income country. Average annual GDP growth during 2009–2018 was 6.4%. After the civil war in Sri Lanka in 2009, gradual recovery in the global economy, and favorable weather conditions in the country are some of the factors that contributed to this growth. However, the growth rate dropped to 3.7% during 2016–2018 due to many factors including extreme weather conditions affecting the agriculture sector.

Expansion of electricity industry. The Ceylon Electricity Board (CEB) was set up in 1969 by the Government of Sri Lanka as the national power utility responsible for power generation, transmission, and distribution. Prior to establishment of CEB, the local authorities and licensees had been responsible for power distribution and supply, while the Department of Government Electrical Undertaking (DGEU) had been tasked with the generation and transmission of electricity. Until the electricity distribution was taken over by CEB, Sri Lanka's electricity supply system was concentrated mainly in cities and towns. With assistance from ADB, Lanka Electricity Company (LECO) was formed in 1983 to gradually take over the distribution operations, then carried out by local bodies. Since then, LECO and CEB have taken over and rehabilitated all the local authority power distribution networks and expanded power distribution to other areas.

Sri Lanka's eletricity-generating system transformed from a predominantly hydropower system to a mixed hydrothermal system over the last 2 decades. Until the mid-1990s, most of the power generation requirements were met with hydropower plants. With full exploitation of the economically viable large-scale hydropower potential in the country, the growing demand for electricity had to be met with the addition of more oil-based power plants since the 1990s. Coal-based power plants were introduced in 2011, further diversifying the energy mix of electricity generation, and reducing the dependency on oil-based power generation.

In the meantime, the power transmission and distribution network was expanded and upgraded to cover the entire country by the implementation of several transmission development projects to ensure the reliability and quality of electricity supply and to enable the evacuation of power from new generation facilities.

Expansion of rural electrification. Establishing the Rural Electrification Division within CEB in 1980 for expansion of rural electrification was the turning point in accelerating electrification in the country. This division identified prospective rural electrification schemes, surveyed and analyzed them, and then packaged them as projects for financing. With the assistance of multilateral and bilateral lending agencies as well as with its own resources, Sri Lanka endeavored to extend the benefits of electrification to as many villages as possible in the rural areas by developing the necessary power distribution infrastructure.

The consistent national policy of providing electricity access to every citizen of the country by all successive governments in the past was a major factor in providing 100% electricity access in the country by 2016. Several policy decisions have contributed to accelerate electricity access to every economic category of the population. Significant among those is the decision taken by the government in 2008 to extend the national grid wherever economically and socially beneficial. Also, the government policy which stipulated that "where such extension is not financially viable to the utility, the Government would provide required support through additional funding from the national budget" is noteworthy. Additional policies that helped low-income groups access electricity included the following:

(i) extending electricity to homes up to 50 meters from the power distribution network with households paying only a fixed charge for the connection,
(ii) devising standardized wiring schemes and providing financial assistance for internal wiring based on low-cost installment payments administered by the utility,
(iii) providing concessional credit with loan recovery in installments through the monthly electricity bill.

While investments through larger projects primarily contributed toward enhancing the medium- and low-voltage power network across the island, the initiatives referred to above facilitated final household connectivity, mainly through appropriate credit mechanisms. All these efforts of the government together with unwavering support from the subject ministry and the two utilities CEB and LECO, in implementing and managing rural electrification projects, resulted in electricity access for the entire population by 2016.

Macroeconomic impact of electrification. Macroeconomic analysis carried out by developing an autoregressive distributed lag (ARDL) model to identify statistical evidence of a long-run or equilibrium relationship between electricity use and economic outcomes shows a strong coupling of the country's economic growth with electricity consumption. The results of the model imply that a 1-percentage-point increase in electricity demand will lead to a 0.63-percentage-point increase in the per capita GDP. The historical analysis of data shows that key indicators such as per capita GDP, per capita electricity consumption, and electricity intensity in the economy show positive trends. Both per capita GDP and per capita electricity consumption have been increasing, while electricity intensity in the economy has stabilized. The Poverty Head Count Index and unemployment rate in the country show a declining trend with increasing electrification in the country.

Socioeconomic impact of rural electrification in the household sector. The field survey conducted to assess the socioeconomic impact of electricity access clearly identified evidence on improvement of the social standards. Results show that socioeconomic conditions of electrified households in the Hambantota district have improved from 2009 to 2016. Employment data indicate a shift from the agriculture sector to commercial and industry sectors. Households were wealthier in 2016 in real terms when compared to 2009 and their expenditure and asset ownership expanded. Household possessions of moveable assets and land other than residential plots increased between those survey periods.

Almost all the households achieved improved lighting as a major benefit of electrification. Other benefits included the opportunity to use electrical appliances such as televisions and mobile phones. These developments have improved the social environment at the dwellings with long hours for entertainment after work in the evening, improved communication, and convenience of using modern equipment for household applications. Children were able to study long hours in the night and thereby improve their educational performance. The use of energy-efficient devices, particularly in lighting, was also observed. The penetration of compact fluorescent lamps lighting amounted to 60% of the households, while about 20% of the households used even more efficient light emitting diode lamps for lighting. This indicates the effectiveness of energy efficiency improvement programs launched by the government in parallel with electrification efforts, and the consciousness of households with respect to efficient use of energy.

Although income-generating activities at household level were limited, the statistics show increased numbers of small- and medium-scale industry and service sector enterprises with increased electrification. The resulting new employment opportunities provided increased levels of income to the rural community and an improved social environment at household level.

1 Socioeconomic Development—Historical Trends

Background

Sri Lanka achieved 100% electricity supply coverage in the country by 2016. The key attributes in the rural electrification approach of the government included a consistent policy on providing electricity access to the entire population, ensuring adequate investments through multilateral and bilateral lending agencies and its own resources, expanding the power transmission and distribution and network, and adopting innovative initiatives to accelerate the electrification with close monitoring of the implementation process. Boxes 1 recounts the government effort to achieve 100% electrification targets and rural economic impact in the country.

The benefits of electrification have had a direct impact in raising living standards of the people in the country. Availability of grid electricity supply and associated infrastructure development also triggered rapid development in rural areas and at national level.

This study attempts to examine various initiatives taken toward full electrification in the country and to assess the socioeconomic impact of such electrification at the household level as well as at the macro level in the country.

Box 1: Rural Economic Impact is the Most Striking

"While increased access to grid electricity has enhanced the quality of living standards of rural communities across Sri Lanka, the most benefited group is the micro and small-scale industries and businesses. The policy decision taken on extending the grid to their doorstep at utility's cost brought enormous relief to these entrepreneurs as three-phase electricity connectivity from the nearest grid point had been too high a cost to bear for small enterprises."

Along with the announcement of the National Energy Policy and Strategies in 2008 the government published a road map and clear milestones to achieve the target of 100% electrification in the country. As the Secretary of the Ministry of Power and Energy at that time, M.M.C. Ferdinando played a central role in not only providing the leadership for a solid energy policy after a lapse of almost a quarter of a century, since the previous policy in the 1980s but also spearheading the 100% electrification drive.

When I took over the ministry in 2006, I had several challenges relating to the electrification target. This includes, among many others, taking immediately necessary policy decisions to implement and accelerate the projects, ensuring adequate financial resources for grid extensions, and most importantly, motivating the staff of the Ceylon Electricity Board (CEB) to undertake the burden of additional workload coming along with this national endeavor.

Box 1 *continued*

One of the most critical policy decisions facilitated by my ministry and taken by the government was to extend the national grid to geographical areas wherever it is economically and socially beneficial. For any electrification schemes not financially viable to the utility, the government was to provide the financing gap to make such schemes financially viable to the utility. In line with this policy decision, a separate budget item was included in the National Budget from 2008 onwards for rural electrification needing such assistance.

In order to manage available financial resources efficiently and expedite the implementation of the rural electrification projects, a policy decision was taken to utilize financial support from multilateral and bilateral lending agencies to procure equipment and material for the required grid extensions while the counterpart financing from the government and the CEB was spent on planning, engineering, and construction of rural electrification projects by CEB's own staff.

I still have vivid memories of one heartbreaking observation we made at the time. We put in all the efforts to bring the electricity grid to these villages. But for many of the low-income families relying on income from sources such as small-scale agriculture, fishing, or some menial work, the cost of connectivity and internal household wiring was too much to bear. This opened everybody's eyes in the line of decision making and the government was determined to make the grid connectivity affordable to every citizen of the country.

By 2011, we adopted that extending electricity supply to the premises of households up to 50 meters from the household premises should be at the cost of the utility, as a part of the corporate responsibility of CEB being a regulated entity by the Utility Regulator, and the households would pay only a fixed charge for the service connection. Also, we introduced standardized wiring schemes for low-income households. We even went beyond, to introduce concessional credit lines to low-income households to pay for the service connection and internal wiring. Credit recovery came in installments through the monthly electricity bill. These schemes were administered by CEB.

Above all, the key factor for the success of this achievement of the 100% electrification target was continuous monitoring and follow-up of progress and motivating the technical staff of CEB by providing financial incentives for taking the burden of additional workload.

M.M.C. Ferdinando
Secretary
Ministry of Power and Energy
(2006–2014)

Study Approach

Energy plays a fundamental part in the economic growth process. The literature review indicates that statistical studies have shown a positive correlation between electricity consumption and economic growth, and a positive and significant causal link from energy use to economic growth. Energy use is either the cause or the facilitator of economic growth. The relationship between energy and economic growth varies by country and within countries.

Access to modern energy (both electric and nonelectric) is a necessary requirement for sustainable development. This notion is based on three basic arguments:

(i) Modern energy may be a crucial input to achieving development goals.
(ii) Modern energy use may enable the poor to engage in improved or new income-generating activities (often called "productive use of energy," as opposed to "consumptive use"), thereby eventually leading to an improvement in their living conditions (Practical Action 2012, UNDP/WHO 2009, DFID 2002, UN 2002, UN Millennium Project 2005, Brew-Hammond and Kemausuor 2009).
(iii) Exclusion from modern energy might be a direct indicator of poverty based on definitions that refer to living standards—for instance, access to electricity is included in the "Multidimensional Poverty Index" by the UNDP (2010).

Of all modern energy access, electricity access is included most frequently as an explicit objective of national development strategies. Hence, the focus in this study is on impacts of increased access to electricity.

The link between increased energy use and the growth of an economy is relevant for many energy sector projects. Projects designed for capacity increase of generation, transmission, or distribution of electricity (including access to people), or for development of oil or gas deposits, will facilitate increased energy production and consumption. Since increased economic growth leads to poverty reduction, there is a link between these energy projects and poverty reduction.

A key purpose of this study is to identify reliable evidence on the links between electricity use and socioeconomic outcomes, at both macroeconomic and microeconomic levels examining the following relationships:

(i) investment in energy infrastructure and gross domestic product (GDP);
(ii) energy use and GDP;
(iii) power quality and reliability and the performance of businesses; and
(iv) household access to electricity supply and various economic outcomes (income, employment, education, etc.).

The first two examine possible linkage at a macroeconomic level, while the next two do so at a microeconomic level. The macroeconomic analysis requires data at macroeconomic level and typically relies on whatever relevant published material is available. The microeconomic analysis requires data from field surveys of households and businesses, and usually relies on sample surveys.

This study is focused on establishing co-relationships for (i) electricity use and GDP, and (ii) socioeconomic impact and increased access to electricity supply.

Most existing studies on electrification impacts are of "uncertain value" due to shortcomings in the applied methodologies, such as a lack of control groups and/or before–after data and a general failure to track the effects on poverty over a long enough period. Electricity is an input factor to a large set of activities ("uses") that can improve welfare, increase productivity, or generate income.

Socioeconomic Developments

Structure of the Economy

Post-independent Sri Lanka had a predominantly agricultural economy with production and trade in three crops: tea, rubber, and coconut. The successive governments since the independence (1948) took several policy initiatives to develop the domestic agriculture sector. Development of agriculture infrastructure such as irrigation schemes, institutions to deliver credit facilities and knowledge of new technologies, introduction of improved seeds, subsidies on fertilizer, and new human settlement schemes were among some of these initiatives. The economy grew at an annual average growth rate of 3.4% during 1951–1960. The period from 1960 to 1977 witnessed an annual average growth rate of 3.8%, with a higher growth rate of 5.3% being recorded during 1966–1970, a period of partial economic liberalization. The growth rate of the economy declined to 2.9% per year during 1971–1977 when there was increased intervention by the government in economic activities and the international environment had also become unfavorable after the first international oil price hike.[1]

The year 1977 was a landmark in the economy and social policies of the post-independence period. The government that came to power in late 1977 introduced drastic policy reforms enabling free imports and exports. Most of the government interventions on economic reforms were toward an outward-oriented strategy that created a new investment environment based on market principles. The economy grew by 6.5% on average during the first 4 years after that economic liberalization.[2]

1 The World Bank Group. 2021. *National Accounts Data Files.*
2 Asian Development Bank (ADB). 2019. *Sri Lanka's Macroeconomic Challenges.* Manila.

Table 1.1: Sector Share of GDP and Growth Rates

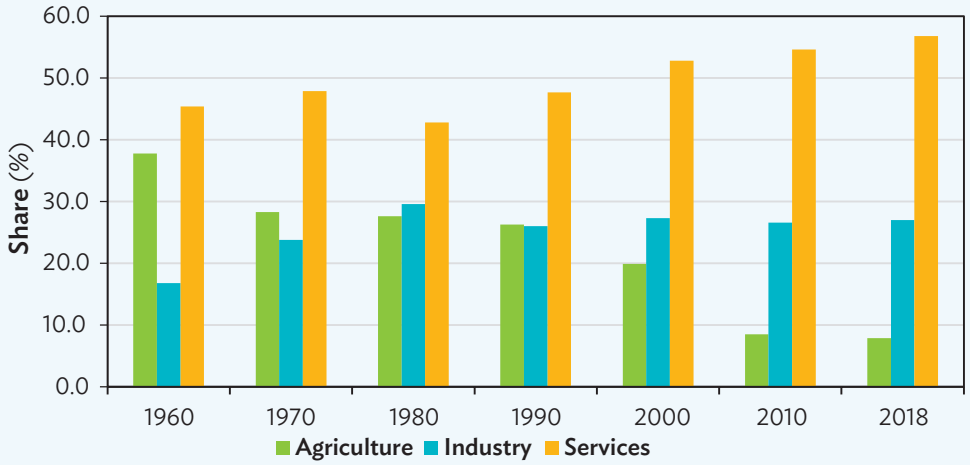
Year	Agriculture	Industry	Services	Period	GDP	Electricity Generation
1960	37.8	16.8	45.4	1951–1960	3.4	
1970	28.3	23.8	47.9	1961–1970	4.4	11.2
	Percent Share of GDP				**Average Annual Growth Rates**	
1980	27.6	29.6	42.8	1971–1980	4.1	7.9
1990	26.3	26.0	47.7	1981–1990	4.3	6.6
2000	19.9	27.3	52.8	1991–2000	5.2	8.0
2010	8.5	26.6	54.6	2001–2010	5.2	4.9
2018	7.9	27.0	56.8	2011–2018	5.3	4.5

GDP = gross domestic product.
Source: Central Bank of Sri Lanka. 2018. *Annual Report*. Colombo.

The average GDP growth rate was around 5% during 1982–1986, but there was a drastic drop of growth rate in 1987–1989, at the height of internal political uncertainty and sporadic civil disturbances, and a drought in 1987. During the post-economic liberalization period of 1987–1996, the economy registered an annual average growth rate of 4.9% and experienced a gradual structural transformation from an agriculture-based economy to a manufacturing and services-based economy (Table 1.1 and Figure 1.1). The agriculture sector, which accounted for 37.8% of GDP in 1960, dropped to 7.9% in 2018, and the industry sector and service sector shares grew from 16.8% to 27.0% and 45.4% to 56.8%, respectively, during the same period. The economy experienced a considerable structural transformation since the independence, particularly after the 1977 economic liberalization and subsequent policy changes toward globalization.[3] The economic growth and the structural transformation were supported by expansions in the services sector, in particular expansion of banking and finance, insurance, real estate, electricity, retail, and wholesale trade, postal services, and telecommunications. The services sector's contribution to GDP increased gradually from 36.9% in 1960 to 40.6% in 1977 and further to 56.8% in 2018.[4]

[3] Asian Development Bank Institute. 2017. *Growth Empirics: Structural Transformation and Sectoral Interdependencies of Sri Lanka*. Tokyo.
[4] Central Bank of Sri Lanka. 2020. *Annual Report—2020*. Colombo.

Figure 1.1: GDP Share of Economic Sectors



GDP = gross domestic product.
Source: Central Bank of Sri Lanka, *Annual Report 2018*. Colombo.

From 1970 to 2009, at various stages, the Sri Lankan economy suffered from civil disturbance in the south as well as in the north. During the civil war from 1983 to 2009, a significant portion of the country's valuable resources couldn't be utilized due to continues treats. If this war was never happened, the economic performance of the country would have been far more impressive.

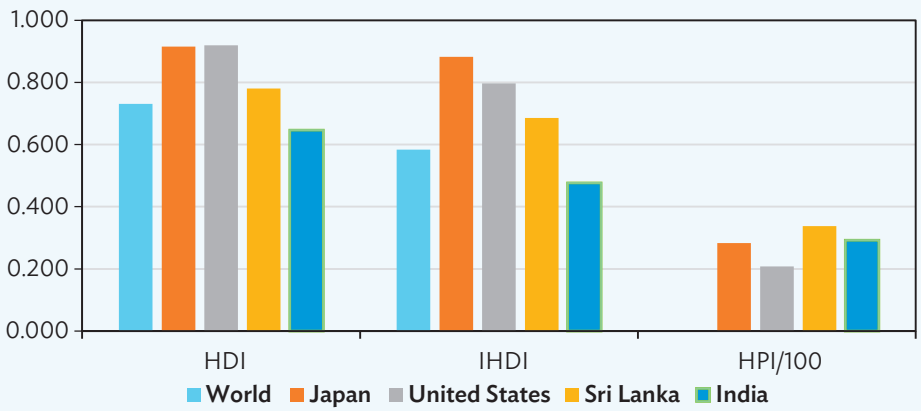
After the civil war in Sri Lanka in 2009, gradual recovery in the global economy, and favorable weather conditions in the country are some factors that enabled an annual average growth rate of 5.6% during the 9 years after 2009.[5]

Human Development

Sri Lanka remained a welfare state in the post-independence period. All successive governments were compelled to maintain that overall welfare status of the economy though marginal changes have taken place during different political regimes that followed. Hence, human development was considered a priority in the policies that were pursued for a long period of time and a considerable portion of government expenditure has been spent on education; health; and other welfare-oriented activities such as nutrition, sanitation, water supply, and housing. Though, in terms of per capita income level, Sri Lanka lost its relative position to many other countries due to slower growth of the economy, it remains in the upper middle-income category. Sri Lanka ranked 71st in the Human Development Index (HDI) out of 189 countries, and it is categorized as a high human development state in 2019 (Figure 1.2).[6]

[5] Central Bank of Sri Lanka. 2015. *Annual Report—2015*. Colombo.
[6] United Nations Development Programme. 2019. *Human Development Report 2019*. New York.

Figure 1.2: Human Development Index



HDI = Human Development Index, IHDI = Inequality-adjusted Human Development Index , HPI = Happy Planet Index.
Sources: Human Development Report 2019 (Data for 2018) and The Happy Planet Index—New Economic Foundation (NEF) in 2016 (Data for 2014).

The Inequality-adjusted Human Development Index (IHDI), which measures the level of human development when inequality (in a country in health, education, and income) is accounted for, reflects improvement in its rank for Sri Lanka though it falls below HDI. The Happy Planet Index (HPI), which reflects how well nations are doing at achieving long, happy, sustainable lives, shows Sri Lanka's position at 28th among world nations. Sri Lanka ranks over the United States (108th), Japan (58th), and the United Kingdom (34th).[7] Overall, this indicates that Sri Lanka was able to progress well in quality of life despite its slow progress in economic development.

Employment

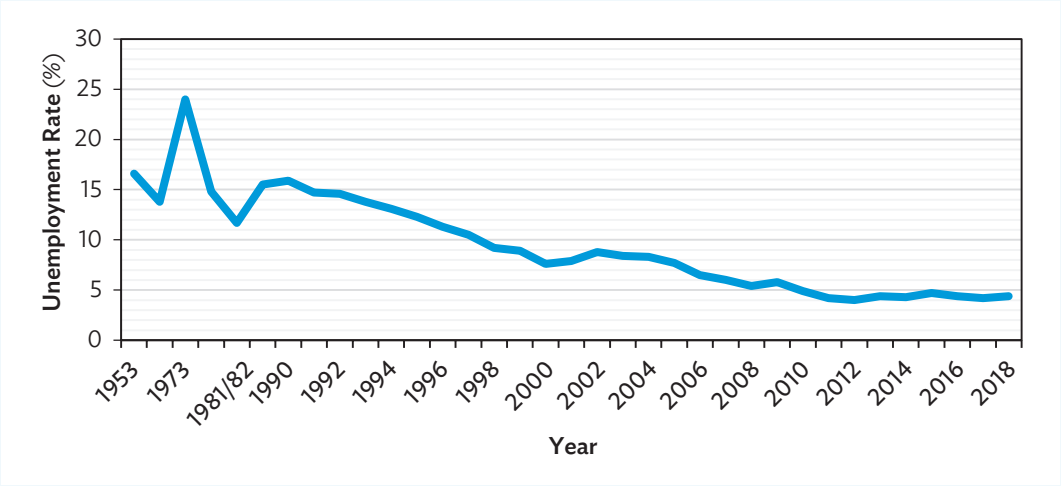
Unemployment emerged as a problem during the latter part of the 1950s. According to the 1953 Consumer Finance Survey (CFS,) the unemployment rate was 16.6%. Consequently, the government placed emphasis on employment-oriented strategies. However, the low rate of growth of employment opportunities in the face of a rapidly increasing labor force generated a high degree of unemployment by the early 1970s. According to the 1973 CFS, the unemployment rate was estimated to be 24%, the highest on record.[8]

With the liberalization of the economy, the unemployment rate declined sharply after 1977. Another factor that contributed to reducing unemployment was the commencement of public sector investment programs such as the Accelerated Mahaweli Development Program, setting up of export processing zones, and urban and housing development projects. According to the 1978–1979 CFS, the unemployment rate had declined to 14.8%. The 1986–1987 survey findings revealed an increase in the unemployment rate to 15.5% mainly due to slowing down of the economy after the 1983 civil disturbance and completion of some of the major development projects.

7 New Economics Foundation. 2016. *The Happy Planet Index*. London.
8 D. Wasantha. 2010. *Consumer Finances Surveys Conducted Since 1953–What the Data Reveal.* Department of Census and Statistics. Colombo.

However, this favorable trend of decline in unemployment rate continued reaching around 5% in 2010 and even lower thereafter.[9]

Figure 1.3: Unemployment Rate



Source: Central Bank of Sri Lanka. 2018. *Economic and Social Statistics of Sri Lanka*. Colombo.

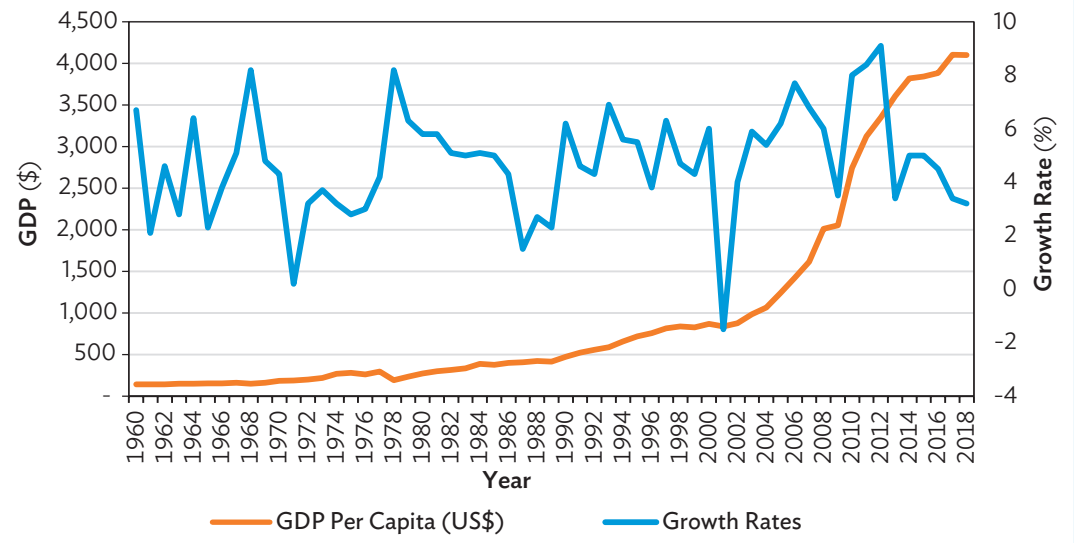
National Income and Income Distribution

The national income of the country was estimated at $843 million in 1950 compared to $88.9 billion in 2018. The population in 1950 was 7.2 million as against 21.7 million in 2018 (footnote 4). The per capita nominal income estimated at $120 (SLRs397) in 1948 (at independence) compared with $4,102 (SLRs666,817) in 2018, which is nearly 34-fold higher but significantly below that of many countries in Asia. At the end of World War II, Sri Lanka was one of the most affluent developing countries in Asia and ranked third in per capita income for South and East Asia following Japan and the Philippines.[10]

Significant growth in the economy after the post liberalization period is clearly reflected by the increase in per capita income of the country. Figure 1.4 shows that in 1960, Sri Lanka's per capita income was $152.[11] It took nearly two and half decades to double that and it was only in 2004 that it exceeded $1,000. However, by 2008, the per capita income doubled to $2,011 and by 2011 it exceeded $3,000 (footnote 2). Though Sri Lanka's income level has grown faster than some of its South Asian neighbors, its growth was much slower than those of many East Asian countries. The East Asian countries have benefited from increase of domestic investment and large inflows of private investment. Sri Lanka's domestic savings remains at a relatively lower level compared to most of the East Asian countries.

9 Department of Census and Statistics. 2020. *Sri Lanka Labour Force Statistics Quarterly Bulletin*. Colombo.
10 World Bank Group. 1987. *Sri Lanka Issues in Macro-Economic and Industrial Development Policy*.
11 S.S. Bhalla and P. Glewwe. 1986. *Growth and Equity in Developing Countries: A Reinterpretation of the Sri Lankan Experience*. Colombo.

Figure 1.4: GDP per Capita and Growth Rates



GDP = gross domestic product.
Source: Central Bank of Sri Lanka. 2018. *Annual Report*. Colombo.

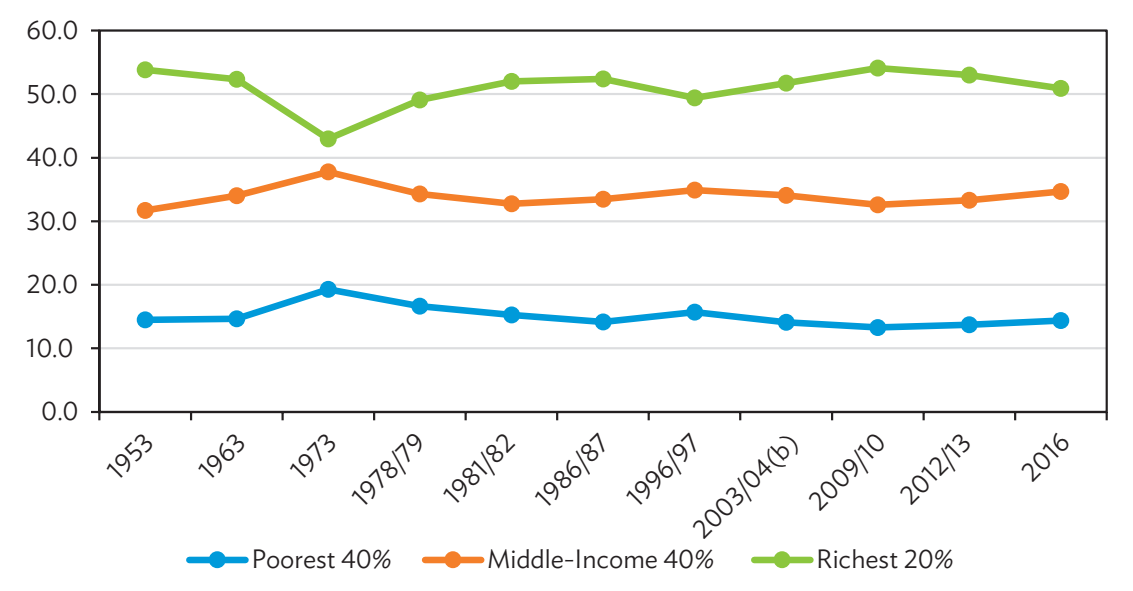
Trends in Income Distribution

By 1973, the share of the income received by the poorest 40% of spending units had increased to 19.3% and the share of the richest 20% of the spending units had declined to 43%. The Gini ratio, which indicates the overall income distribution position, improved from 0.46 in 1953 to 0.35 in 1973. The high income share of the richest 20% in 1953 was due to low taxation and the high level of private ownership of property and real assets. From 1956 onward, there was greater state intervention in the economy and as a result, economic opportunities for the private sector declined.[12]

The share of the middle-income group remained between 30% and 34% after 1973, while the share enjoyed by the poorest 40% of the spending units progressively fell from 19.29% in 1973 to 16.06% in 1978–1979 and further to 15.25% in 1981–1982 and 13.7% in 2012–2013. That share increased to 14.4 % in 2016 (Figure 1.5).[13]

[12] Institute of Policy Studies and the Department of Economics and Statistics of the University of Peradeniya. 2010. *Economic and Social Development Under a Market Economy Regime in Sri Lanka*. Colombo.
[13] Department of Census and Statistics. 2016. *Household Income and Expenditure Survey*. Colombo.

Figure 1.5: Percentage Share of Income Groups by Year



Sources: Central Bank of Sri Lanka. 2004. *Consumer Finance and Socio-Economic Survey 2003/04*. Colombo; Department of Census and Statistics. 2016. *Household Income and Expenditure Survey 2009/10,2012/13*. Colombo.

2 Overview of the Expansion of the Electricity Industry

Historical Evolution

Electricity was first introduced to Sri Lanka by a private firm "Boustead Brothers," generating electricity on a commercial basis to meet the needs of the Colombo Municipal Council for a tramway scheme in 1895. The Colombo Municipal Council offered concessionary terms for this project and electricity was first supplied to the Colombo Fort area and a few government offices.[14] Electricity regulations in Sri Lanka can be traced back to as early as 1895, the first legislation on electricity that was enacted in Sri Lanka was the Electricity Ordinance No. 5 of 1895, which regulated only electricity distribution (Box 2).

Box 2: Electricity Ordinance No. 5 of 1895

"An Ordinance to provide for the protection of persons and property from the risks incidental to the supply and use of electricity for lighting and other purposes."

Source: Ceylon Electricity Board. 2021. *History of Electricity in Sri Lanka.* Colombo.

Electric tramways were open for traffic in Colombo in January 1900 and were operated by Colombo Electric Tramways and Lighting Company under Boustead Brothers who also constructed the Pettah Power Station with a 3-megawatt (MW) capacity in 1902 as the first large-scale power plant in the country. It was commissioned under the first scheme of electrification in Colombo. As the electricity sector progressed, Electricity Ordinance No. 36 of 1906 was introduced enabling local authorities to operate electricity supply schemes (Box 3). Under this ordinance many municipal and urban local authority organizations installed their own thermal generation plants to provide electricity mainly for urban areas such as Nuwara Eliya, Gampaha, Veyangoda, and Avissawella.

Box 3: Electricity Ordinance No. 36 of 1906

"An Ordinance for facilitating and regulating of supply and use of electrical energy for lighting, traction and other purposes."

Source: Ceylon Electricity Board. 2021. *History of Electricity in Sri Lanka.* Colombo.

However, the electricity sector had been entirely transferred to the state following the establishment of a separate government department in 1926, which was later renamed as the Department of Government Electrical Undertaking (DGEU). By this time more attention had been drawn toward the development of hydropower as a

[14] Ceylon Electricity Board. 2021. *History of Electricity in Sri Lanka.* https://ceb.lk/ceb-history/en.

result of the efforts of D. J. Wimalasurendra who worked as a district engineer of the Public Works Department. A paper titled *Economics of Power Utilization in Ceylon* was presented by him to the Engineering Association of Ceylon, recommending harnessing of the hydropower potential of the Mahaweli and Kelani rivers and establishing a national power grid.[15]

A national-level transmission and distribution grid network was established with commissioning of the first major hydropower scheme, the Laxapana Power Station Hydro Electric Scheme Stage 1 (25 MW) in 1950.[16] With this development, most of those local authorities that had been providing electricity by thermal generation opted to connect to the national grid. Further, by 1950 new DGEU area offices in Norton Bridge, Nuwara Eliya, Diyathalawa, Panadura, Negombo, Awissawella, and Peradeniya were established, extending electricity to some of the suburban areas. Distributed electricity to Jaffna peninsula was introduced in 1951 by purchasing electricity from Kankasanthurai Cement Factory by DGEU.

Electricity Act No. 19 of 1950 was introduced taking into consideration these new developments in the electricity sector (Box 4).

Box 4: Electricity Act No. 19 of 1950

"An Act to regulate the generation, transportation, transformation, distribution, supply and use of electrical energy."

Source: Ceylon Electricity Board. 2021. *History of Electricity in Sri Lanka.* Colombo.

In 1951, the Electricity Act was promulgated to regulate the power sector. The regulations made under Section 60, Clause 2 of this act are known as "Electricity Regulations 1951."

However, expansion of the transmission and distribution grids as well as generating capacity addition was slow during the following few decades and it took almost 30 years for the installed capacity to reach 500 MW. The local authorities and licensees had been responsible for distribution and supply, while the DGEU had been tasked with the generation and transmission of electricity. The slow growth in the sector was mainly attributed to this setup as local authorities in suburban and rural areas were not technically and financially strong enough to manage and expand electricity distribution.

In 1969, the Ceylon Electricity Board (CEB) was established by the government as the national power utility responsible for generation, transmission, and expansion of distribution network by enacting Act No. 17 of 1969. While expansion of the distribution network was undertaken by CEB, local authorities continued to maintain the distribution areas that they had been maintaining as licensees under the new Electricity Act (footnote 14).

Until the electricity distribution was taken over by CEB, Sri Lanka's electricity supply system was concentrated only in cities and towns. In 1983, Lanka Electricity Company (LECO) was formed, and both LECO and CEB have

[15] Ministry of Power and Energy. 2021. Commemorating D. J. Wimalasurendra Father of Hydro Power. http://powermin.gov.lk/english/?p=1934.

[16] Japan International Cooperation Agency and Economic Development Department. 2005. The follow-up study on the rehabilitation of hydropower stations in the Kelani River Basin for Hydropower Optimization in Sri Lanka. Colombo.

taken over and rehabilitated the local authority distribution networks. This transfer of assets was completed by mid 1990s.[17]

An independent regulator for the electricity industry, the Public Utilities Commission of Sri Lanka (PUCSL), was established under the provisions of the Public Utilities Commission of Sri Lanka Act, No. 35 of 2002. The PUCSL is the economic, technical, and safety regulator of the electricity industry in Sri Lanka and the designated regulator for petroleum and water services industries (footnote 17).

The PUCSL was empowered to execute regulation when individual industry legislations are enacted and made effective. Electricity Act No. 20 of 2009 legislation allowed the PUCSL to operate as the power sector regulator.

The key milestones of power sector reforms are summarized in Box 5.

Box 5: Key Milestones of Power Sector Reforms and Impact on Power Sector Development

1969 – Enacting of the Ceylon Electricity Board Act No. 17 of 1969 and the Ceylon Electricity Board was set up as the national power utility responsible for generation and transmission which contributed to rapid expansion of electricity distribution network in the rural areas of the country.

1983 – Establishment of Lanka Electricity Company, a government-owned distribution company, established for management and operation of electricity distribution areas managed by local authorities. The reliability, power quality, and service quality of poorly managed distribution network in the local-authority-managed areas was greatly improved and distribution losses in Lanka Electric Company area was brought down to 4.5%.

2002 – Public Utilities Commission Act No. 35 of 2002 was enacted by the Parliament and the Public Utilities Commission of Sri Lanka was established as the regulator of the sector.

2009 – Sri Lanka Electricity Act No. 20 of 2009 was approved by the Parliament and regulation of the sector has been transferred to the Public Utilities Commission of Sri Lanka.

Source: ADB. 2015. *Assessment of Power Sector Reforms in Sri Lanka*. Manila.

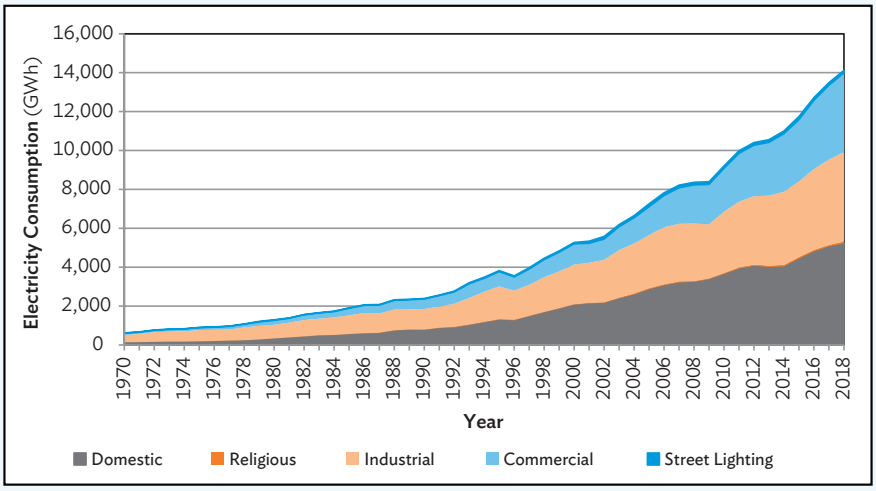
Electricity Demand Growth

Electricity demand in Sri Lanka has been growing at a steady pace during the last 4 decades, mostly due to the increased rate of electrification in the country and developments in the service and industry sectors. Figure 2.1 shows the electricity use by different consumer categories.

The electricity consumption has been increasing at an average rate of 4.8% during the period 2008–2018.[18] The share of electricity consumption in the domestic sector increased significantly from 2000 to 2018, and was the largest consumption group by 2018 out of the three main tariff categories in Sri Lanka: domestic, industrial, and commercial. Figure 2.2 shows the changing market share for each customer group.

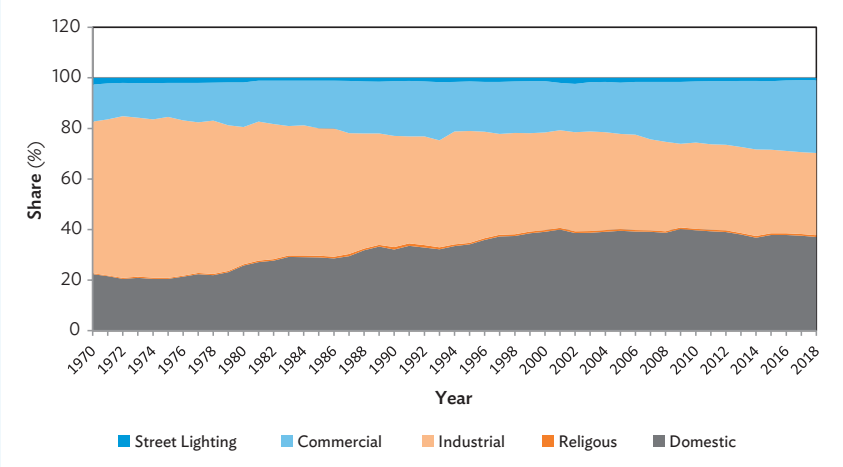
[17] ADB. 2015. *Assessment of Power Sector Reforms in Sri Lanka*. Manila.
[18] Ceylon Electricity Board. 2018. *Annual Report–2018*. Colombo.

Figure 2.1: Electricity Demand Growth, 1970–2015



GWh = gigawatt-hour.
Source: Sustainable Energy Authority of Sri Lanka. 2018. *Sri Lanka Energy Balance*. Colombo.

Figure 2.2: Share of Electricity Consumption by Consumer Categories



Source: Sustainable Energy Authority of Sri Lanka. 2018. *Sri Lanka Energy Balance*. Colombo.

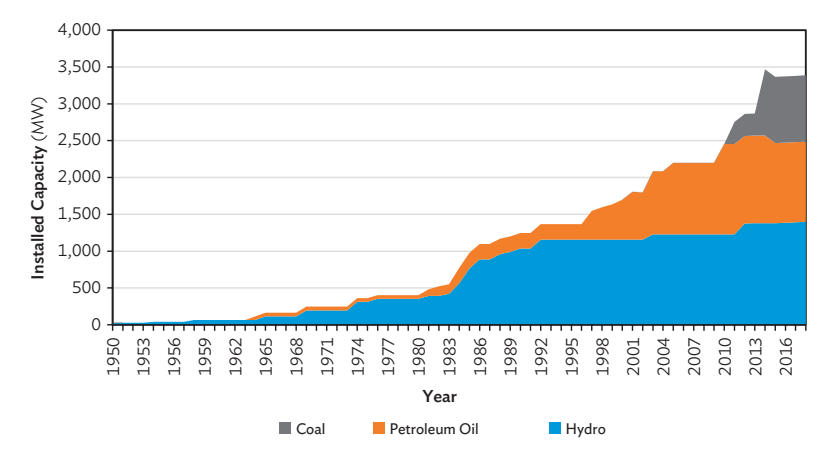
The shares of the domestic and the commercial sectors have increased, while the industry sector has been decreased. Until late 1990s, electricity consumption was dominated by industry; since 2000, the domestic sector has overtaken industry as the largest user, and the commercial sector's share has also been increasing. The rapid growth in electrification, particularly in the rural areas, has caused the increased share of domestic sector sales. However, the electricity consumption pattern shows a marginal decrease in the domestic sector since around 2010. This could be due to saturation in the domestic sector with movement toward 100% electricity coverage and increased development in the commercial sector and industry sector. Increased use of energy-efficient items such as efficient lighting in the domestic sector may also have been a factor. The

main contribution to the increased per capita electricity consumption is the contribution of growth in the commercial and industry sectors.[19]

Electricity Generation

Electricity generation capacity has been developed to meet growing demand. The historical growth of generation capacity is shown in Figure 2.3.

Figure 2.3: Generation Capacity Growth



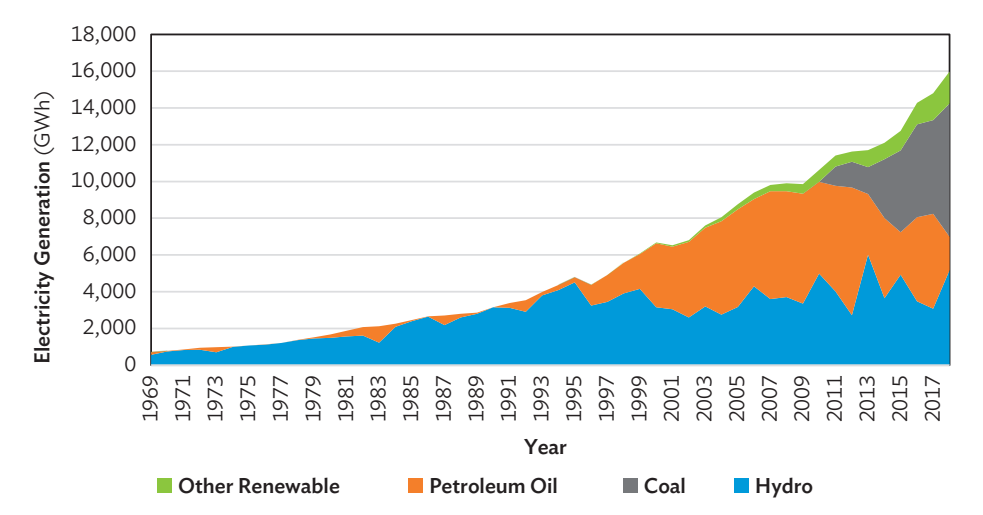
MW = megawatt.
Source: Sustainable Energy Authority of Sri Lanka. 2018. *Sri Lanka Energy Balance*. Colombo.

Since commissioning of the first major hydro-electricity scheme, the Laxapana Hydro Electric Scheme Stage 1 (25 MW) in 1950, hydroelectricity has been the principal source of electricity generation in Sri Lanka until 2005. The economically viable hydroelectric power potential in the country was largely harnessed by 2018 and the remaining medium-sized hydropower plants are under construction. Eighteen large hydroelectric power stations were in operation by 2018, with a total installed capacity of 1,377 MW (footnote 18).

Petroleum-oil-based thermal power plants to supplement hydropower plant and meet growing electricity demand were also added to the power system commencing with the 50 MW steam power plant at Kelanitissa Power Station commissioned in 1964 and gas turbine and diesel power plant thereafter. Coal-based power generation plants were introduced in 2011, further diversifying the energy mix of electricity generation and reducing the dependency on oil-based power generation. Total installed capacity of coal-fired power plant in the power system is 900 MW (footnote 18). The electricity generation mix since 1970 is shown in Figure 2.4.

[19] Sri Lanka Sustainable Energy Authority. 2015. *Sri Lanka Energy Balance–2015*. Colombo.

Figure 2.4: Electricity Generation Mix

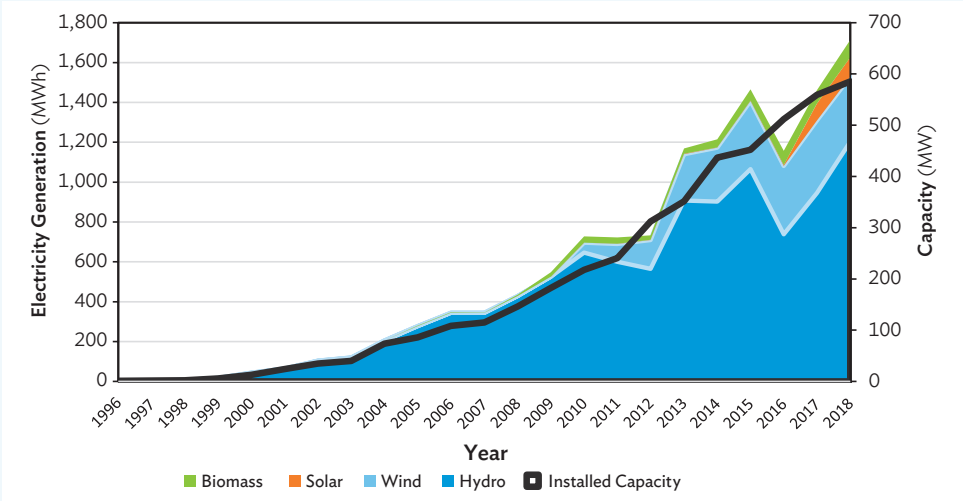


GWh = gigawatt-hour.
Source: Sustainable Energy Authority of Sri Lanka. 2018. *Sri Lanka Energy Balance*. Colombo.

Electricity generation from nonconventional renewable energy (NCRE) sources (wind, mini hydro, solar, and biomass) have also been a contributor to electricity generation during recent years. The share of NCRE in 2017 stood at 13.4% of total electricity generation. Figure 2.5 shows the generation mix of NCRE and installed capacity.

Electricity generation from NCRE gained a new impetus with the introduction of a Standardized Power Purchase Agreement and favorable purchase tariff in 1996 for renewable energy plants of capacity less than 10 MW, thus

Figure 2.5: Electricity Generation and Installed Capacity of Nonconventional Renewable Energy



MW = megawatt, MWh = megawatt-hour.
Source: Sustainable Energy Authority of Sri Lanka. 2018. *Sri Lanka Energy Balance*. Colombo.

expanding private sector investment for such plants. These policy initiatives led to a rapid deployment of small hydropower plant in the country. This development was further catalyzed with the introduction of a cost-based technology specific three tier tariff in 2008 for purchase of electricity from small renewable energy-based power plants of capacity of less than 10 MW (footnote 17). Figure 2.5 also shows the impact of these policy initiatives in terms of increased electricity generation from those power plants. Figure 2.6 shows a typical household with grid connected solar photovoltaic panels on rooftop. Solar photovoltaic systems had also contributed in remote isolated rural communities in the initial stage of electrification drive in the country. Currently, the solar rooftop systems support in maintaining continuity of electricity supply during power interruption in urban and sub-urban areas when combined with battery energy storage.

Figure 2.6: Household with Grid Connected Solar Photovoltaic Panels on Rooftop

Access to clean energy. The Government of Sri Lanka together with ADB are helping to promote rooftop solar photovoltaic systems in Sri Lanka (photo by Ameesha Wijayatunga).

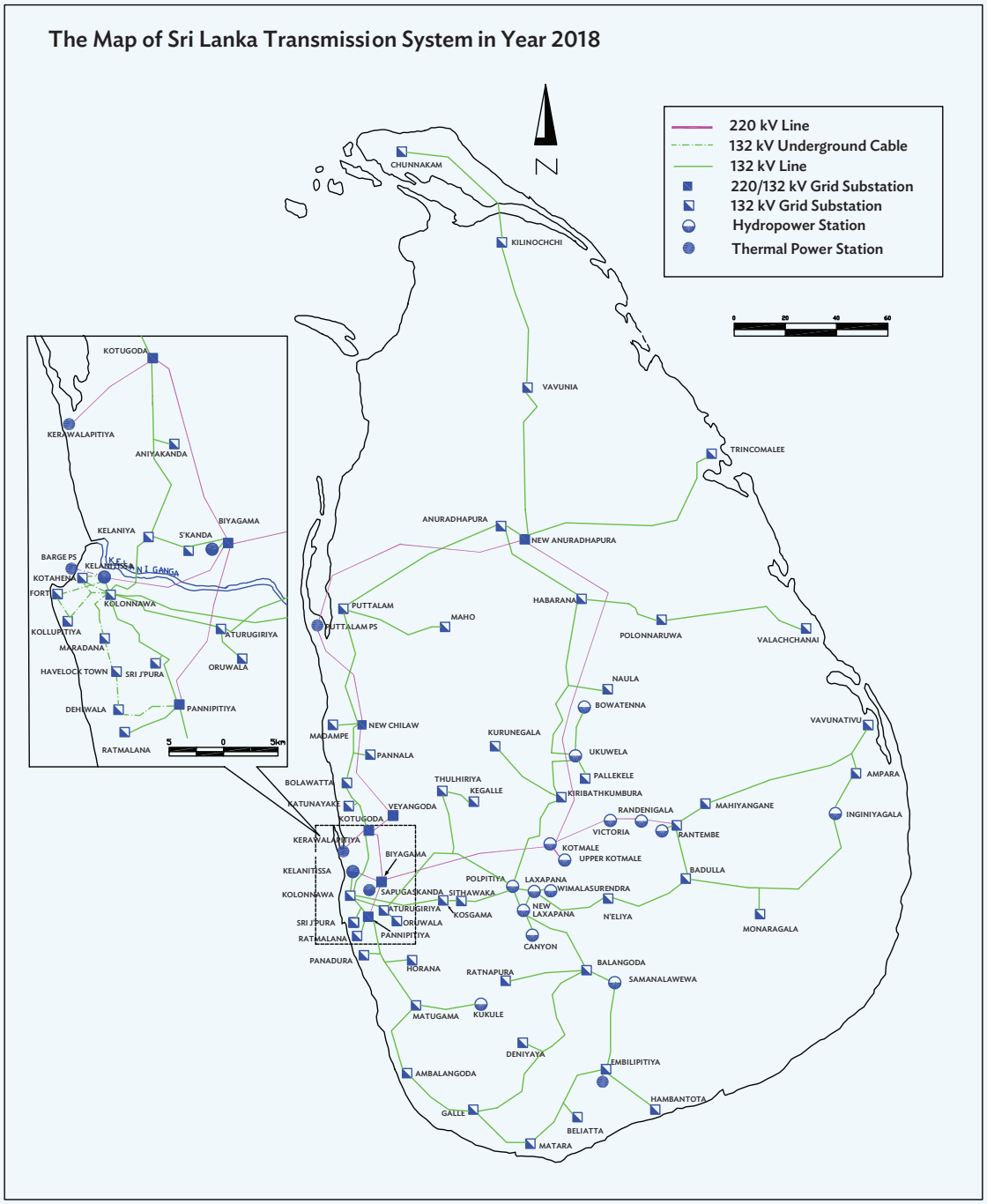
Transmission and Distribution Network Expansion

The power transmission and distribution network has been expanded and upgraded to meet growing electricity demand through the implementation of a number of transmission development projects to ensure the reliability and quality of electricity supply while enabling the evacuation of power from new generation facilities. Necessary improvements were also done to increase the integration of renewable energy source-based power generation into the grid.

The transmission system comprises of 220-kilovolt (kV) and 132 kV transmission lines. The present transmission system has 220 kV/132 kV/33 kV grid substations located at Biyagama, Kotugoda, Anuradhapura, Pannipitiya, and Kelanitissa. In addition, the system consists of 49, 132 kV/33 kV grid substations and 5, 132 kV/11 kV grid

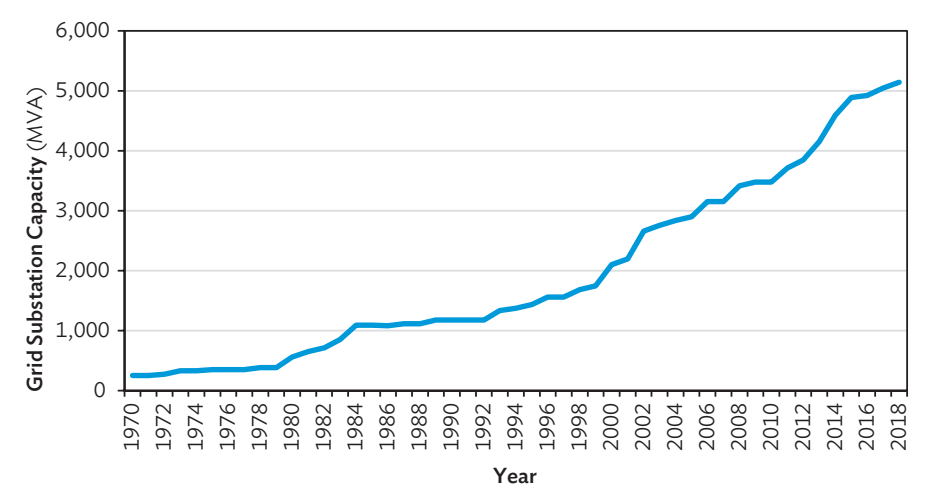
substations in the Colombo city area. Figure 2.7 shows the status of the transmission network in 2018. Figure 2.8 shows the capacity increase of 220 kV and 132 kV grid substations in the country. The expansion of low-voltage and medium-voltage line lengths is shown in Figure 2.9.

Figure 2.7: Transmission Network in 2018



kV = kilovolt.
Source: Ceylon Electricity Board Statistical Digest 2018.

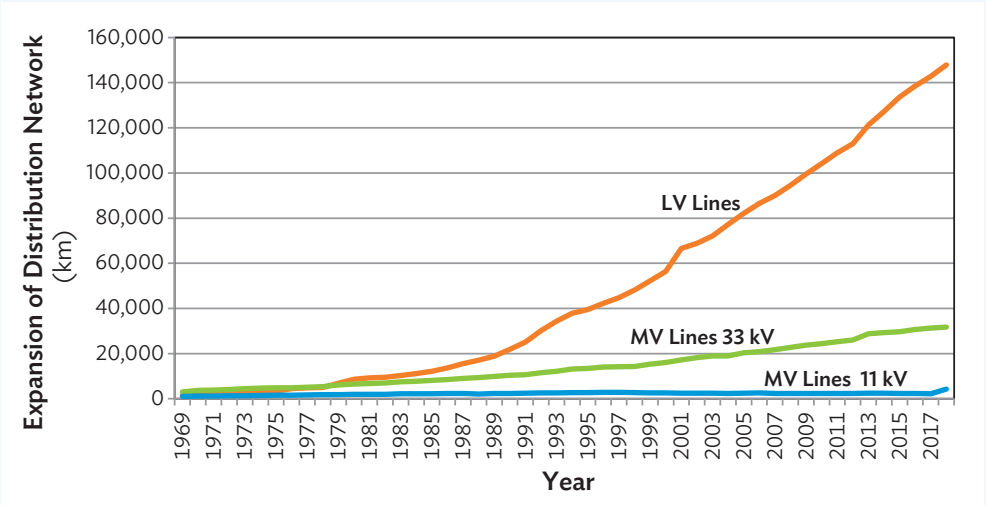
Figure 2.8: 220 kV and 132 kV Grid Substation Capacity



MVA = megavolt-ampere.

Source: Transmission and Generation Planning Branch, Ceylon Electricity Board. 2018. *Database of Transmission and Distribution*. Colombo.

Figure 2.9: Expansion of Electricity Distribution Network



km = kilometer, kV = kilovolt, LV = Low Voltage, MV = Medium Voltage.

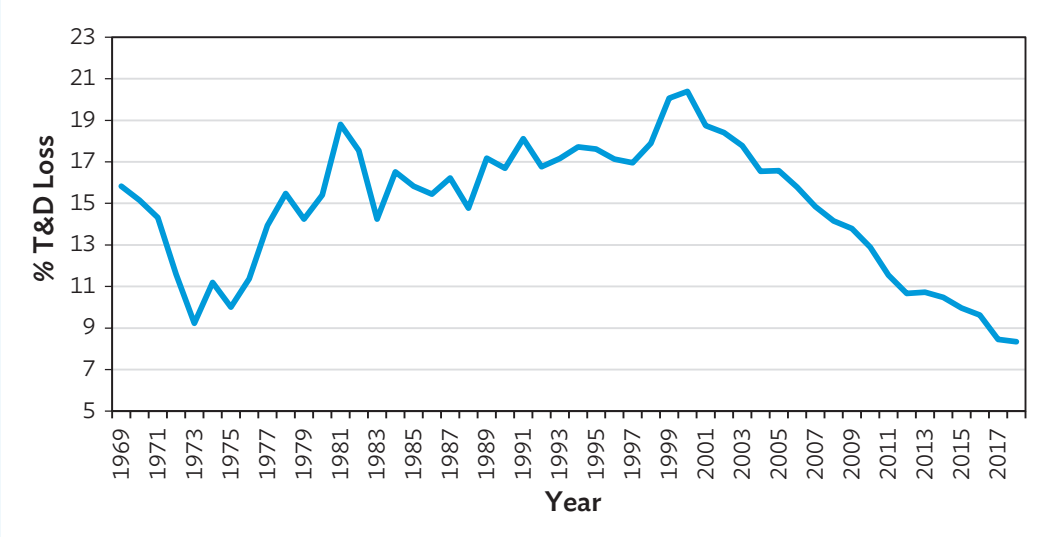
Source: Transmission and Generation Planning Branch, Ceylon Electricity Board. 2018. *Database of Transmission and Distribution*. Colombo.

The low-voltage network expanded rapidly since the early 1980s with establishment of the rural electrification division in CEB and with the flow of external funding from international lending agencies for rural electrification. At the formation of CEB in 1969, total line length of the low-voltage network was about 6,900 kilometers, which doubled every 10 years. The medium-voltage network also expanded in the same manner.[20]

System Loss Reduction

As a result of planned network improvement at all voltage levels, significant system loss reduction was achieved especially from the year 2000 onward (Figure 2.10).

Figure 2.10: Transmission and Distribution Loss



T&D = transmission and distribution.

Source: Transmission and Generation Planning Branch, Ceylon Electricity Board. 2018. *Database of Transmission and Distribution.* Colombo.

[20] Ceylon Electricity Board. 2015. *Historical Data Book 1969–2015.* Colombo.

3 Expansion of Rural Electrification

Institutional Development

CEB expanded its distribution network to rural areas in the early 1970s and built "rural electrification schemes" using a variety of funds. Initially, funds came from largely local sources such as development funds, and through other multipurpose development projects.

In the late 1970s, rural electrification was identified as a priority function of CEB, and a separate project division was established in 1980. This division was responsible for identification of prospective rural electrification schemes, evaluating their technical and economic feasibility and for undertaking their implementation in a more systematic manner. Proposed rural electrification schemes were surveyed and analyzed and packaged into projects and presented for financing. Figure 3.1 shows a rural electrification line.

Figure 3.1: Low-Voltage Aerial Bundle Conductor Line through a Jungle

Rural electrification. The Government of Sri Lanka has dedicated to achieving 100% electrification in the country and rural development via reliable electricity supply (photo by Keshan Samarasinghe).

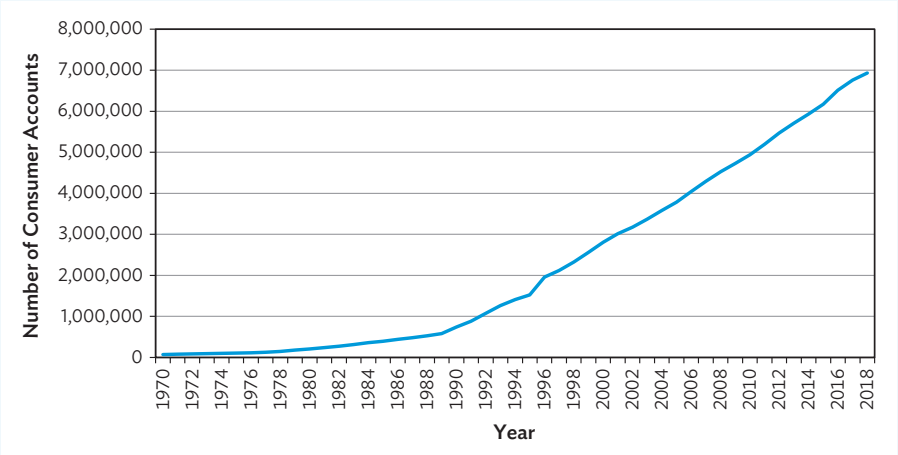
By 1970, CEB had a total of about 70,000 customers, of which about 53,000 were household customers. It is estimated that about 8% of the country's estimated 3.1 million households were electrified by 1970; about one-fifth of these customers were served directly by CEB, while the others were served by the local authorities (footnote 20).

Rural electrification work by CEB in the early 1980s was organized through load promotion. The "Load Promotion Cell" in the CEB worked on developing new customer bases among rural and suburban customers, as well as among industries. Load promotion work covered areas of the existing network as well as new distribution areas. Specific promotional work included a loan scheme to cover house-wiring costs and electricity service connection costs for households, introduced through the state-owned Peoples Bank (footnote 18).

The first formal Rural Electrification Project (RE 1 Project) was funded by the Asian Development Bank (ADB) in 1980 with a loan of $11.3 million. That was followed by the implementation of two more projects with ADB assistance ($74.8 million for RE 2 Project in 1990 and $79.4 million for RE 3 Project in 1996). In addition, Japan International Cooperation Agency (JICA) also provided a loan amounting to $43.7 for improvement of the medium-voltage distribution network. These loans stimulated extension of the distribution grid to many rural areas.[21]

A key feature in maintaining the effectiveness of the rural electrification program was the selection of potential projects that maximized economic and social benefits. A project or scheme typically targeted a village or area with about 140 dwellings likely to be connected, and these were supplied via a single 100-kilovolt-ampere distribution transformer. The government provided funds to CEB as equity contributions. Figure 3.2 shows the growth profile of CEB accounts from 1970 to 2018.

Figure 3.2: Growth Profile of Ceylon Electricity Board Accounts



Source: Ceylon Electricity Board. 2018. *Database of Consumer Accounts*. Colombo.

[21] Department of External Resource. 2021. *Data Base of External Resources*. Colombo.

With the formation of LECO as a subsidiary of CEB in 1983, through the assistance of ADB, those power distribution areas under local authorities were gradually taken over by LECO. Connection of new customers by both CEB and LECO through clearly identified rural electrification projects led to a rapid growth in the electrification ratio. The number of households receiving electricity grew from 8% in 1970 to 29% in 1990 and 63% of total households in the country by 2000.[22] Figure 3.3 shows an innovation by LECO.

Figure 3.3: A Single-Pole Transformer Originated by Lanka Electric Company

Intervention for distribution networks. Lanka Electric Company is dedicated to providing reliable electricity supply with minimum disturbances (photo by Charitha Sandaruwan).

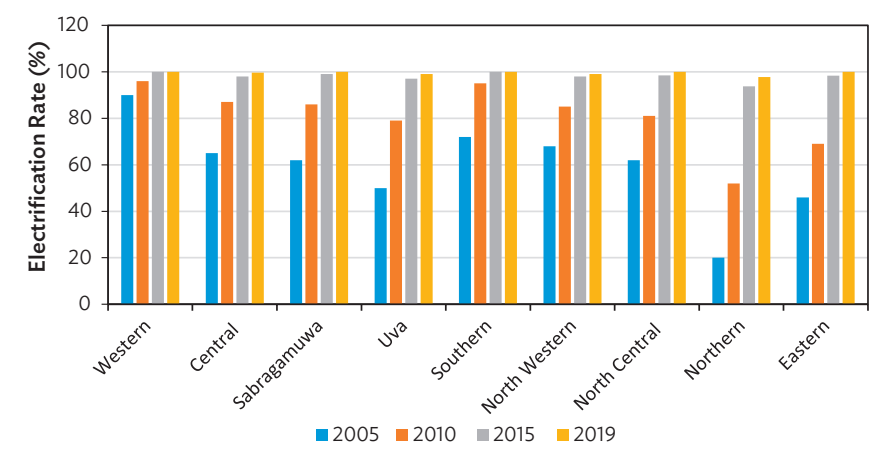
[22] Ceylon Electricity Board. 2016. *Statistical Digest–2016*. Colombo.

Rural Electrification Projects at the Provincial Level

Electrification of rural areas poses many challenges, prominent among them are the high capital investment, operational costs, and the difficulties associated with extending grid-connected electricity lines to remote areas. That resulted in disparity in access to electricity in some of the districts. The conflict-affected areas in the northern and eastern provinces as well as less developed provinces such as the Uva province had lower levels of electrification.

The Ministry of Power and Energy initiated individual projects in 2008 for each of these provinces to address their specific needs. These projects included the "Nagenahira Navodaya" in the Eastern Province, "Uthuru Wasantham" covering the Northern Province, and "Uva Udanaya" in the Uva Province. As a result, the districts of Mulathivu and Kilinochchi, which had less than 4% of electrification in 2008, were provided with 100% electricity coverage by 2016. Figure 3.4 illustrates the increase of electrification rate during 2005 to 2019 at the provincial level.

Figure 3.4: Electrification Levels by Province



Source: Ceylon Electricity Board. 2019. *Database of Distribution Network*. Colombo.

Policy Interventions and Strategies

National Energy Policy

Rural electrification gained a new impetus in 2008 with the announcement of the National Energy Policy and Strategies of 2008, and clear milestones to achieving the target of 100% electrification in the country. The relevant policy element stated that "energy requirements to fulfill the basic needs of the people and to enhance their living standards and opportunities for gainful economic activities will be adequately satisfied at the lowest cost to the economy."[23]

[23] Ministry of Power and Energy. 2008. *National Energy Policy and Strategies of Sri Lanka*. Colombo.

Further, it was decided that the national grid should be extended wherever economically and socially beneficial, and that where electrification schemes are not financially viable to the utility, the government should provide any financing needed to make such schemes financially viable to the utility. Accordingly, a separate budget item was included in the national budget from 2008 for rural electrification extensions.

With these developments several bilateral as well as multilateral lending agencies committed financial support for both distribution and transmission network expansion in the country.

Last-Mile Service Connection

The government has been implementing a wide range of rural electrification projects since the 1970s and it was witnessed that there were many rural households in the network-expanded areas which had not obtained electricity access for years. The main reason for that was the unaffordability of prospective consumers to pay for the electricity service connection.

Household connectivity charges of CEB used to be directly proportional to the distance between the house and the nearest CEB access point, and they increase by every meter of distance. The cost of connectivity also increased disproportionately beyond 100 meters from the CEB access point. These connectivity charges had also grown at an average rate of 10% per annum. The cost of internal household wiring was also found to be unaffordable to a majority of low-income families. It was therefore well acknowledged that the success of rural electrification and the government's commitment of 100% electrification, were dependent on making grid connectivity affordable to every citizen of the country. Box 6 recounts the impact of electrification on a small business.

In this context, taking into consideration the policy decision of providing electricity to every citizen in the country, the government decided to adopt the following strategies in 2011.

(i) Extending electricity supply to the premises of the households (up to 50 meters from the supply system) where households will pay only a fixed charge for the service connection.
(ii) Devising standardized wiring schemes for low-income households including financial assistance for internal wiring based on installment payments with such schemes administered by the utility.
(iii) Introducing concessional credit to low-income households to pay for service connection and internal wiring with credit recovery in installments through the monthly electricity bill.

Credit Lines Facilitating the Household Connections

There have been several initiatives focused on facilitating final household connectivity through appropriate credit mechanisms.

Most successful among them were the last-mile customer connection projects implemented by CEB in collaboration with the People's Bank from 1987 to 2002. This credit scheme enabled electricity access to over 450,000 households across the country during that period.

Figure 3.5: Medium-Voltage Line Passing Through a Paddy Field to Supply Electricity

Last-mile connectivity. The Government of Sri Lanka has been implementing a wide range of rural electrification projects for rural development (photo by Keshan Samarasinghe).

During 2004 to 2007, another initiative with similar focus was piloted by the government, in collaboration with ADB and the Japan Fund for Poverty Reduction (JFPR), with the support of microfinance institutions that played the role of Implementing Agencies (IAs) at the beneficiary level.

Investments in Rural Electrification

The Government of Sri Lanka has been consistently working to extend grid connectivity to the rural and remote–rural pockets within the island. Many projects have been implemented over the years, under a wide spectrum of institutional and funding arrangements.

Since the early 1970s, funding was provided through the national budget for rural electrification. ADB was the first multilateral lending agency to consider a loan for rural electrification. ADB provided a loan amounting to $11.3 million for rural electrification (RE1 Project) in 1980. Along with the intervention of ADB in financing of RE projects, a significant change in expansion of distribution occurred.[24]

[24] M. Rajaguru. 2017. *A Forward March towards an Energy Empowered Nation Case Study in Sri Lanka*. Colombo.

Figure 3.6: An Electrified Coconut Husk Chip Factory

Eco-friendly industry. Electricity supports in strengthening eco-friendly small- and medium-scale industries (photo by Keshan Samarasinghe).

Box 6: M. N. Aruna Marasinghe from Kurunegala: Impact on a Small Business

I am from Kuliyapitiya, North Western Province. I started a coconut husk chips business with encouragement from one of my close friends. Before I came into this business, I worked in a coconut fiber factory and in the copra business. As I remember, we have had electricity supply in our area since 1992. Initially, I installed a small crushing machine to process coconut husk, and it was powered from supply drawn from my home. It was a profitable business. Then, I wanted to expand into a separate factory to produce coconut husk chips.

We did not know that the new coconut husk chips machine needed high-capacity electricity supply connection to operate smoothly. At that time, we had access to only single-phase electricity supply and the nearest transformer was 1.2 kilometers away from our factory. I made several requests for a three-phase supply connection from Ceylon Electricity Board (CEB) and the Divisional Secretariat Office. But the distance from the transformer to the factory was the barrier for the connection to proceed. I ended up replacing the machine with a diesel-powered crusher. I could not continue the business because I had to pay SLRs3,500 per day for fuel. The fuel cost was exorbitantly high, and my business could not stand that.

Finally, I managed to get a three-phase connection to the factory since the government took a policy decision to give three-phase electricity supplies to all small- and medium-scale industries regardless of the distance from the nearest

continued on next page

Box 6 *continued*

existing transformer. When we got three-phase supply, the machine operated smoothly. Now I can generate adequate profit from my business, and I have hired three people to work in the factory.

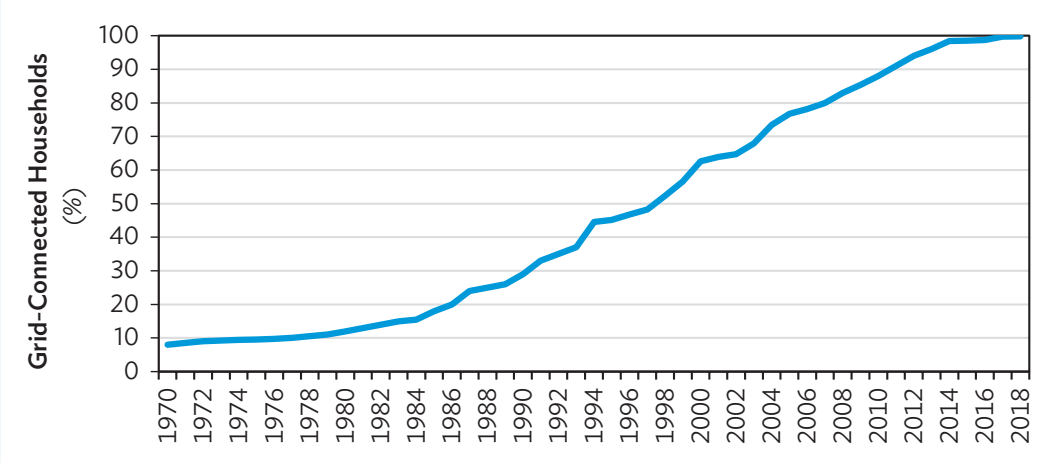
There is a huge demand for coconut husk chips. If I can get 60-ampere connection, I can install a new machine and expand my production. Currently, we can only reserve 30-ampere capacity from the three-phase line. Since we do not have a transformer in our village and the distance from the nearest transformer is still too long, we can't get more power from the grid. My request to the authorities is to please help us by installing a new transformer in the village. Then, we can further improve our production. I am really thankful to CEB and the authorities for providing a reliable electricity supply.

Source: Authors' survey and interviews.

The addition of 660 MW of power generation capacity in the 1980s and expansion of the power transmission network under the Accelerated Mahaweli Development Program provided a large incremental capacity in generation for meeting the power demand.[25]

With the completion of Rural Electrification Project 1 (RE 1), ADB provided a second loan of $74.3 for RE 2 in 1990 followed by a loan of $79.4 million for RE 3 in 1996 (footnote 21). These loans stimulated extension of the distribution grid to many rural areas and as a result, total electrification level reached 63% by 2000 (Figure 3.7) and the CEB's customer base increased from 0.2 million in 1980 to 2.8 million in 2000 (Figure.3.2).

Figure 3.7: Percentage of Grid-Connected Households



Source: Ceylon Electricity Board. 2018. *Database of Consumer Accounts*. Colombo.

[25] ADB. 2015. *Mahaweli Water Security Investment Program*. Manila.

The Ministry of Power and Energy initiated the development of individual projects for each of the provinces to address their specific needs since 2008. These projects were financed by separate lending agencies. Projects which played a vital role in enabling Sri Lanka to expand its electrification status during the last 3 decades are presented in Table 3.1.

Table 3.1: Rural Electrification Projects Funded by International Lending Agencies

Project	Lending Agency	Total Loan ($ million)	Project Period
RE 1–Rural Electrification Project	Asian Development Bank	11.3	1980
Secondary Towns Power Distribution Project (LECO)	Asian Development Bank	11.9	1985
Secondary Towns Power Distribution Project (LECO)	Asian Development Bank	37.1	1988
RE 2–Power System Expansion Project	Asian Development Bank	74.8	1990
RE 3–Second Power System Expansion Project	Asian Development Bank	79.4	1996–2003
Medium Voltage Distribution Development Project	Government of Japan–JICA	43.7	1998
RE 5–Rural Electrification Project	Government of Kuwait–Kuwait Fund	10.7	2000
RE 6–Power Sector Development Project	Asian Development Bank	69.8	2003–2006
RE 7–Rural Electrification Project 7	EXIM Bank of China	24.2	2003
RE 4–Fourth Rural Electrification Project	Swedish International Development Agency	28.8	2004–2011
RE 8–Rural Electrification Project 8	Export Development Bank of Iran	83.4	2010
Northern Province Power Sector Development Program (Uthuru Wasanthaya)	EXIM Bank of China	31.8	2010–2014
RE 4 Extension	Swedish International Development Agency	54.1	2011–2013
Lighting Sri Lanka–Uva Province (Uva Udanaya)	EXIM Bank of China	24.9	2011–2014
Lighting Sri Lanka–Eastern Province (Negenahira Navodaya)	EXIM Bank of China	31.6	2012–2014
Eastern Province Distribution Improvement Project	Asian Development Bank	20.0	2012–2015
Supporting Electricity Supply Reliability Improvement Project	Asian Development Bank	115	2017–2022

EXIM = Export–Import, JICA = Japan International Cooperation Agency, RE = rural electrification.

Source: External Resources Department of Sri Lanka. 2018. *Database of External Resource Mobilization.* Colombo.

Apart from the externally funded projects specified above, there have been investments from the Government of Sri Lanka (through the Decentralized Budget, Provincial Council Budget, Gama Neguma Program, and others) and the CEB through its System Development and System Augmentation Programmes. One of the highlights of the government-initiated projects is the "Lighting Sri Lanka Project," which was operative in about nine districts since 2008, focusing on extending medium- and low-voltage networks (Box 7).

Box 7: Policy Interventions and Strategies Adopted to Promote Rural Electrification

1980 – Rural electrification was identified as a priority function of the Ceylon Electricity Board (CEB), which established a separate project division and staff to identify prospective rural electrification schemes, evaluate their technical and economic feasibility and to undertake their implementation in a systematic manner

1980 – Rural electrification schemes were packaged into projects and presented for financing by international lending agencies. The first such project was funded by the Asian Development Bank (ADB) in 1983, followed by implementation of two more projects with the assistance of ADB. This approach catalyzed the rapid expansion of electrification of the country with electrification level rising from 12% in 1980 to 63% in 2000.

1983 – The first-ever National Energy Policy was published in 1984 identifying the providing of basic energy needs as one of the main policy elements.

1986 – CEB decided to utilize loans of international lending agencies to obtain materials for rural electrification projects and handle the construction work of all the projects by CEB with local funding for better utilization foreign loans.

1987 – The first credit-based "last-mile electricity service connection model" by CEB with People's Bank was introduced for internal house wiring and service connection, focusing on low-income households; later the same was extended to everyone who was willing to go through credit line. This credit scheme enabled electricity access to over 450,000 households across the island from 1987 to 2002. Total loan disbursements during the period accounted to over SLRs2,851 million.

2008 – The National Energy Policy published in 2007 continues to recognize the provision of basic needs of energy as one of the main policy elements. This policy element was defined as: "Energy requirements to fulfill the basic needs of the people and to enhance their living standards and opportunities for gainful economic activities will be adequately satisfied at the lowest cost to the economy."

2008 – Rural electrification gained a new impetus with the announcement of that National Energy Policy and the clear target of achieving 100% electrification in the country. Further, it was decided that the national grid should extend wherever economically and socially beneficial, and where schemes are not financially viable to the utility, the government should provide supplementary financing to make such schemes financially viable.

2008 – Several bilateral as well as multilateral lending agencies committed financial support for both distribution and transmission network expansion in the country.

2008 – The Ministry of Power and Energy decided to adopt a new strategy by developing individual projects for each of the provinces to address the specific needs of the particular province. These projects were offered to separate lending agencies for financing.

2008 – Provisions for expansion of rural electrification was included in the national budget as separate provincial projects to meet construction cost of rural electrification projects. Nine such projects were included in the national budget.

continued on next page

Box 7 *continued*

2011 – CEB devised standardized wiring schemes for low-income households and introduced concessional credit line to low-income households to pay for service connection and internal wiring and recovered the loan in installments through monthly electricity bill. This credit line was established with financial assistance from ADB and Samurdhi Bank.

2011 – To make the electricity service connection charges affordable to low-income households, the Ministry of Power and Energy decided to extend the electricity supply to the premises of the households (up to 50 meters from household premises) where households will pay only a fixed charge for the service connection.

2015 – The credit line for last-mile service connection was expanded further with additional funding from Samurdhi Bank as well as ADB to provide loans to provide service connection to all the remaining low-income households.

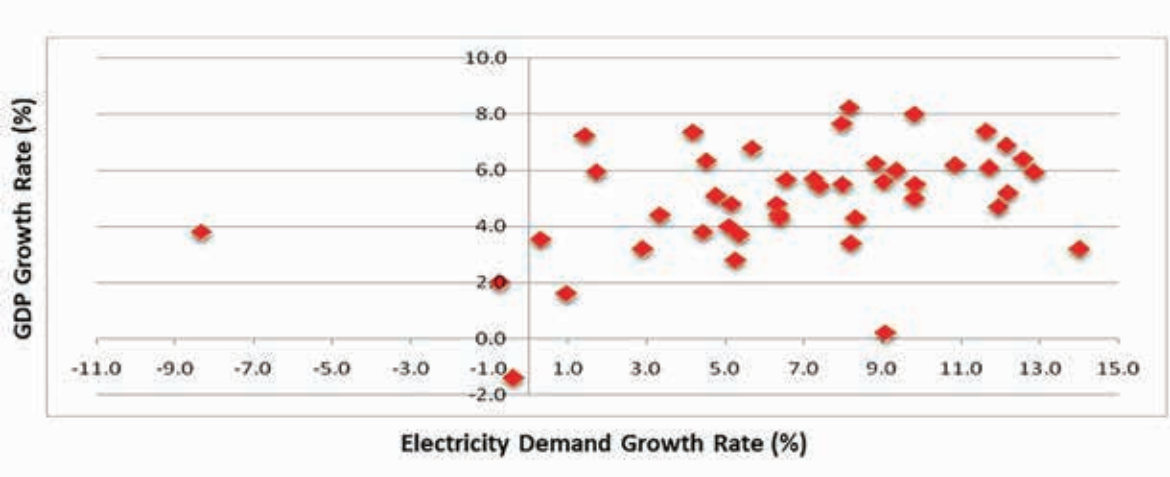
Source: Authors' data collection and presentation.

4 Analysis of the Macroeconomic Impact of Electrification

Background of Macroeconomic Studies

The link between the use of electricity and the output (GDP) of an economy has been the subject of an extensive academic literature. For the more recent studies, the aim has been to test whether higher electricity use leads to GDP growth, or GDP growth leads to more electricity consumption, or both links coexist, or no causal relation exists between the two variables.

Figure 4.1: GDP and Electricity Demand Growth Rates, 1970–2015



GDP = gross domestic product.
Source: Central Bank of Sri Lanka. 2016. *Database of Statistic of GDP Growth*. Colombo.

Maintaining an adequate and reliable power supply may be one of the most critical factors which support economic growth. Figure 4.1 shows plots of GDP growth (y-axis) and corresponding electricity demand growth (x-axis) from 1970 to 2015 in Sri Lanka.

The main objective of this study is to examine as to whether there is a stationary, long-run equilibrium relationship between electricity consumption, economic growth, and employment in Sri Lanka using the bounds testing for longer periods approach applying an autoregressive distributed lag (ARDL) bounds test with co-integration. The study will also examine the characteristics of the causality relationships between the variables.

Model Specification

Consistent with previous empirical studies on long-run relationships between per capita GDP, electricity generation, and employment, the proposed model for Sri Lanka as a standard log-linear function takes the following form:

$$\ln PGDP_t = \alpha_0 + \alpha_1 \ln EC_t + \alpha_2 \ln EMP_t + \varepsilon_t \quad (1)$$

Where ln*PGDP* is the natural logarithm of real per capita GDP in SLRs, ln *EC* is the natural logarithm of electricity demand in gigawatt-hours (GWh), ln *EMP* is the natural logarithm of employment in terms of the number of employed people, and ε_t is the error term. α_0, α_1, and α_2, are the elasticities to be estimated.

After the civil war in Sri Lanka in 2009 and dawn of peace after nearly 3 decades, there has been a structural break since 2010. During the period 2010 to 2015, the average annual growth rate of the economy increased from around 5% to 7%. In order to capture the effect in the model, a dummy variable, BREAK, has been constructed, that takes the value 1 for the observations from 2010 and 0 everywhere else.

Annual GDP data, employment data, and midyear population figures used for the period 1970 to 2015 are from the Department of Census and Statistics Sri Lanka. Electricity demand data are from the CEB.

Methodology

The methodology used here is based on the autoregressive distributed lag (ARDL) framework. The estimates obtained from the ARDL method of co-integration analysis are unbiased and efficient given that: (a) it can be applied to studies that have a small sample, such as the present study; (b) it estimates the long-run and short-run components of the model simultaneously, removing problems associated with omitted variables and autocorrelation; and (c) the ARDL method can distinguish between dependent and independent variables.

Suppose that with respect to the model there is a long-run relationship among ln*PGDP*, ln *EC*, and ln *EMP*. Without having any prior information about the direction of the long-run relationship among the variables, the following unrestricted error correction (EC) regressions are estimated, considering each of the variables in turn as the dependent variable:

$$\Delta \ln PGDP_t = a_{GDP} + \sum_{i=1}^{p} \beta i_1 \Delta \ln PGDP_{t-i} + \sum_{i=0}^{q} \beta i_2 \Delta \ln EC_{t-i} + \sum_{i=0}^{r} \beta i_3 \Delta \ln EMP_{t-i} + \Theta_1 \ln PGDP_{t-1} + \Theta_2 \ln EC_{t-1} + \Theta_3 \ln EMP_{t-1} + \omega_{1t} \quad (2)$$

$$\Delta \ln EC_t = a_{EG} + \sum_{i=1}^{p} \beta i_4 \Delta \ln PGDP_{t-i} + \sum_{i=0}^{q} \beta i_5 \Delta \ln EC_{t-i} + \sum_{i=0}^{r} \beta i_6 \Delta \ln EMP_{t-i} + \Theta_4 \ln PGDP_{t-1} + \Theta_5 \ln EC_{t-1} + \Theta_6 \ln EMP_{t-1} + \omega_{2t} \quad (3)$$

$$\Delta \ln EMP_t = a_{EMP} + \sum_{i=1} \beta i_7 \Delta \ln PGDP_{t-i} + \sum_{i=0} \beta i_8 \Delta \ln EC_{t-i} + \sum_{i=0} \beta i_9 \Delta \ln EMP_{t-i} + \Theta_7 \ln PGDP_{t-1} + \Theta_8 \ln EC_{t-1} + \Theta_9 \ln EMP_{t-1} + \omega_{3t} \quad (4)$$

Where, Δ is the first difference operator; p, q, and r are the lag length; beta's are the coefficients relating to the short-run dynamics of the model's convergence to equilibrium; and θ_{GDP}, θ_{EG}, and θ_{EMP} measure the speed of adjustment. The residuals, ω_{1t}, ω_{2t} and ω_{3t} are assumed normally distributed and white noise.

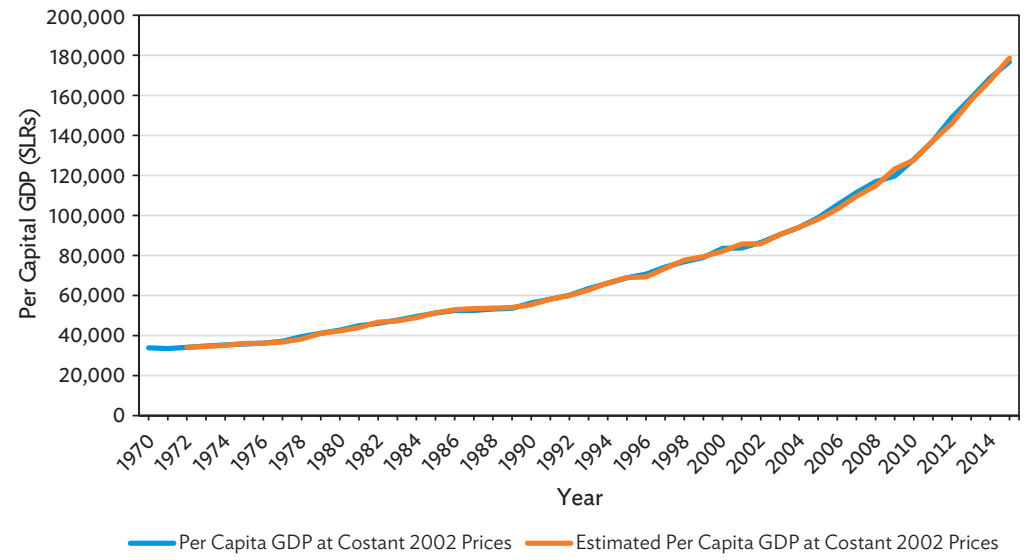
Interpretation of the Results

Usually, labor is one of the key variables of the general production function, but analytical results of the time series data of employment show that there is no statistically significant relationship between employment and per capita GDP or electricity demand. The period of the study is limited because of the lack of continuous time series data on employment. Employment data for the period 1993-2002 excludes northern and eastern provinces, for 2003 excludes Northern Province, and for 2004 excludes Mullaitivu and Kilinochchi districts. That may be a reason for the employment data used for the model, compiled by the Department of Census and Statistics being incompatible with the other variables. As a result, the model may have suffered from omitted bias.

Figure 4.2 shows goodness of fit of the final model by comparing predicted values of per capita GDP with the actual data:

Final Model: $\ln PGDP_t = 0.376478 + 1.14937 \ln PGDP_{t-1} - 0.29491 \ln PGDP_{t-2} + 0.199014 \ln EC_t - 0.161686 \ln EC_{t-1} + 0.030212 BREAK$

Figure 4.2: Actual and Predicted Fit



GDP = gross domestic product.
Source: Authors' analysis and results.

Policy Implications

The study investigated the linkages between economic growth, electricity demand, and employment in Sri Lanka between 1970 and 2015. The specific objective of the study was to determine whether a long-run equilibrium relationship exists between the variables and identify the direction of the causality relationships.

The results imply that a **1%** increase in electricity demand will lead to a **0.63%** increase in per capita GDP. Similarly, the coefficient implies that an increase of **1.0%** in per capita GDP will increase electricity demand by **1.51%**. However, the results show that there is no statistically significant relationship between employment and per capita GDP as well as electricity demand in the short run as well as in the long run.

Analytical results of the model estimate the impact in 2015 of a 1% increase in electricity consumption on the national economy at around SLRs70 billion ($0.5 billion) based on GDP at current market prices. Overall, the results suggest that even in the short run, a decrease in electricity consumption will lead to a fall in economic growth. Therefore, devoting further resources to electricity generation, transmission, and distribution should not be considered wasting valuable resources since it will result in further economic development over time. The results support the efforts of the Government of Sri Lanka to expand electricity supply given the positive impact on the country's economic development.

The results show that there is a long-run relationship between the variables and the analysis shows the existence of unidirectional causality relationship between electricity demand and economic growth. Any form of power interruption and rationing of electricity consumption may cause an adverse effect on the economic growth in Sri Lanka. New electricity power plants need to be constructed considering rational alternative electricity generation sources together with expansion of power transmission and distribution to prevent electricity shortages and satisfy the growing electricity demand. These generation sources would include a substantial content of renewable energy sources such as biomass (Figure 4.3).

Finally, there is the question of the range of applicability of the results. While the statistical approach adopted instills confidence that the coefficients of the functional relations have been estimated with sufficient precision, it is important to note that the results are valid only over the range of data values used in the analysis as well as the accuracy of the data.

Figure 4.3: A Wood Crusher Supplying Wood Chips for Biomass Power Plants

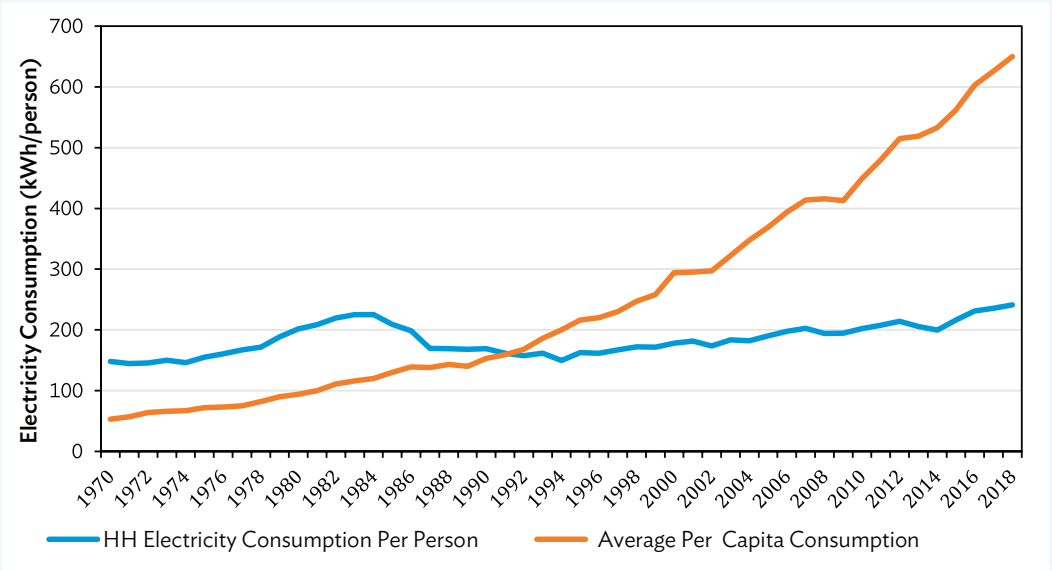
Energizing the nation. Biomass supply chain is crucial to achieving renewable energy targets in the country (photo by Keshan Samarasinghe).

5 Impact of Rural Electrification and Key Economic Indicators

Per Capita Electricity Consumption

Per capita consumption of total electricity usage in the country increased from 53 kilowatt-hours per person (kWh/person) in 1970 to 562 kWh/person in 2015, showing over a tenfold increase over the period. However, the increase of consumption of electricity per person in the domestic sector was marginal over that period. The average consumption per person in the domestic sector was 138 kWh/person in 1970 and it increased to 198 kWh/person in 2015 (footnote 20).

Figure 5.1: Electricity Consumption per Person in the Domestic Sector and per Capita Electricity Consumption



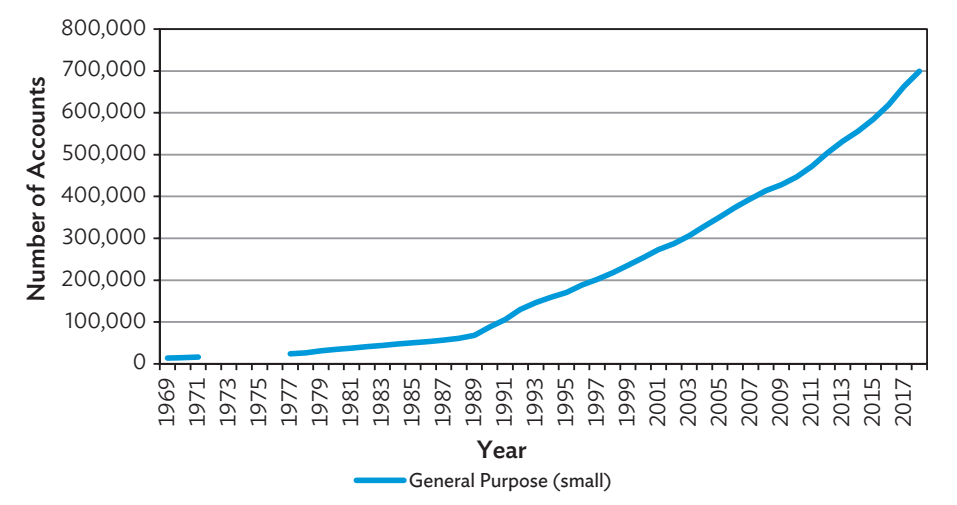
HH = household, kWh/person = kilowatt-hour per person.
Source: Ceylon Electricity Board. 2018. *Database of Electricity Consumers*. Colombo.

The rather flat average electricity consumption per household customer could be partly due to more conscious behavior by household electricity customers following increases in the price of electricity and increasing block tariff. Rural electrification would also have had an impact by expanding the number of rural customers, a majority of whom are in the lower end of the consumption profile. Further, improved energy efficiency in electricity usage such as the use of compact fluorescent lamps, energy-efficient appliances, and awareness programs would have contributed to maintain a steady level of per capita electricity consumption in the household sector.

Growth of Industrial and Commercial Sectors

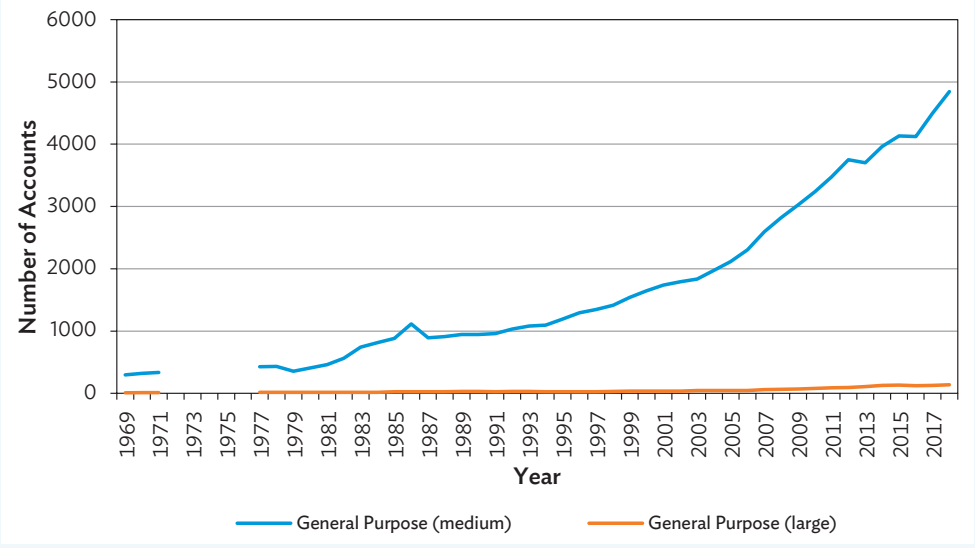
The growth of consumer accounts of CEB in the commercial (general purpose) sector are shown in Figures 5.2 and 5.3. For the industry sector, the growth of consumer accounts are shown in Figures 5.4 and 5.5.

Figure 5.2: Growth of General Purpose (Small) Accounts of Ceylon Electricity Board



Source: Ceylon Electricity Board. 2018. *Database of Electricity Consumers*. Colombo.

Figure 5.3: Growth of General Purpose (Medium and Large) Accounts of Ceylon Electricity Board



Source: Ceylon Electricity Board. 2018. *Database of Electricity Consumers*. Colombo.

The growth trends of small-scale commercial establishments show a rapid increase in establishment of new commercial businesses, especially since late 1980s. Similar trend is shown in the increase of general purpose (medium) establishments of commercial businesses. The economic reforms introduced in 1977 would have provided the opportunities for investors to invest and the availability of electricity would have been the main ingredient for establishment of such businesses.

The growth of small- and medium-scale industrial accounts also shows similar patterns. Setting up of both commercial and industrial establishments accelerated with increased electrification in the country, creating new employment opportunities and reducing poverty levels in the country while contributing to GDP increase. Box 8 recounts the impact of electrification on a fishing village.

Box 8: B. Nataraja from Batticaloa: Life in a Fishing Village

I'm from Batticaloa, Eastern Province. We are living in a fishing village, and we used to go for fishing in the evening and come back in the midnight or early morning. We used kerosene torches and *huluatta* (locally made coconut leaf sticks with fire stock) when we went for fishing. I have taken terrible risk when the lights went off usually because of rain. Most of the time, we couldn't sell whole fishes in the same day, and we didn't have facilities to preserve fish as it is. So, we had to make dried fish or throw it away in the rainy season.

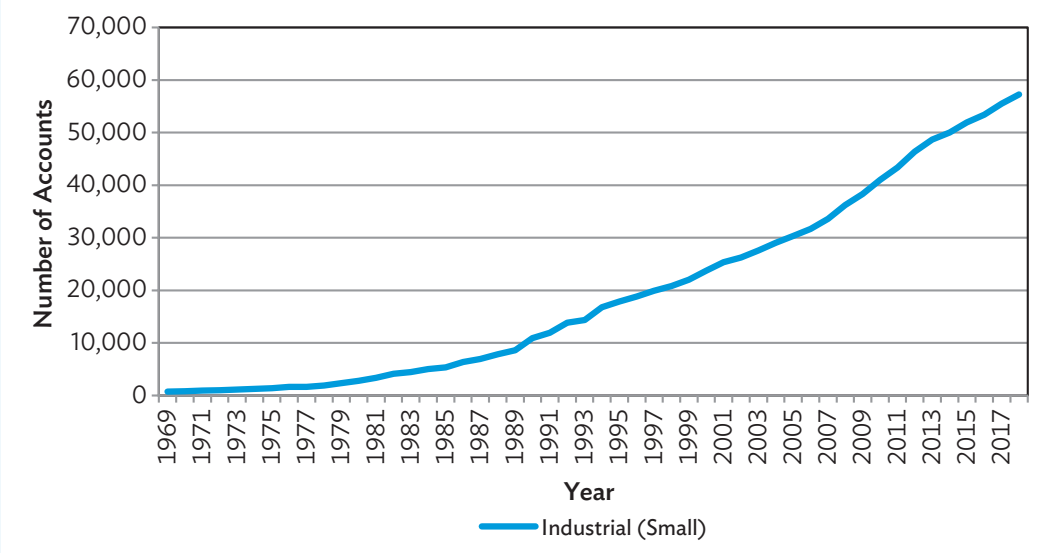
We had very low level of infrastructure facilities even before the tsunami tragedy. We only got electricity in 2006 since our villages were developed under tsunami rehabilitation projects. We hadn't used many electronic items before getting electricity. We didn't have garages and welding shops. At that time, we had to go Valachchenai town, and it is about 3–4 kilometers away from the village. Most people worked only at daytime since it was very difficult to work at night.

Our lives were completely changed because of electricity. Now we can keep refrigerators and ice plants using electricity. This is enabling our community to generate extra income by preserving fresh fish and sending caught fish to cities, even when we didn't go for fishing alone due to lack of reliable lights and navigation systems. Usually, we went as a group including three to four people. Now, we tend to go for fishing individually because we have rechargeable batteries, generators, and lights.

Particularly, women got massive benefit from electricity than men. Previously, they had to grind spices and rice themselves for cooking. Now they have blenders at home and grinding mills in the village. Now I see our women are saving their valuable time and they are doing self-employment businesses. In our area, we can spot snakes frequently. People were scared to walk out at night even on the streets. Now people are not scared to go out at night specially women since we have streetlights. We are privileged to get access to electricity because we are now safe and enjoy our lives.

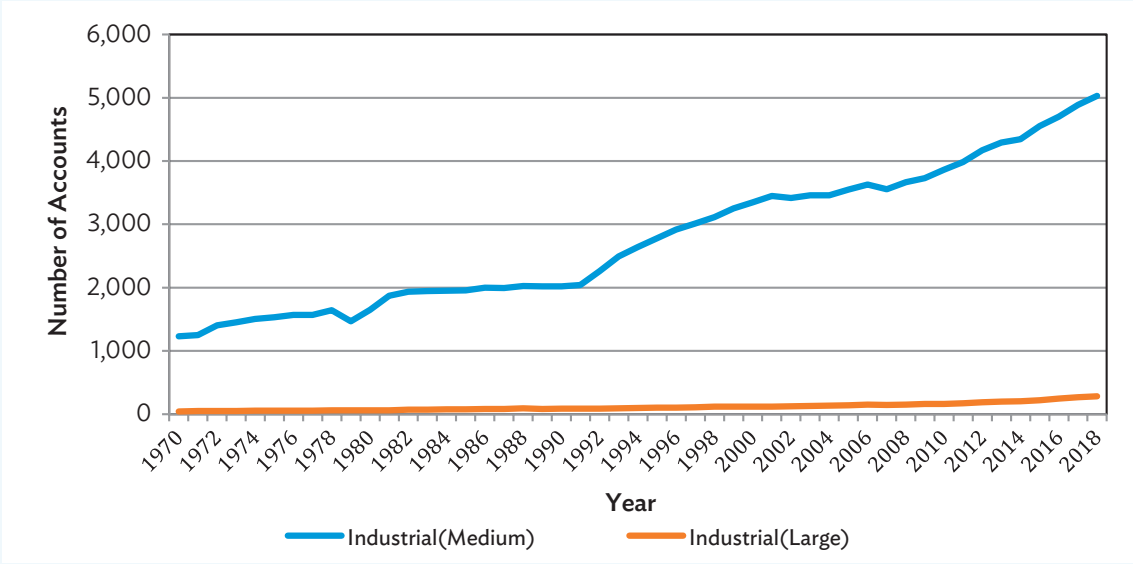
Source: Authors' survey and interviews.

Figure 5.4: Growth of Industrial (Small-Scale) Accounts of Ceylon Electricity Board



Source: Ceylon Electricity Board. 2018. *Database of Electricity Consumers*. Colombo.

Figure 5.5: Growth of Industrial (Medium and Large) Accounts of Ceylon Electricity Board



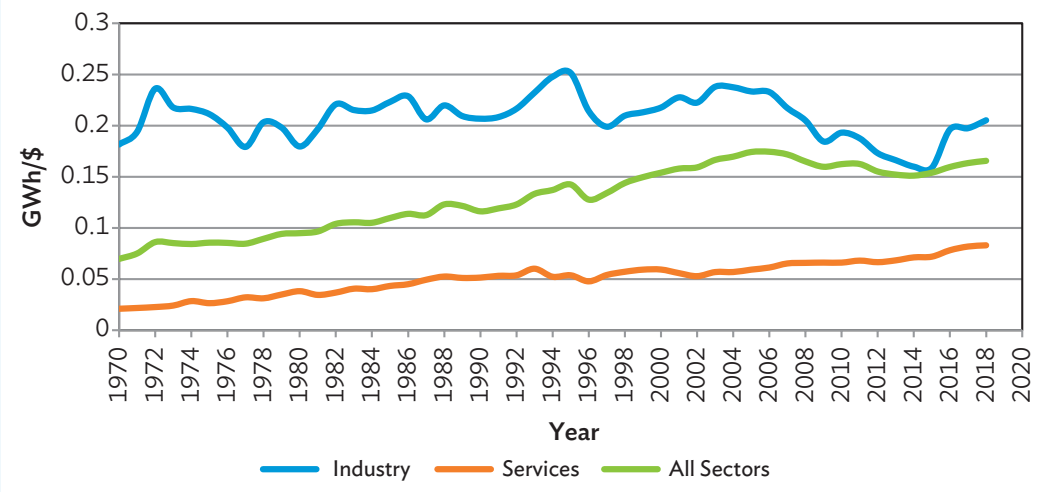
Source: Ceylon Electricity Board. 2018. *Database of Electricity Consumers*. Colombo.

Electricity Intensity

Electricity intensity in the service sector (measured by electricity use in GWh per GDP contribution of that sector) has increased at an average rate of 2.8% a year and Figure 5.6 shows an almost 3.5-fold increase from 1970. That increase is likely to be associated with improved quality of services within the service providers such as airconditioned building space and use of modern equipment. Further, the tourism sector, which is one of the main contributors to GDP share of the service sector introduced several high-end tourist hotels in the country with high electricity use.

Electricity intensity in the industry sector decreased from 2006 onward with the manufacturing industry gradually giving way to less energy-intensive industries. Many industries in the industry sector are less energy-intensive and more labor-intensive such as the apparel industry. The growth of less energy-intensive industries would have contributed to the decrease of energy intensity in the industry sector. High price of electricity could also be a major factor hindering the addition of energy-intensive industries in Sri Lanka.

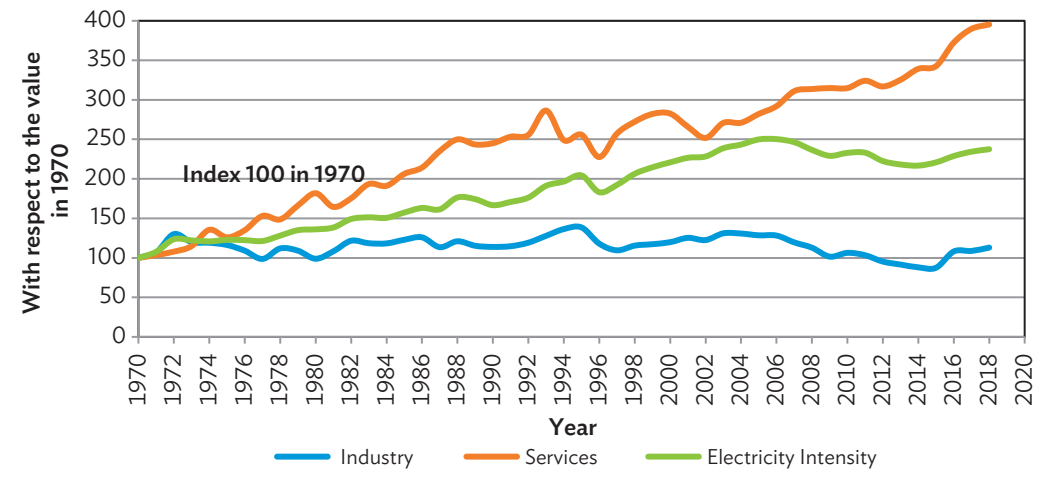
Figure 5.6: Electricity Intensity of GDP
(kWh/ GDP [at constant 2010 $])



GDP = gross domestic product, GWh = gigawatt-hour, kWh = kilowatt-hour.

Sources: Ceylon Electricity Board. 2018. *Electricity Demand and Supply Database*. Colombo; Department of Census and Statistics. 2018. *Database of GDP and Employment*. Colombo.

Figure 5.7: Total and Sector Electricity Intensity Relative to 1970 Levels

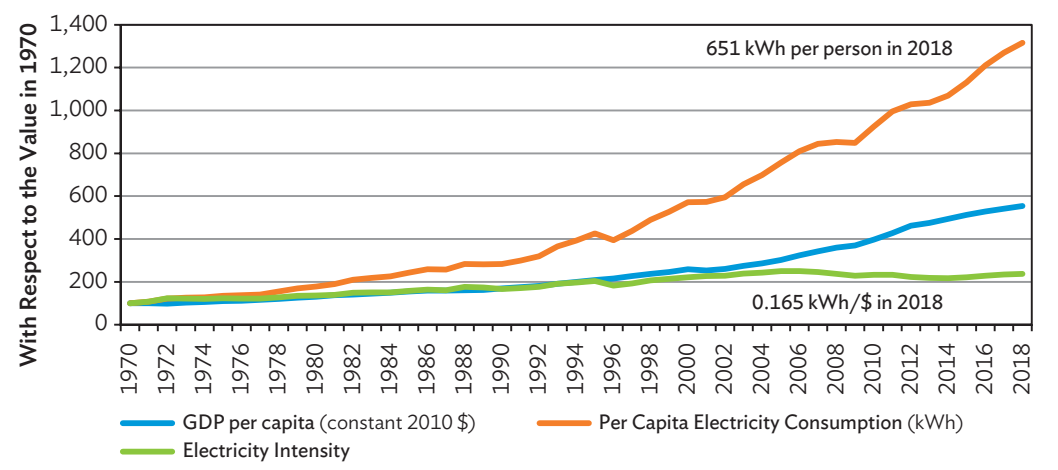


Sources: Ceylon Electricity Board. 2018. *Electricity Demand and Supply Database*. Colombo.
Department of Census and Statistics. 2018. *Database of GDP and Employment*. Colombo.

Comparison of Key Economic Indicators

Key economic indicators such as per capita GDP, per capita electricity consumption, and electricity intensity have shown positive trends as can be seen in Figure 5.8. Both per capita GDP and per capita electricity have been increasing, while electricity intensity has stabilized.

Figure 5.8: Key Economic Indicators



GDP = gross domestic product, kWh = kilowatt-hour.

Sources: Ceylon Electricity Board. 2018. *Electricity Demand and Supply Database*. Colombo.
Department of Census and Statistics. 2018. *Database of GDP and Employment*. Colombo.

6 Socioeconomic Impact of Rural Electrification in Hambantota District

This study was conducted to understand the level of success achieved through Sri Lanka's initiative to provide electricity accessible to all. It uses household-level data gathered for previous studies and published data from various national agencies to understand the impact of electrification on households in Sri Lanka. Patterns of electricity use by household were also examined to draw insights to make future electricity supply in Sri Lanka more equitable and efficient.

Research Methodology

Description of Data Sources

The major aims of this study are analyzing trends of rural electrification in Sri Lanka and its resulting impacts. The study uses secondary data compiled by previous researchers and published data by national agencies. The major focus of the study is Hambantota, a coastal district of the country situated in the Southern Province. The secondary data was collected from a socioeconomic survey of rural electrification schemes across the district that was conducted in 2009 under the patronage of the Ministry of power and Energy. The study covered 509 households that had obtained electricity from the national grid at the time of the study and 2,100 households that had not obtained a connection but intended to get a connection under the then active "Lighting Hambantota" Project of the Government of Sri Lanka. Both samples were selected following statistical methods to represent diverse socioeconomic conditions that prevailed in the area during the time of the study. According to national authorities, all households in Hambantota district had electricity by 2011.

A second independent survey was conducted in 2016 on a sample of randomly selected households. All households in the district and hence all households in the sample had grid electricity at the time of the second survey. A total of 301 households from Hambantota district were included in this survey.

The two surveys were of different sizes and matched with comparable socioeconomic conditions in this comparative study. The sample size for 2009 was 401, while for 2016 the sample size was 301.

Comparison of Samples for Hambantota District, 2009 and 2016

An initial examination of the data collection detail revealed that the 2009 survey aimed to collect lesser detail when compared to the 2016 study. Differences in questions and levels of measurements were noted. Data for the 2009 study was available in Microsoft Excel format, while that for the 2016 study was in SPSS statistical package format. Data from the 2009 study was re-arranged in SPSS format to enable comparisons between survey periods after questions were matched and appropriate modifications/transformations were done. Comparable

compiled data for both survey periods included: basic household characteristics, asset ownership, use of electrical appliances, income and expenditure, electricity consumption quantities and costs, and perceptions of benefits of electrification and problems associated with supply quality. All assets in the 2009 survey were recorded originally in binary format. In contrast, this was recorded in the 2016 survey as counts of each available asset/equipment/appliance with the household.

The following approach was adopted in the study to analyze the socioeconomic impact of rural electrification in Hambantota district.

(i) Identify the growth pattern of electricity use in industrial/commercial activities in the electrified areas of Hambantota district and relate to economic output.
(ii) Investigate the correlation of electricity consumption and GDP in Hambantota district.
(iii) Analyze socioeconomic status at the district level resulting from electrification and its impact on the households and the community in general by comparing the data gathered during this period (2009–2015) for Hambantota district.

Hambantota District

Hambantota district is one of the three administrative districts in the Southern Province of Sri Lanka. Spanning an area of 2,609 square kilometers, it is divided into 12 divisions, the next in the hierarchy of administration, and 592 Grama Niladhari areas, the lowest units in the administrative division structure of the country.

Agriculture and fishery continued to be the mainstay of economic activities of the area. Major irrigation schemes and traditional smallholder production systems dominated the economic activities of the area. The district accounted for 6.0% of the major irrigated area and is the seventh largest paddy production district in the country. It accounts for 5.5% of the nation's fishing fleet and for 12.9% of the total marine fish production. Home gardens with perennial vegetation provide a large part of the income to families in the western parts of the district.

The district was ranked the third-poorest district in the country and the poorest coastal district in the country in 2003, and 32% of its people were identified as poor in 2003

Figure 6.1: A CEB Transformer in Kataragama

Energizing rural villages. The Ceylon Electricity Board is further strengthening its distribution network to provide reliable electricity supply for rural communities (photo by Charitha Sandaruwan).

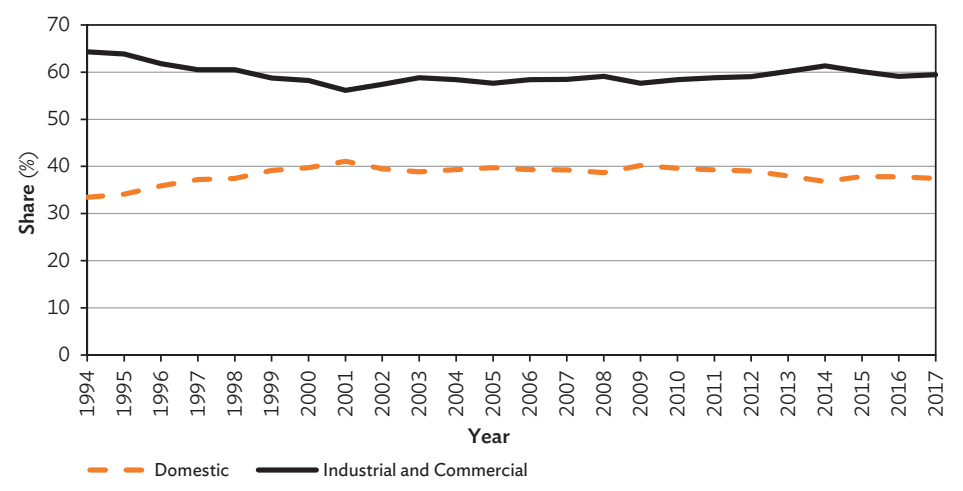
(Department of Census and Statistics 2004). However, socioeconomic conditions of the Hambantota district improved rapidly over the last 15 years.

The economy of Hambantota benefited through increasing demand for services and goods by locals visiting several sites of religious and cultural importance. More recently, both local and foreign visitors travelled to the area for recreational purposes. Attractions include national wildlife parks and beaches that are considered pristine. Several notable development initiatives, including the seaport and airport and linking the area with the more developed western province of the country via the recently constructed expressway and railway, brought in the preconditions for a vibrant industrial and services base. These changes in demand for services generated substantial productive activity and created many employment opportunities in services and industry that led to a major shift of the sectors that provided employment. The major employment patterns in Hambantota for three selected years for the period 2009–2018 are shown in Table 6.2 and Figure 6.7.

Growth Pattern of Electricity Use in Industrial and Commercial Activities

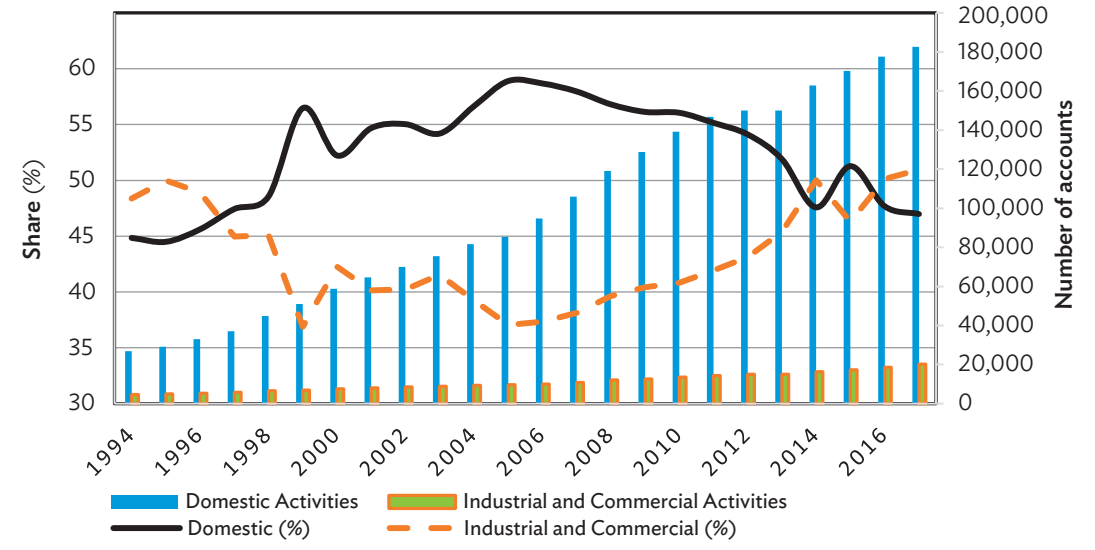
The analysis here mainly focuses on comparing electricity usage in income-generating sectors such as industry and commercial together with domestic sector electricity usage mainly consisting of activities such as lighting, cooking, and other household applications. Figure 6.1 shows a typical CEB transformer used for rural electricity supply. The electricity consumption patterns of the domestic sector and the industry and commercial sectors together, for Sri Lanka and for the Hambantota district for the period 1994 to 2017, are presented in the Figures 6.2 and 6.3, respectively.

Figure 6.2: Share of Domestic Sector and Industrial and Commercial Sectors Electricity Consumption in Sri Lanka



Source: Authors' analysis and results.

Figure 6.3: Share of Domestic Sector and Industrial and Commercial Sectors Electricity Consumption in Hambantota District



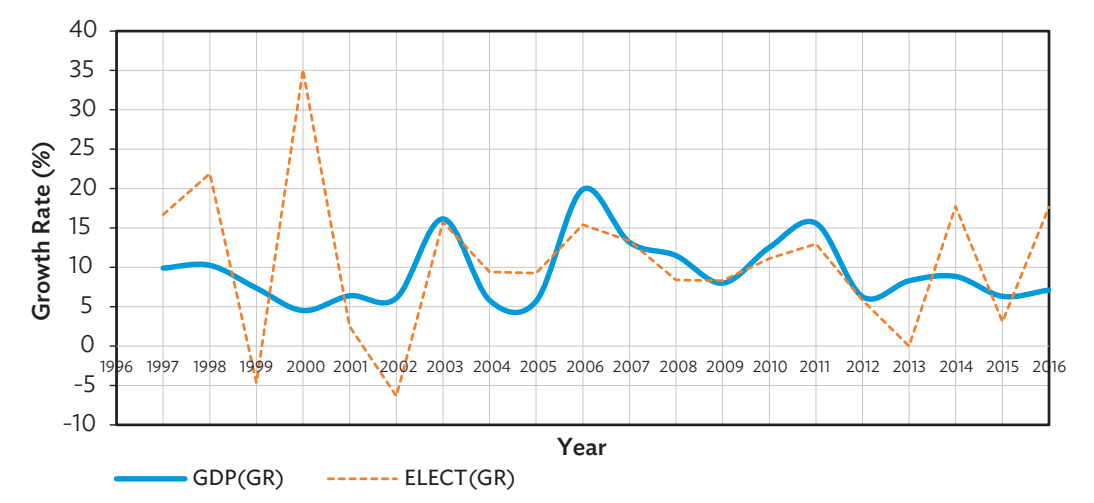
Source: Authors' analysis and results.

In contrast to the Hambantota district, the share of domestic sector island-wide electricity consumption increased from 33.5% in 1994 to 41.1% by 2001, remained around 40% up to 2009, and decreased to 37.5% by 2017, while the share of industry and commercial sectors electricity consumption decreased from 64.3% in 1994 to 59.5% in 2017. The shift in electricity consumption pattern in the Hambantota district from the domestic sector to the industrial and commercial sectors clearly indicates the increase in electricity usage in income-generating activities with significant impact on economic growth. Further, expansion of industrial and commercial activities is evident since 2006 from the increased electricity connections in both the sectors.

Long-Term Relationship between Electricity Consumption and GDP of Hambantota District

Growth rates of electricity consumption and real GDP in Hambantota over the period 1996 to 2016 as shown in Figure 6.4 show a correlation between these two measures that justifies investigation to determine a statistical relationship.

Figure 6.4: Growth Rates of Real GDP and Electricity Consumption in Hambantota District



ELECT = electricity consumption, GDP = gross domestic product, GR = growth rate.
Source: Authors' analysis and results.

All the data used in this study are annual observations covering the period 1996 to 2016 obtained from two data sources. The real GDP data, measured at constant 2002 prices in SLRs million, are based on the estimates from expenditure data available at district level from the periodic Household Income and Expenditure Survey conducted by the Census and Statistics Department of Sri Lanka, whereas electricity consumption data is from the database of the Sustainable Energy Authority of Sri Lanka.

The Model

The standard linear function form of a long-run relationship between electricity consumption and real GDP in Hambantota District has been defined as follows:

$$GDP_t = c + \beta 1\ EC_t + \beta 2\ GDP_{t-1} + E_t \qquad (6.3.1.1)$$

where GDP is the real GDP in SLRs million, EC is electricity consumption in gigawatt-hours (GWh), E_t is the error term, and the others are constants.

A multiple linear regression approach was employed to examine the statistical relationship between GDP and electricity consumption in Hambantota District. Results are presented in Table 6.1. Actual and predicted relationships are shown in Figure 6.5 and 6.6.

Table 6.1: Model Parameter Estimates

Dependent Variable: District GDP
Method: Least Squares
Date: 11 December 2018 Time: 12:53
Sample (adjusted): 1997, 2016
Included observations: 20 after adjustments

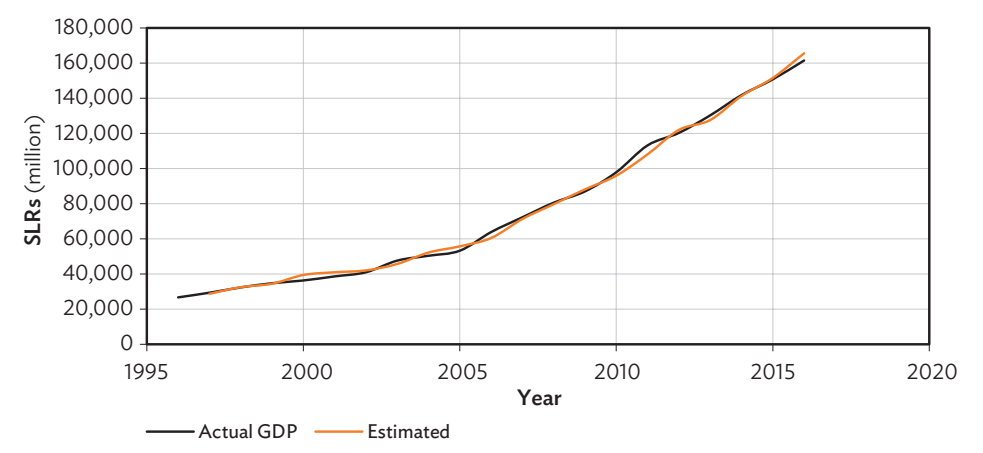
Variable	Coefficient	Standard Error	t-Statistic	Probability
ELECT	177.3642	62.4362	2.8407	0.0108
GDP (–1)	0.7917	0.1048	7.5563	0.0000
R-squared	0.99	Mean dependent var		79156.26
Adjusted R-squared	0.99	S.D. dependent var		43561.79
S.E. of regression	2375.903	Akaike info criterion		18.47878
Sum squared residual	1.02E+08	Schwarz criterion		18.57836
Log likelihood	-182.78	Hannan-Quinn criterion		18.49822
Durbin–Watson statistic	1.8057			

ELECT = electricity consumption, GDP = gross domestic product, SD = Standard Deviation, SE = Standard Error.
Source: Authors' analysis and results.

As the above model is statistically significant, estimated parameters were used to predict GDP of period t as follows:

$$GDP_t = 177.3642\ EC_t + 0.7917\ GDP_{t-1} \qquad (6.3.1.2)$$

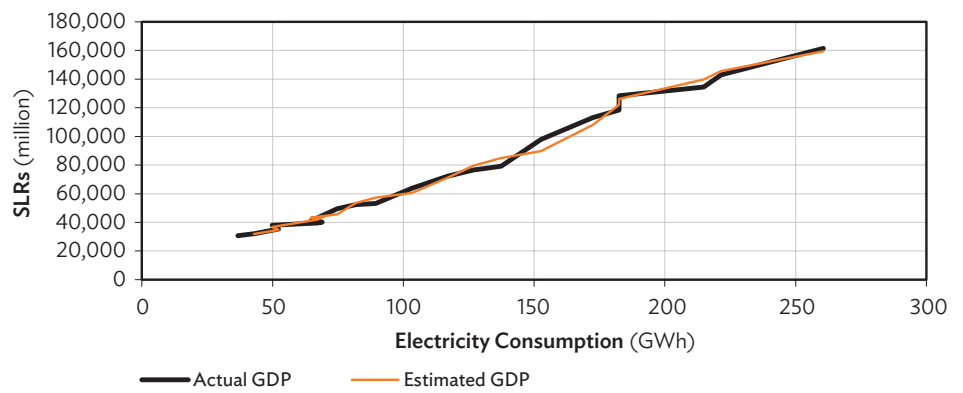
Figure 6.5: Comparison of Predicted and Actual GDP of Hambantota District



GDP = gross domestic product.
Source: Authors' analysis and results.

According to the above model (EQ 6.3.1.2), the estimated parameters imply that a 1% increase in electricity demand will lead to 0.3% increase in the GDP. Similarly, the coefficient of EQ 6.3.1.2 implies that GDP increase of 1.0% will increase electricity demand by 3.5%. It shows that there is a direct correlation between GDP and electricity demand. It also suggests that increase in electricity demand in the Hambantota district has a positive contribution toward increase in economic growth in the district.

Figure 6.6: Relationship between Predicted GDP, Actual GDP, and Electricity Consumption of Hambantota District



GDP = gross domestic product, GWh = gigawatt-hour.
Source: Authors' analysis and results.

Employment Pattern in Hambantota District

The demand for services from other areas as well as the demand for services from agriculture and fisheries activities generated many employment opportunities in the Hambantota District. The major employment patterns in the district for 2009–2018 are shown in Table 6.2 and Figure 6.7. These statistics shows a clear shift of employment from agriculture to the service and industry sectors due to creation of new opportunities in the service and industry sectors with increased penetration of electricity in the area.

Table 6.2: Employment in Hambantota District by Major Industry Groups, 2009–2018

Sector	Total in Hambantota District	Total in Hambantota District	Total in Hambantota District
	2009	2016	2018
Agriculture	108,346	90,127	71,945
Industry	59,455	64,685	70,549
Services	76,232	91,621	95,310
Total	244,033	246,433	237,804

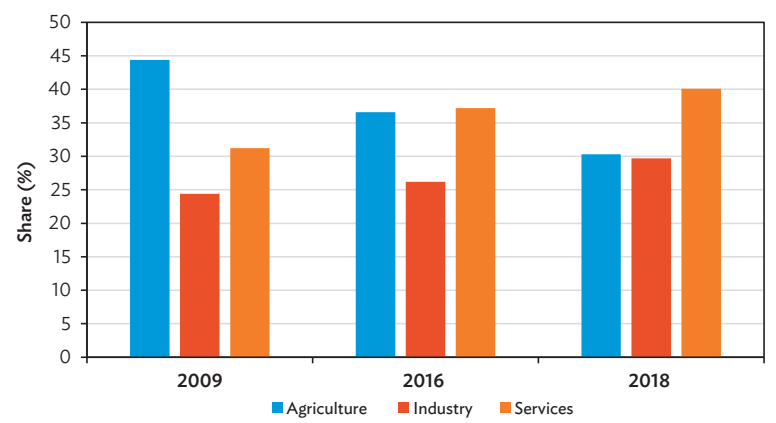
continued on next page

Table 6.2 *continued*

Sector	Total in Hambantota District	Total in Hambantota District	Total in Hambantota District
	2009	2016	2018
Sector Shares			
Agriculture	44.4	36.6	30.3
Industry	24.4	26.2	29.7
Services	31.2	37.2	40.1

Data Source: Department of Census and Statistics. 2018.*Sri Lanka Labor Force Survey*. Colombo.

Figure 6.7: Employment Pattern of Hambantota District, 2008 and 2018



Source: Authors' analysis and results.

Comparison of Socioeconomic Development in Hambantota District—Results of Field Surveys (2009 versus 2016)

Data for 2009 survey were made compatible with 2016 data by conducting relevant transformations prior to the analysis. Data from national published sources were used to supplement primary data.

Figure 6.8 shows the cumulative percentage of sample households that got grid connection by year. About a third of all households had a connection by mid-1990s. Electrification of households proceeded at a very high rate since then. About 85% of households had connected to the national grid by the time the baseline survey was done in 2009. Almost all the households in the entire district were provided with grid electricity by 2012. Boxes 9 and 10 further recount the positive impacts that electrification had from different perespectives. Figure 6.19 shows an electrified fence to protect cultivated land from animals.

Box 9: H.G.K. Warnasheeli from Hambantota: Immense Impact of Electricity on Village Lives

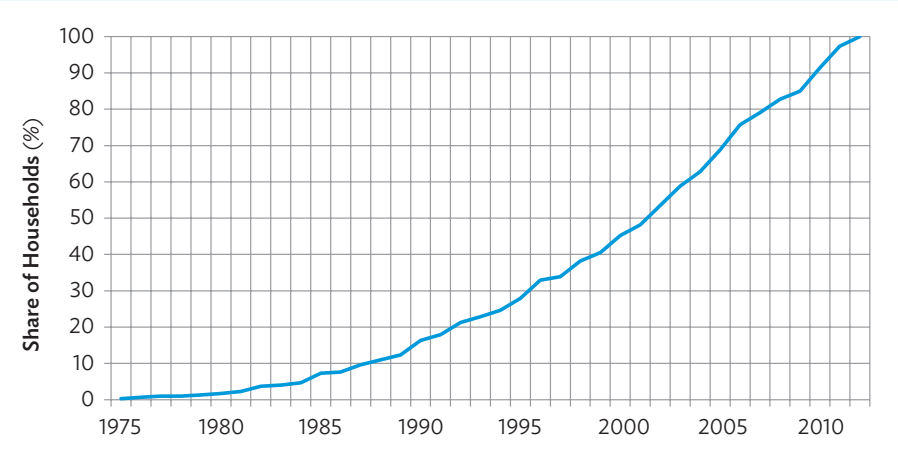
I came from Tissamaharamaya, Southern Province, a remote rural village at the time. I can still remember the day when I came here with my husband after getting married. That was sometime in the early 1990s. The nearest proper town was Tissamaharamaya 10 kilometers away. We did not have electricity supply at home. All what we had were a few kerosene lamps to light up the house in the evenings and nights. Obviously, no gas cylinders for cooking, and we had to depend on fuelwood. We used to spend many hours during the week collecting fuelwood from the nearby forest. We had to walk all the way to a common well to get water for drinking and other household requirements. We had to walk again to a different common well or the village tank for bathing. Though it was the norm at the time, later we realized the enormous time these activities consumed from our precious little time in life. We could have used this time for other important things, like earning an additional income for living, learning something more, or caring for children. I can still remember my children used to face difficulties such as breathing issues due to smoke coming out of kerosene lamps and strain in the eyes when studying with low lighting levels from those lamps. Sometimes more than my children, I used to be so scared of their use of kerosene lamps since accidents from those lamps were very common.

We were extremely fortunate that we got electricity connections to the village and at home in 2002. This was completely a new beginning. I started a small business of palmyrah weaving. This became our main income earner by 2005. Our electricity supply was always available most of the day and night except when some unplanned faults occured. Therefore, we could run the production even during nighttime. Now our life is completely transformed compared to the time before 2002. We use electricity and liquefied petroleum gas or LPG for cooking and for other day-to-day activities. We have pipe-borne water in the house. My youngest daughter entered a state university. She could spend all the time for studies whether it is daytime or nighttime. Efficient high-quality lighting and fans for ventilation have become standard comforts at a home where we could not dream of having such comforts before 2002.

I see many in our village running not only small household businesses like spice grinding mills and grocery shops but also large ones like timber mills and furniture manufacturing. I still remember, the timber mill used to take more than four days to complete a small order from a villager. Now it is just a day most of the time and the output is of very high quality. Electricity has given them the opportunity for automation and to use new machines. During this period, I have seen the capacity and output of small- and medium-scale businesses growing tremendously in the village because now we have not only access to electricity but also high reliability of that electricity supply.

Source: Authors' survey and interviews.

Figure 6.8: Cumulative Number of Households in Hambantota District with a Grid Connection by Year



Source: Authors' analysis and results.

Demographic Characteristics of Sample Households

Demographic characteristics of sample households are presented in Tables 6.3 to 6.5. The average household size was 4.5 in 2009 and 4.3 in 2016, showing a declining trend in the number of family members living in a single house.

Table 6.3: Number of Family Members by Survey Year

Number of Family Members	% Households		Cumulative %	
	2009	2016	2009	2016
1	1.2	3.0	1.2	3.0
2	4.7	9.0	6.0	12.0
3	16.1	20.9	22.1	32.9
4	28.5	26.2	50.6	59.1
5	27.0	26.2	77.7	85.4
6	13.9	9.0	91.6	94.4
7	5.0	5.0	96.5	99.3
8	2.7	0.7	99.3	100
9	0.5	-	99.8	-
10 or more	0.2	-	100.0	-
Total	100.0	100.0		

Source: Authors' analysis and results.

The household head data shows that the dominant age group had shifted from age 45–54 in 2009 to age 55–64 in 2016, indicating natural aging of the household heads. Households that declared themselves as female-headed were higher in 2009.

Table 6.4: Age Categories of Household Heads by Survey Year

Age Category	% Households		Cumulative %	
	2009 (n = 403)	2016 (n = 301)	2009	2016
Less than 25 Years	10.7	–	10.7	–
25–34 Years	21.8	4.7	32.5	4.7
35–44 Years	20.3	17.9	52.9	22.6
45–54 Years	27.8	25.9	80.6	48.5
55–64 Years	14.6	36.2	95.3	84.7
65–74 Years	4.2	10.3	99.5	95
75 years or over	0.5	5.0	100	100
Total	**100**	**100**		

Source: Hambantota Electrification Survey 2016.

Table 6.5: Household Heads' Gender by Survey Year

Gender	% Households		Cumulative %	
	2009 (n = 403)	2016 (n = 301)	2009	2016
Female	40.7	19.3	40.7	19.3
Male	59.3	80.7	100	100
Total	**100**	**100**		

Source: Hambantota Electrification Survey 2016.

Household Income and Expenditure

Distribution of households by total monthly household income and total monthly household expenditure is presented in Tables 6.6 and 6.7 (see also Figures 6.9 and 6.10). Current values were reported by households during both survey periods. Monetary values for 2016 (in SLRs) were converted to 2009 values using Consumer Price Index before households were assigned to categories.

It can be observed that households had better incomes and higher expenditure in 2016 when compared to 2009. The households with higher income, especially the category of monthly income above SLRs25,000 has significantly increased to 37% in 2016 compared with 13% in 2009. Similarly, the lower-income households (<SLRs15,000), which were 55% of total households in 2009, decreased to 37% in 2016. These figures indicate improved economic conditions in the area. However, the lowest income category remained almost at the same level (3% in 2009 and 2.7% in 2016).

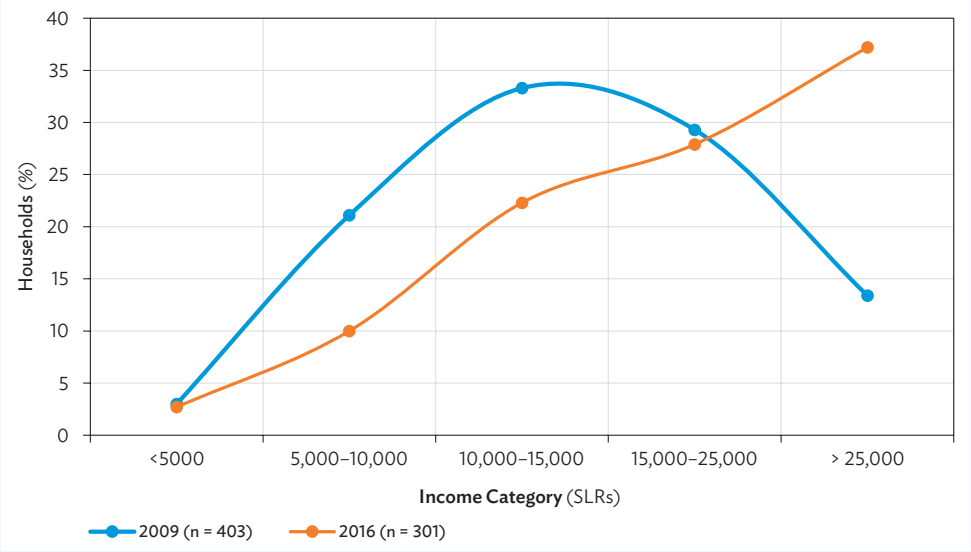
The household expenditure patterns show the increased spending capacity of households in 2016 compared with 2009. This can be a direct impact of industrialization and higher employment opportunities as a result of which households got better incomes and used such incomes to buy goods and services.

Table 6.6: Total Monthly Household Income Category by 2009

Income Category (In 2009 constant SLRs)	% Households		Cumulative %	
	2009 (n = 403)	2016 (n = 301)	2009	2016
< 5,000	3.0	2.7	3.0	2.7
5,000–10,000	21.1	10.0	24.1	12.7
10,000–15,000	33.3	22.3	57.3	35.0
15,000–25,000	29.3	27.9	86.6	62.9
> 25,000	13.4	37.2	100.0	100.0
Total	**100.0**	**100**		

Source: Hambantota Electrification Survey 2016.

Figure 6.9: Comparison of Household Income Distribution in Hambantota District



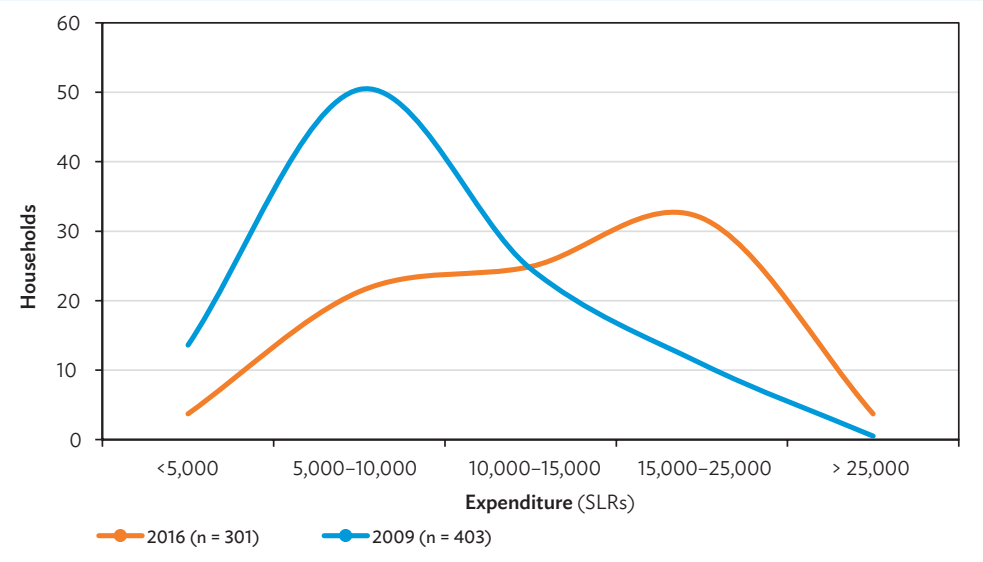
Source: Authors' analysis and results.

Table 6.7: Total Monthly Household Expenditure by Category by Survey Year

Expenditure (SLRs)	% Households		Cumulative %	
	2009 (n = 403)	2016 (n = 301)	2009	2016
<5,000	13.6	3.7	13.6	3.7
5,000–10,000	50.4	21.3	64.0	24.9
10,000–15,000	24.6	24.9	88.6	49.8
15,000–25,000	10.9	31.9	99.5	81.7
> 25,000	0.5	3.7	100.0	100.0
Total	**100.0**	**100.0**		

Source: Hambantota Electrification Survey 2016.

Figure 6.10: Comparison of Monthly Household Expenditure in Hambantota District



Source: Authors' analysis and results.

Type of Housing Structure

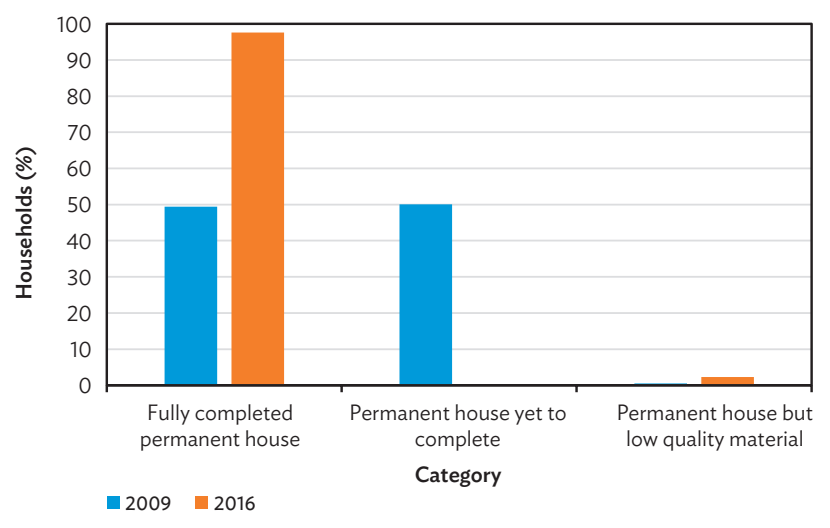
The survey results of 2016 reported that almost all houses are fully completed permanent structures. The same observation reported in the 2009 survey indicated that about 50% of the houses were incomplete structures. This indicates an achievement in quality of life over the 6 years between the survey years. The types of housing structure is presented in Table 6.8 and Figure 6.11.

Table 6.8: Types of Housing Structure and Survey Year

Type of Housing Structure	Households (%)		Cumulative (%)	
	2009	2016	2009	2016
Fully completed permanent house	49.4	97.6	49.4	97.6
Permanent house yet to complete	50.1	–	99.5	–
Permanent house but low quality material	0.5	2.3	100	100
Total	100	100		

Source: Hambantota Electrification Survey 2016.

Figure 6.11: Comparison of Housing Structure in Hambantota District



Source: Hambantota Electrification Survey 2016.

Value of Total Assets

Value of total assets considered as the sum of the values of fixed and movable assets in 2009 and 2016 are presented in Table 6.9 and in Figure 6.12.

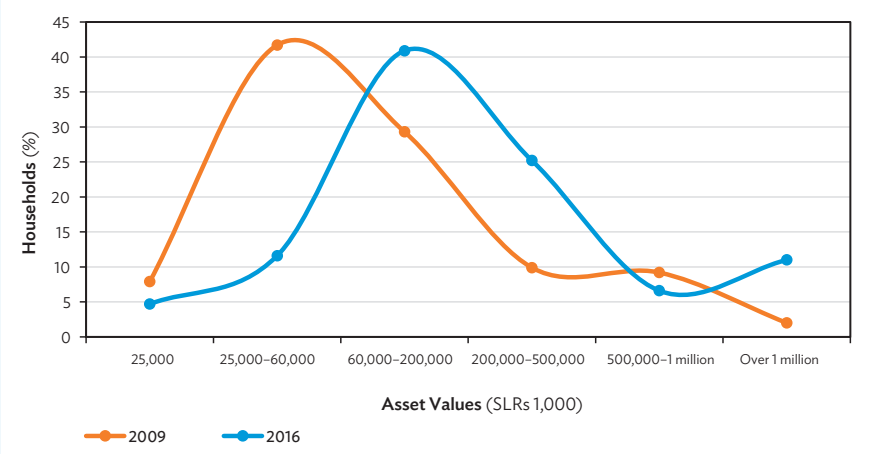
Table 6.9: Asset Value Categories and Survey Year

Value (SLRs)	% Households		Cumulative %	
	2009	2016	2009	2016
< 25,000	7.9	4.7	7.9	4.7
25,000–60,000	41.7	11.6	49.6	16.3
60,000–200,000	29.3	40.9	78.9	57.1
200,000–500,000	9.9	25.2	88.8	82.4
500,000–1,000,000	9.2	6.6	98.0	89.0
>1,000,000	2.0	11.0	100	100
Total	**100**	**100**		

Source: Hambantota Electrification Survey 2016.

The mean value of all household assets in 2016 constant values increased by SLRs205,841, from SLRs193,843 in 2009 to SLRs399,684 in 2016.

Figure 6.12: Asset Values between 2009 and 2016 in Hambantota District



Source: Authors' analysis and results.

Ownership of Movable Assets

Among the movable assets, motor bicycles were the most common form of asset. The household ownership of motor bicycles has increased to 58% in 2016 from 26% in 2009. The percentage of households that owned trishaws also shows an increasing trend with 12% in 2016 compared to 5% in 2009. The types of movable assets owned by the households are presented in Table 6.10 and Figure 6.13.

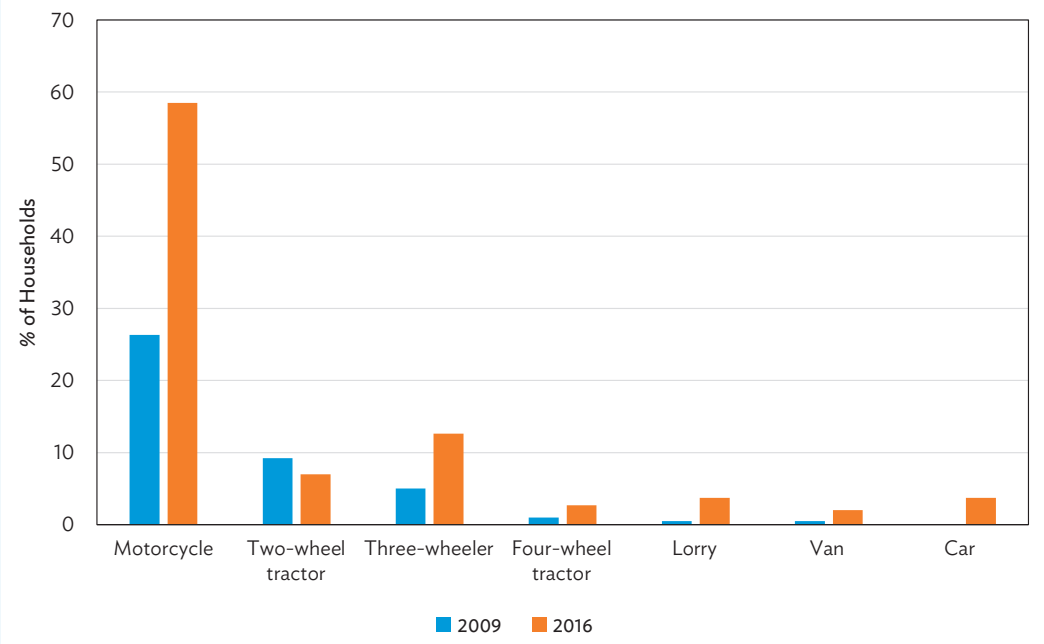
Table 6.10: Movable Asset Types Owned by Households by Survey Year

Asset Type	% Households			
	2009 (n = 403)	2016 (n = 301)	Value in 2016> Value in 2009	Difference Exceeds 5% of the lower value
Motorcycle	26.3	58.5	Y	Y
Two-wheel tractor	9.2	7.0		Y
Three-wheeler	5.0	12.6	Y	Y
Four-wheel tractor	1.0	2.7	Y	Y
Lorry	0.5	3.7	Y	Y
Van	0.5	2.0	Y	Y
Single Day Boat	0.3	–	NA	NA
Car	0.0	3.7	Y	Y
Bus	0.0	0.3	Y	Y
Total	**42.8**	**90.4**		

Y = Yes, NA = Not Applicable.

Source: Hambantota Electrification Survey 2016.

Figure 6.13: Multiple Categories of Vehicle Ownership as a Percentage



Source: Authors' analysis and results.

Ownership of Multiple Vehicles

The survey results show that the percentage of households that owned at least one vehicle (moving asset) was about a third of the sample population in 2009, and two-thirds of the sample population did not own any type of personal vehicle. This changed by 2016 when about 80% of the households owned at least one vehicle.

Details of vehicle ownership is shown in Table 6.11. The percentage of households owning more than one mobile asset increased by four times in percentage terms indicating possession of wealth and availability of more controllable transportation options to households in 2016 than in 2009.

Table 6.11: Total Number of Vehicles Owned and Survey Year

Number	% Households		Cumulative %	
	2009 (n = 403)	2016 (n = 301)	2009	2016
0	63.5	21.3	63.5	21.3
1	30.5	46.8	94	68.1
2	5.7	23.6	99.8	91.7
3	0.2	7.0	100	98.7
4	–	1.3		100
Total	100	100		

Source: Hambantota Electrification Survey 2016.

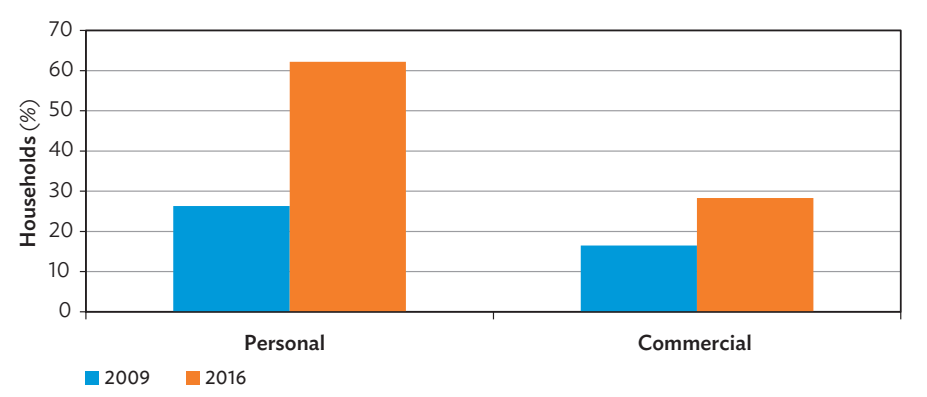
Vehicle population was further categorized as personal and commercial vehicles (Table 6.12 and Figure 6.14).

Table 6.12: Percentage of Households Owning a Personal Vehicle

Asset Type	% Households	
	2009 (n = 403)	2016 (n = 301)
Personal	26.3	62.2
Commercial	16.5	28.3

Source: Hambantota Electrification Survey 2016.

Figure 6.14: Percentage of Households Owning a Personal Vehicle



Source: Authors' analysis and results.

All changes are significantly different by a margin of more than 5%. Most notable is the increase in ownership of a motorcycles as a personal vehicle and that of a three-wheeler as a commercial vehicle. While the motorcycle is primarily a personal mode of transport, shared-rides, special trips, and use during emergencies are common in the society in the case of three-wheelers. We can therefore deduce that increasing abundance of these two types of vehicles had contributed to better living conditions of communities as a whole, even though some households did not own any vehicle. Growth of commercial vehicles indicates increased opportunities for employment and further support for movement of the community and produce.

Ownership of Electrical Appliances

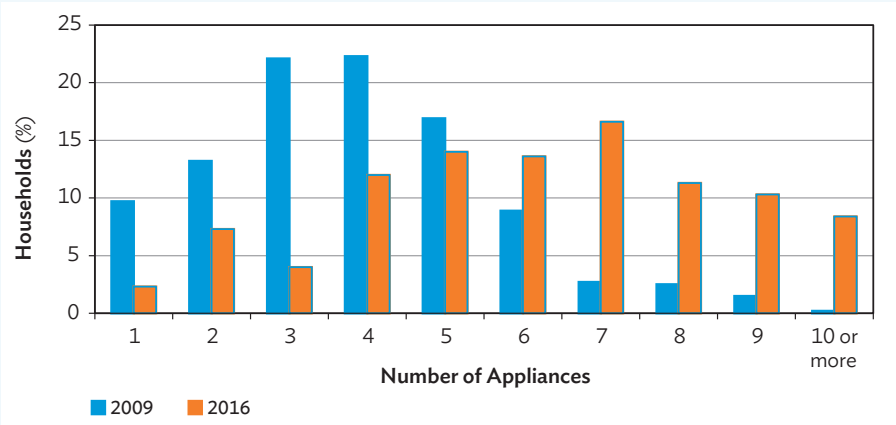
Table 6.14 presents households' possession of multiple electrical appliances. About a one-third of sample households possessed more than seven electrical appliances in 2016 while the same was true for only an insignificant fraction of 3% in 2009. This is a clear indicator of abundance of wealth and the willingness of households to use more appliances powered by electricity in the latter period. This pattern is clearly shown by Figure 6.15.

Table 6.13: Percentage of Households Owning Multiple Electrical Appliances by Survey Year

Number of Equipment	% Households		Cumulative %	
	2009	2016	2009	2016
0	0.2	0.3	0.2	0.3
1	9.7	2.3	9.9	2.7
2	13.2	7.3	23.1	10.0
3	22.1	4.0	45.2	14.0
4	22.3	12.0	67.5	25.9
5	16.9	14.0	84.4	39.9
6	8.9	13.6	93.3	53.5
7	2.7	16.6	96	70.1
8	2.5	11.3	98.5	81.4
9	1.5	10.3	100	91.7
10 or more	0.2	8.4	–	100
Total	100.0	100.0		

Source: Hambantota Electrification Survey 2016.

Figure 6.15: Distribution Patterns of Household Ownership of Electrical Appliances



Source: Authors' analysis and results.

Electricity for Lighting

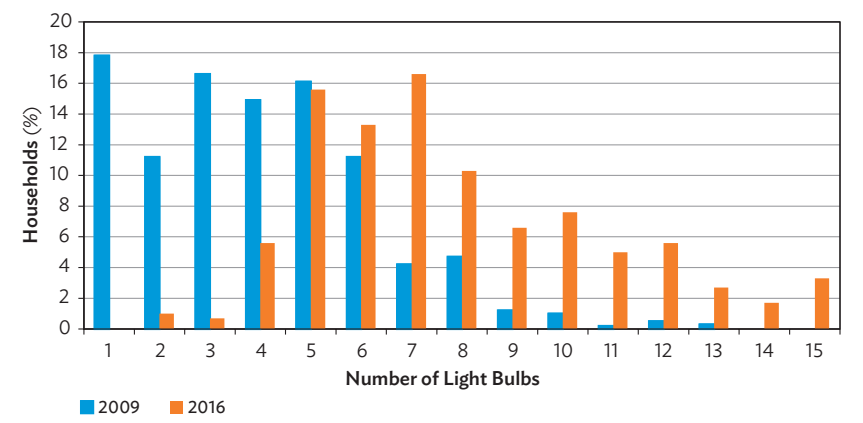
The use of light bulbs in households is shown in Table 6.15. The percentage of households using more light bulbs at home has shifted to higher categories in 2016 compared to 2009. This is an indication of better housing, better living conditions, and better perceptions on lighting.

Table 6.14: Number of Electric Bulbs and Survey Year

Number of Bulbs	% Households		Cumulative %	
	2009 (n = 403)	2016 (n = 301)	2009	2016
1	17.8		17.8	
2	11.2	1.0	29.0	1.0
3	16.6	0.7	45.6	1.7
4	14.9	5.6	60.5	7.3
5	16.1	15.6	76.6	22.9
6	11.2	13.3	87.8	36.2
7	4.2	16.6	92.0	52.8
8	4.7	10.3	96.8	63.1
9	1.2	6.6	98.0	69.8
10	1.0	7.6	99.0	77.4
11	0.2	5.0	99.2	82.4
12	0.5	5.6	99.8	88.0
13	0.3	2.7	100.0	90.7
14	–	1.7	–	92.4
15	–	3.3	–	95.7
More than 15	–	4.3	–	100.0
Total	**100**	**100**		

Source: Hambantota Electrification Survey 2016.

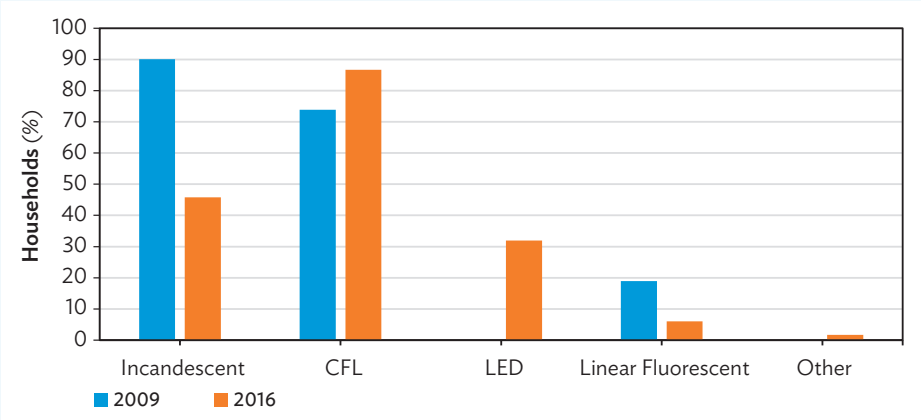
Figure 6.16: Percentage of Household Bulb Count, 2009 and 2016



Source: Authors' analysis and results.

A marked increase in the use of efficient light bulbs was observed, especially the increase usage of LED and CFL bulbs for lighting. Figure 6.17 shows the types of bulbs used by households.

Figure 6.17: Electric Bulb Usage by Type



CFL = compact fluorescent lamp, LED = light emitting diode.
Source: Authors' analysis and results.

Table 6.16 showing household lighting demand and different levels of wattage for 1,000 lumens of light indicates moving toward more energy-efficient lighting sources (Figure 6.18). As the number of bulbs and demand for higher lumens for home lighting clearly increased from 2009 to 2016, it can be concluded that electricity played a prominent role in the lives of people in Sri Lanka in 2016.

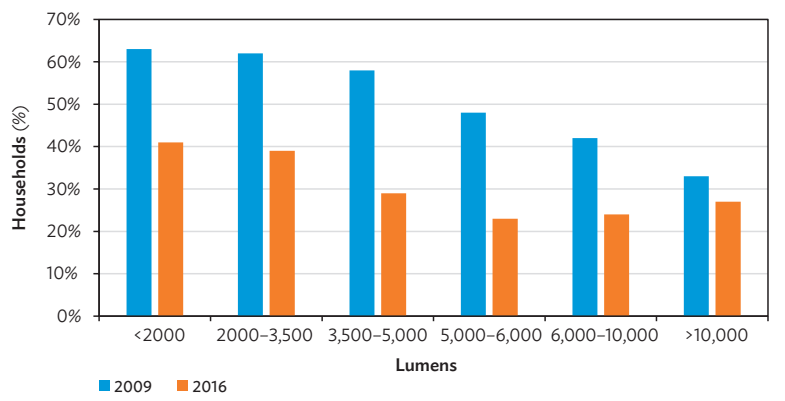
Table 6.15: Mean Wattage Installed for 1,000 Lumens of Home Lighting, 2009 and 2016

Types (Lumens)	% Households		Mean of W/1K Lu	
	2009 (n = 403)	2016 (n = 301)	2009	2016
Less than 2,000	13.2	7.6	63.8	40.8
2,000–3,500	34.5	28.2	62.5	38.8
3,500–5,000	25.6	25.9	57.4	28.7
5,000–6,000	12.2	16.3	49.0	24.0
6,000–10,000	11.9	13.6	42.5	25.3
Over 10,000 Lumens	2.7	8.3	33.9	26.6
Total	**100**	**100**		

W/1K Lu = wattage per 1,000 lumens.
Source: Hambantota Electrification Survey 2016.

Households in lesser installed lumen categories used higher watts in general. This observation is consistent across all categories in 2009. However, in 2016 the mean watts per 1,000 lumens for the higher lumen categories increased slightly. It can be clearly noted that 2016 households used less watts for lumen of home lighting than in 2009. This is due to availability of energy-efficient lighting technologies adopted by households in 2016.

Figure 6.18: Mean Wattage per 1,000 Lumens by Category of Total Lumens



Source: Authors' analysis and results.

Box 10: C. Dissanayake from Hambantota: Turning Point in Lives

I was born and raised in Hakmana, Southern Province. I came to live in Tissapura in 1985 with the job I got as a maintenance operator in a project of the Department of Irrigation. We didn't have electricity in Tissapura when we came and we didn't have electricity in Hakmana. We had a few kerosene lamps to light up the house in the nights. We didn't know and did not want to know what was happening outside of the house at night. We always felt that our lives were unsafe in the night, and standard of living was not so good. Many in my village abandoned their lands and went to find jobs in the cities. We didn't have enough clean water for drinking and other household requirements at the time. Only 15 gallons (about 60 liters) of water was provided for a week by the government. This obviously meant that we didn't have enough water for paddy cultivation which was supposed to be a lifeline for survival. Therefore, our paddy cultivation was limited to once a year. We didn't have a rice mill in our village and the closest rice mill was 8–10 kilometers away from the village.

In 2002, electricity connection became available to our village. As I remember, there were 285 houses when we got electricity. This is when everyone wanted to settle in their villages and abandon their thoughts of migrating to other cities. They knew that they could do many things using electricity. I could see our children studying longer hours and they had improved their knowledge well. Many of them got selected to proceed with their secondary education in prestigious schools. Many of them were granted bursaries since our people didn't have a fixed income. Now we have a television, and we can get to know and see most of the things we couldn't see with our own eyes. Most importantly, Ceylon Electricity Board permitted us to install rice mills within 800 meters from transformers. Now we have four rice mills in our village, and we don't have to spend for transporting our crops far away.

Damage brought about by elephants to both materials and humans was one of the biggest problems in our area. Elephants used to destroy our crops and properties. As I can remember, elephants had killed three villagers. Farmers also had killed elephants. Since we had access to electricity, an electric fence was installed. Now elephants can't enter the vulnerable agricultural lands and residential areas. Before building the electrified fence, we used to keep an electric light switched on because elephants are scared to come to a well-lit area at night. Now the situation is even better. We can pass a message to fellow villagers immediately when the elephants come to some areas now that mobile phones have become common in the village. I am delighted to say that we are now safe and comfortable and enjoy our lives because we have access to electricity.

Source: Authors' survey and interviews.

Figure 6.19: Electric Fence to Protect Cultivated Land in Rural Village

Human–elephant conflict. The Government of Sri Lanka together with the community built an electric fence to protect agricultural lands and minimize conflict between humans and elephants (photo by Charitha Sandaruwan).

7 Conclusions

Sri Lanka reached 100% electricity coverage in 2016. Establishing the Rural Electrification Division in the CEB in 1980 within the institutional set up for expansion of rural electrification was the turning point in accelerating electrification in the country. This division identified prospective rural electrification schemes, surveyed and analyzed them, and packaged them into projects for financing. With the assistance of international lending agencies, Sri Lanka endeavored to extend the benefits of electrification to as many villages as possible in the rural areas by developing the necessary infrastructure.

The consistent national policy of providing electricity access to every citizen of the country by all governments in the past was one of the major factors that enabled 100% electricity access in the country by 2016. Several policy decisions also contributed to accelerating rural electrification and providing electricity access to every economic category of the population. The government decision that the "national grid should be extended wherever economically and socially beneficial, and where schemes are not financially viable to the utility, the Government should provide any shortfall to make such schemes financially viable" and the government providing additional funding from the national budget are noteworthy. The policy of extending electricity supply to homes up to 50 meters from the power distribution network with households paying only a fixed charge for the connection supported affordability. Additional policies that helped low-income households access electricity included standardized wiring schemes and concessional credit so that payment for the service connection and internal wiring could be made in installments through the monthly electricity bill. These initiatives focused on facilitating final household connectivity and were supplemented by investments in larger projects that primarily contributed toward enhancing the medium- and low-voltage network across the country. The efforts of the government combined with the dedication of Ministry of Power and Energy and CEB/LECO staff to implement rural electrification projects resulted in providing 100% electricity access to the entire population in the country by 2016.

Macroeconomic analysis carried out by developing an auto-regressive distributed lag (ARDL) model to identify statistical evidence of a long-run or equilibrium relationship between electricity use and economic outcomes confirmed that they are strongly coupled. The results of the model imply that a 1% increase in electricity demand leads to a 0.63% increase in the per capita GDP. The historical analysis of data shows that the key indicators in the form of per capita GDP, per capita electricity consumption, and electricity intensity show positive trends. Both per capita GDP and per capita electricity consumption have been increasing, while there were stabilized trends in electricity intensity. The Poverty Head Count Index and the unemployment rate in the country show a declining trend with increase of electrification in the country.

The field survey conducted in Hambantota to assess the impact of electricity access clearly identified evidence of improvement in the social standards. Results show that socioeconomic conditions of electrified households in Hambantota district improved from 2009 to 2016, the survey years. Employment data indicate a shift from agriculture sector activity to commercial and industry sector activity. A parallel increase in electricity consumption by industry and commercial sectors also took place. District output which is also an indicator of

household income had a predictable and positive relationship with electricity use. Increased use of electricity by industries had a clear impact on household income.

Households were wealthier in 2016 in real terms when compared to 2009, with growth in their expenditure and asset ownership. Households' moveable assets and land other than residential plots increased between the survey years. Households possessed higher counts and greater diversity of electrical appliances in 2016 than in 2009. With increasing demand for electricity, home lighting expressed as installed lumens per household significantly increased, while, with the use of more energy-efficient lighting, demand for electricity in terms of wattage per lumen of lighting decreased. The more affluent houses used more energy-efficient lighting technologies and a combination of electrical appliances.

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On the Road to Achieving Full Electrification in Sri Lanka

This study examines how Sri Lanka achieved countrywide electrification by 2016 and looks at its socioeconomic impact. It notes that electrification helped raise living standards and triggered rapid development in rural areas, creating new investment opportunities at the national level. The study was initiated by Sri Lanka's Ministry of Power and Energy with support from the Asian Development Bank.

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