Ministry of Urban Development and Housing

Sri Lanka Sustainable Housing and Construction Roadmap

2020 - 2050

Supported by

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Sri Lanka
Sustainable Housing and Construction Roadmap
2020 - 2050

Ministry of Urban Development and Housing

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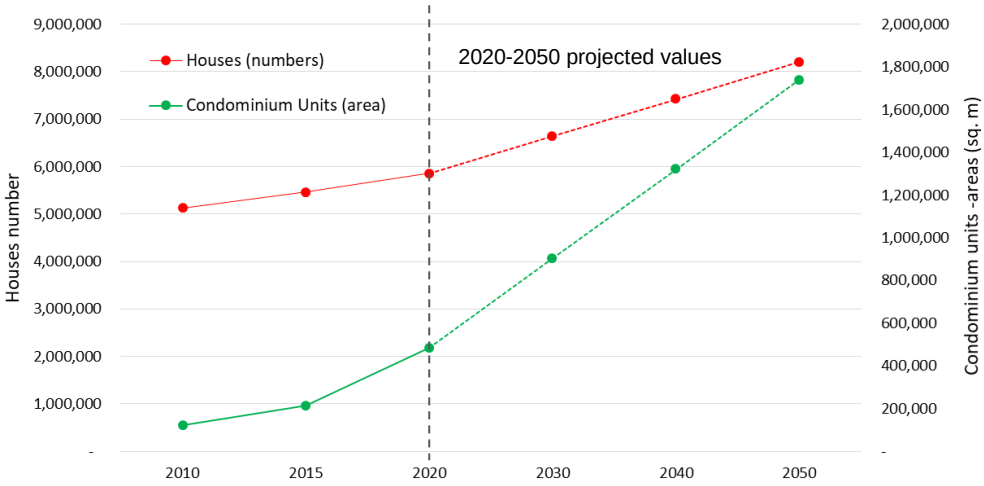
RE-Think Buildings Programme:

The United Nations **RE-Think Buildings Programme** is a joint initiative led by UN-Habitat in partnership with UNEP and UNOPS, and in support of the One Planet Network Sustainable Buildings and Construction (SBC) Programme for SDG12. The overall aim of the joint programme is “Promoting a common approach to supporting countries in leveraging their buildings, construction, and housing sector to achieve the SDGs”. The project outputs had the following objectives during its implementation 2020-2022. 1) provide strategic support to the United Nations Country Teams to help countries in improving the sustainability of buildings and their impact on the environment, in particular on carbon emissions, 2) support governments in transforming their buildings and construction sector to be a resource efficient, low carbon and climate resilient sector, through coherent policy support and results-focused programming based on science and facts. The programme was piloted in Sri Lanka and Burkina Faso for 2020/2022.

EXECUTIVE SUMMARY

Housing sector of Sri Lanka at a glance



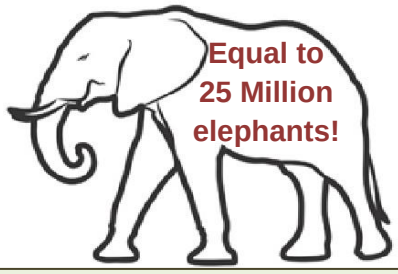
As of 2020:

- Rural houses - **78.4%**
- Urban houses - **17.2%**
- Estate houses- **4.3%**
- Permanent houses - **81.4%**
- Semi-permanent - **17.7%**
- Homeless and landless families - **216,000**

Environmental impacts of housing construction and demolition 2020 – 2050

What is the carbon footprint of 2.3 million new houses?

125 Million tonnes of CO2 emissions



3.25 million existing houses will be demolished

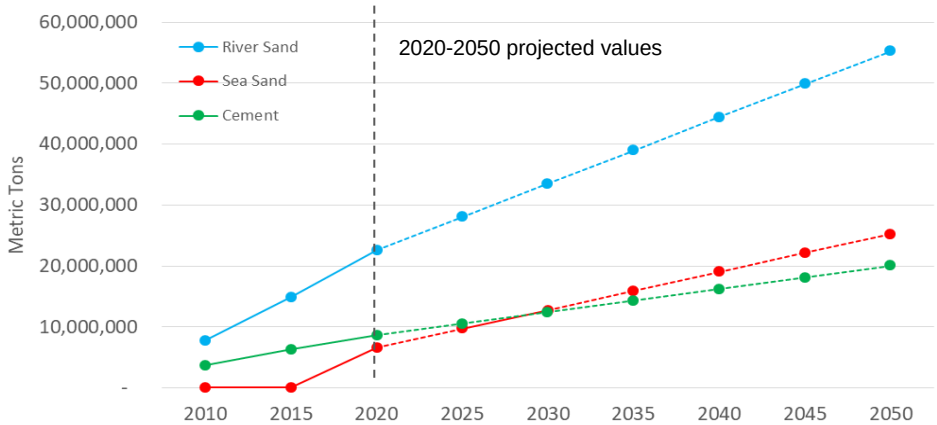
Generating **620 million cu m** of debris

This can fill 250,000 Olympic Swimming Pools!

If we renovate **50%** of the houses to be demolished by 2050, it will save **50 million tonnes of CO^2**.

Equal to planting 20 million trees.

Demand for building materials' sharp increase 2020-2050



Other materials (2020-2050)

> 25 billion bricks
> 3 billion cement blocks
> 6.5 million cu m of timber

Overarching challenges to sustainable/low-carbon (SBC) housing construction

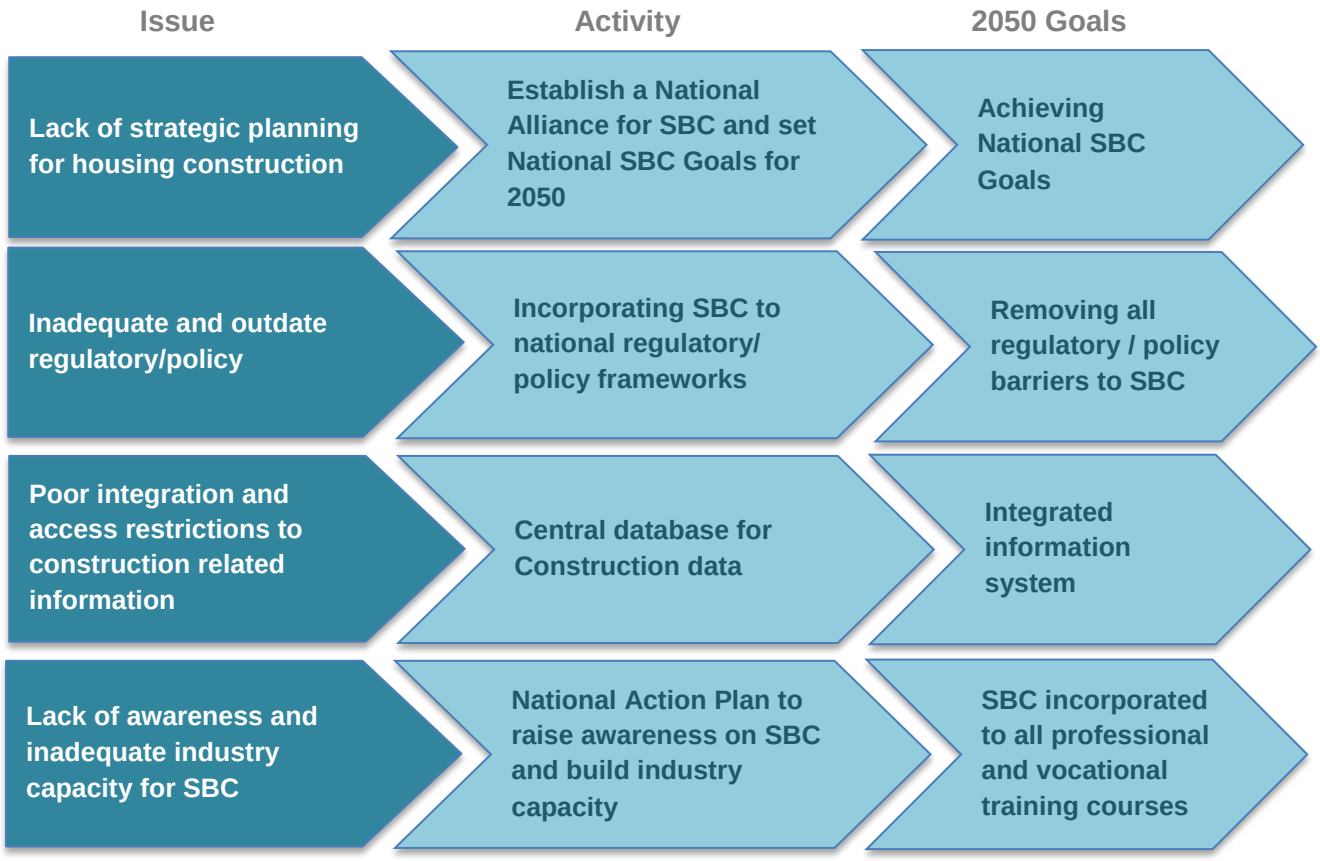
- No mechanism for integrated strategic planning covering all aspects of housing construction
- Inadequate laws, regulations and weak enforcement capacities to support SBC and sustainable building material sourcing. Outdated regulations acting as barriers for mainstreaming SBC
- Lack of participation and engagement opportunities for women and underrepresented groups in decision-making processes related to housing and construction
- Poor monitoring, data management and lack of access to information related to housing and construction
- Inadequate resource / finance allocation for research, promotion and mainstreaming SBC practices and sustainable building materials in housing construction
- Lack of capacity and skills for mainstreaming SBC among construction industry stakeholders particularly at artisan and vocational level. Construction norms and standards unsupportive of SBC.

Sustainable Housing Construction Roadmap – Sri Lanka

Vision 2050

"By 2050, housing and construction in Sri Lanka are socially inclusive, environmentally sustainable and carbon neutral"

Some major goals and activities proposed by the Roadmap



Chapter 1: Introduction

This report presents the findings of the Sustainable Building Construction Country Assessment for Sri Lanka (SBC-CA) and a Roadmap for Sustainable Housing and Construction and achieving NDCs in the construction industry in Sri Lanka. It examines the current status, and potential opportunities and challenges for adopting Sustainable Building Construction (SBC) practices and policies. The Country Assessment and the Roadmap are structured on the approach laid out by the 'Global Alliance for Building Construction (Global ABC) Roadmap for Buildings and Construction 2020-2050, where 8 Action Areas have been identified for the transition towards sustainability in the Construction Sector:

1. Urban planning
2. New Buildings
3. Existing Buildings
4. Building Operations
5. Appliances and Systems
6. Materials
7. Resilience
8. Clean Energy

The Roadmap outlines recommendations to be implemented in each of these broad areas of action together with overarching policy recommendations. The methodology of conducting the Country Assessment was based on the *Resource Efficiency Country Construction Assessment Tool (RE-CCAT).*

The Resource Efficiency *Country Construction Assessment Tool (RE-CCAT) developed by UNOPS, UNEP and UN-Habitat* was developed for the purpose of construction sustainability analysis and informing policy and action, which it supports (1) the country building and housing context analysis and, (2) the enabling environment assessment to identify the challenges and opportunities to improve planning, delivery and management of resource efficient buildings and housing. The tool follows the 10 stages of the building lifecycle from strategic planning to decommissioning and analyses of 7 enabling environment domains: 1] Institutional arrangements, 2) Processes, 3) Policy, laws and regulations, 4) Funding and financial management, 5) Knowledge and technical resources, 6) Stakeholder engagement and, 7) Data management, monitoring and reporting.

Data for analysis was acquired through 1) desktop study, 2) key informant interviews, 3) short consultations and, 4) workshops which provided inputs and feedback from the multi-stakeholder expert group. The report is organised into three parts. The first part provides an overview of the country construction industry, the housing sector, environmental management and the vision for climate resilience. The second, gives the context and the way-forward for the eight Action Areas identified for the transition towards SBC. The third presents cross-cutting challenges and enablers identified in the study, provides conclusions and overarching policy recommendations and the Roadmap for SBC towards 2050.

Chapter 2: Country overview

2.1. Geography and climate

Sri Lanka, an island of 65,610 sq. km, on the Southern tip of the Indian sub-continent, has high topographical, geological, and eco-climatic diversity. The diverse topographical features vary according to altitude, from sea level to 2,524m. The country's complex geology is formed of a variety of rock types including gneiss, granite, limestone, quartzite, and various sedimentary formations such as alluvial/ lagoonal clay and sand deposits. Climatically it is divided into four main zones – Wet zone, Dry zone, Intermediate zone, and Semi-arid zone. The tropical monsoonal climate with two monsoons, makes Sri Lanka wetter than most other parts of the Indian subcontinent. Both rainfall and temperature vary widely across different parts of the country. This geographic and climatic diversity supports a wide variety of ecosystem types in the country of rain forests, dry deciduous forests, wetlands, grasslands and coastal ecosystems. It also gives rise to many natural hazards - droughts, floods, landslides, cyclones, and coastal erosion - that annually cause significant economic and human losses. These topographical, climatic and ecological features and complexity pose many challenges to the construction industry and for managing its environmental and climate impacts.

2.2. Demography and socio-economic development

Sri Lanka was classified as an upper-middle income country with a Per Capita Gross Domestic Product - GDP (nominal) of USD 3,680, in 2020. GDP was estimated to be USD 80,676,681[1] with the services sector making the largest contribution to the economy of 54.6% of the GDP. Sri Lanka's GDP growth reached a peak of 8% between 2010 and 2014, but has declined sharply in recent years. Sri Lanka has historically performed well in social development. The Human Development Index (HDI) for Sri Lanka was 0.782 in 2019, placing it as high in human development. However, it also suffers from many chronic social and economic problems such as acute income disparities and gender inequality. It has a high Gini index value of 39.6 (2016) and UNDP ranked Sri Lanka 75th on the Gender Inequality Index (GII). About 50% of the 2.3 million urban population is estimated to dwell in slums. Sri Lanka also has a substantial number of IDPs and refugees – annual displacement was estimated to be around 135,000 in 2021[2]. Table 1 gives some additional social and poverty indices.

Table 2.1: Some important social statistics on Sri Lanka (Source: Climate Risk Profile Sri Lanka)

Indicator	Value
Population Undernourished	22.1% (2014-2016)
National Poverty Rate	4.1% (2016)
Share of Wealth Held by Bottom 20%	7% (2016)
Infant Mortality Rate (Between Age 0 and 1)	0.82% (2010-2015)
Dependents per 100 Independent Adults	71 (2015)

2.3. Governance and political context

Sri Lanka is a unicameral parliamentary democracy with an elected Executive President. It has both unitary and federal characteristics in the three layers of government: National Government, Provincial Councils, and Local Government Agencies (LGA). The parliament has

[1] World Bank - *GDP per capita (current US$)* - Available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=LK

[2] IDMC - Figures Analysis 2021 - Sri Lanka, Available at https://www.internal-displacement.org/sites/default/files/figures-analysis-2021-lka.pdf

the sole authority to make legislation. The executive comprises the President, the Cabinet Ministries, and the Public Administration System. Different social and economic subject areas (eg. health, agriculture, industries) come under the national and provincial ministries. The Thirteenth Amendment to the Sri Lankan constitution delineates which tier of government is responsible for the different subject areas. The administrative structure of Sri Lanka is also three-tiered, comprising Village Officers - Grama Niladhari (GN), Divisional Secretaries and District Secretaries. Over the past three decades, efforts for devolution of administration through District and Divisional Secretariats have provided excellent platforms for ground-level representatives from different agencies to interact and coordinate but much remains to be improved. Recent years has seen intense political volatility in Sri Lanka, and frequent change in governments. In 2022 the precarious foreign debt situation caused the worst economic crisis in the country since independence, along with an acute shortage of some essential goods, which has sparked widespread public unrest. Bilateral and multilateral humanitarian assistance and debt restructuring are expected to ease the situation by early 2023, but the long-term recovery will be slow.

2.4. Materials and construction practices

The construction industry is the largest consumer of natural resources in Sri Lanka, including bulk minerals (sand, rock, clay), timber and fibre. A major portion of construction activities and materials sourcing, remain informal or partially regulated. Price inflation of construction materials has been variable, but generally very high. Building material production is a major contributor to Green House Gas (GHG) emissions from the industrial sector. Cement production, calcite and dolomite production and use, and steel rolling, account for about 92% of the industrial GHG emissions[3]. Although the industrial sector only makes up about 2.5% of Sri Lanka's total GHG emissions, the construction industry has a much larger indirect contribution through power and transport demands, which are yet to be quantified.

In rural and suburban areas, the most commonly used building materials for housing construction are: random rubble foundations, brick or cement block walls, timber roof structure, and cement-fibre or metal sheets roof covering. However, for larger higher income housing projects in the urban sector more technically advanced practices are increasingly used. Some estimates indicate that construction material quarrying amounted to 44% of all raw-material extraction for domestic use in Sri Lanka[4]. Construction material quarrying increased by 179.6 % from 8.4 million tonnes in 1990 to 23.5 million tonnes in 2018[5].

A significant portion of construction work is still a part of the informal economy, which is hard to quantify. This is a major barrier to developing and maintaining proper construction procedures and quality management processes, including sustainability measures. Recently some initiatives have been adopted towards the sustainability of the construction sector such as Green Building certification, and Green Material certification. From 2009, 80+ buildings and 45+ materials have been certified by the Green Building Council of Sri Lanka[6]. The initiatives are further discussed under Section 4.2 (Action Area 2: New buildings).

[3] Ministry of Environment Sri Lanka (MoESL). 2011. Second National Communication on Climate Change. Colombo: MoESL

[4] SCP Hotspot Analysis – Sector Profiles Sri Lanka, Available at http://scp-hat.lifecycleinitiative.org/sector-profiles/

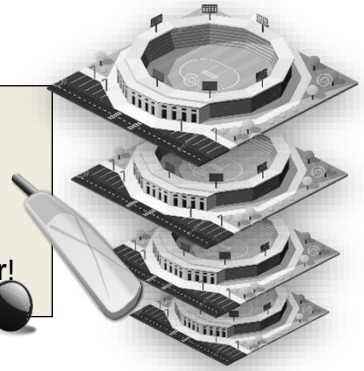
[5] ibid

[6] Green Building Council of Sri Lanka - https://www.srilankagbc.org/

2.5. Buildings and housing sector

According to the Census of Population and Housing in 2011, there were 5,264,282 housing units in the country. Of which, 78.4% were rural, 17.2% urban and 4.3% were in the plantation sector. 81.4% of the houses were classified as permanent, while 17.7% were semi-permanent[7]. Housing needs due to population growth in Sri Lanka have been moderate. However, there is a significant and urgent demand for permanent housing driven by other factors, such as displacement due to conflicts (Civil War 1983-2009), disasters, and infrastructure projects, and also unsuitable quality of existing housing. The Housing Needs Assessment of 2016[8] identified a critical need to improve the quality of existing housing. According to the Sri Lanka government criteria, a house with concrete or masonry foundation, masonry external walls and a permanent roof[9] is considered a permanent house. As of 2016, more than 275,000 of the existing housing units were temporary constructions and about 40,000 of these were in a highly undesirable (impoverished) state. There were over 800,000 families without a house and there were about 216,000 homeless and landless, families. There had been various government-led housing projects historically in Sri Lanka in urban, rural, and estate sectors, UDA's Middle Income Housing Programme, and Low-income Housing Projects are some examples. While some of these schemes were targeted at providing housing for landless-homeless people, some were "urban regeneration programs" where families were evicted from the informal and unauthorized buildings and relocated to multi-story housing schemes. 23 such low-income multi-story housing schemes (12,771 Housing Units) have been built in Colombo metropolitan region[10]. Following the end of the Civil War in 2009, it was estimated that approximately 168,000 households had to be resettled, which had been partially fulfilled from 2010-2020 through bilateral and multi-lateral aid programs (eg. 50,000 houses constructed 2012-2020 under assistance from the Government of India). Section 4.2 presents more details about different aspects of the housing sector and housing construction.

Currently 500,000 sq.m. of condominium space added per year
It will be over 1.75 million sq.m. per year by 2050
The space covered is more **than100 cricket grounds a year**!

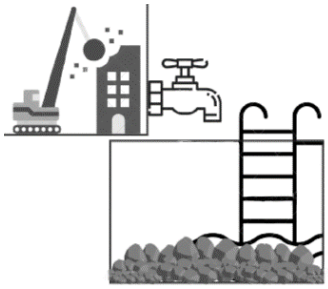


2.6. Environmental degradation and climate change impact

According to the Convention of Bio-diversity (CBD), Sri Lanka has the richest species concentration in Asia[11]. There is also a wide diversity of forest and ecosystem types in the island. Development activities and urbanization have taken a[12] massive toll on Sri Lanka's ecosystems. The forest cover which was over 45% in the mid-last century fell below 30% by the mid-1980s[13]. The construction industry is a major contributor to the country's

[7] Census of Population and Housing 2011, Department of Census and Statistics Sri Lanka.
[8] Ministry of Housing and Construction (MoHC). 2016. Housing Needs Assessment and Data Survey. MoHC: Colombo, Sri Lanka
[9] Concrete slab or timber/steel frame sheltered with roofing tiles or metal/cement-fiber sheets
[10] Urban Development Authority, Sri Lanka - https://www.uda.gov.lk/urban-regeneration-programme.html
[11] Convention on Biological Diversity – Sri Lanka country profile - https://www.cbd.int/countries/?country=lk
[12] Urban Development Authority - https://www.uda.gov.lk/urban-regeneration-programme.html
[13] https://rainforests.mongabay.com/deforestation/forest-information-archive/Sri_Lanka.htm

environmental degradation. Mineral extraction such as sand mining, rock quarrying, soil and clay excavation have had devastating impacts on ecosystems. The impacts of river sand mining, such as bank erosion, ground water drawdown and salinity intrusion are particularly catastrophic and now affecting every major river system[14] in the country. Solid waste related pollution also gives rise to major environmental issues in the country, with a daily solid waste generation of more than 7000 metric tons[15]. It is estimated globally that the construction industry contributes about 40% of the total solid waste volume directly or indirectly. In Sri Lanka, materials such as concrete has shown waste percentages as high as 25%[16]. Illegal dumping of construction waste in sensitive ecosystems is also causing severe impacts[17].

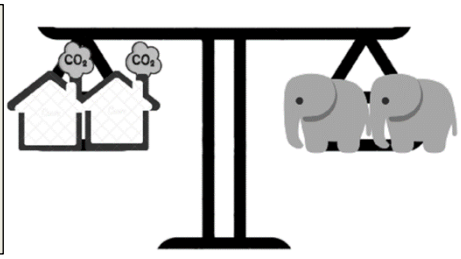


More than 3.25 million houses to be demolished 2000-2050
This will produce over 620 million cu.m of debris
This can fill 250,000 Olympic swimming Pools!

Renovate half of the buildings without demolition will save > 50 million tonnes of CO2! **Equal to planting 20 million trees!**

Total annual GHG emissions in Sri Lanka are estimated to be 18,454,691 (2016), with a per capita value of 0.88 tons per person (1 ton per person as of 2020), which is lower than the global average of 4.47 tons CO^2 per person. It is estimated that the construction sector contributions to the carbon footprint was 5.3 million tonnes CO^2 eq. (10% of the total)[18].

By 2020 5.8 million housing units, and 8.2 million houses by 2050
Over 2.3 million new houses will emit more than 125 million tonnes of CO2
It is equal to **25 Million elephants!**



Sri Lanka is recognized as highly vulnerable to climate change impacts, ranked 100th out of 181 countries in the 2017 ND-GAIN Index[19]. The temperature rise due to climate change in Sri Lanka is estimated to be 0.8°C–1.2°C the lowest emission scenario[20]. This is also predicted to increase the disaster risks ie. increased flooding, flash floods, and landslides[21]. The construction industry will also be affected by climate change impacts, due to the predicted increase in disaster events and extreme heat. Events such as floods and heat waves can reduce the durability of the structures and further increase their vulnerability to hazards. Heat waves will increase air conditioning energy usage and associated increased carbon

[14] Ratnayake, R. Riversand mining- Boon or Bane? (2008). Available at: http://lankajalani.org/wp-content/uploads/2017/04/RSM-English.pdf.
[15] Environmental Foundation Ltd. (EFL), Sri Lanka - https://efl.lk/status-waste-management-sri-lanka/
[16] Rameezdeen, R., Kulatunga, U. & Amaratunga, D., 2004. Quantification of Construction Material Waste. s.l., The University of Salford.
[17] Central Environmental Authority - Technical Guideline of Solid Waste Management Sri Lanka
[18] SCP Hotspot Analysis – Sector Profiles Sri Lanka, Available at http://scp-hat.lifecycleinitiative.org/sector-profiles/
[19] ND-GAIN Country Index 2022 Available at https://gain.nd.edu/our-work/country-index/
[20] Climate Risk Country Profile: Sri Lanka (2020): The World Bank Group and the Asian Development Bank.
[21] ibid

emissions. Increasing disaster events can also hamper the construction process and material supply chains.

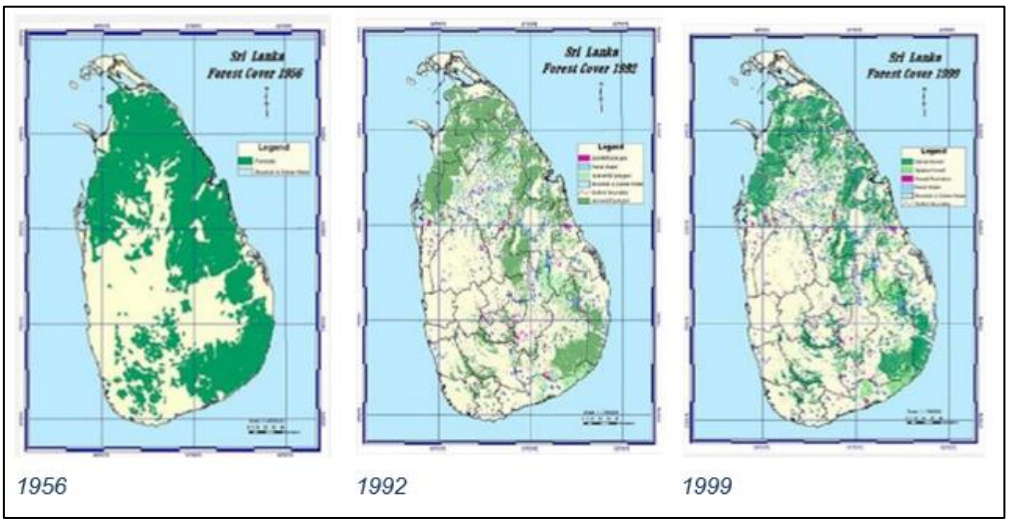


Figure 2.1: Sri Lanka forest cover variation 1950-2000 (Source – Ministry of Environment Sri Lanka)

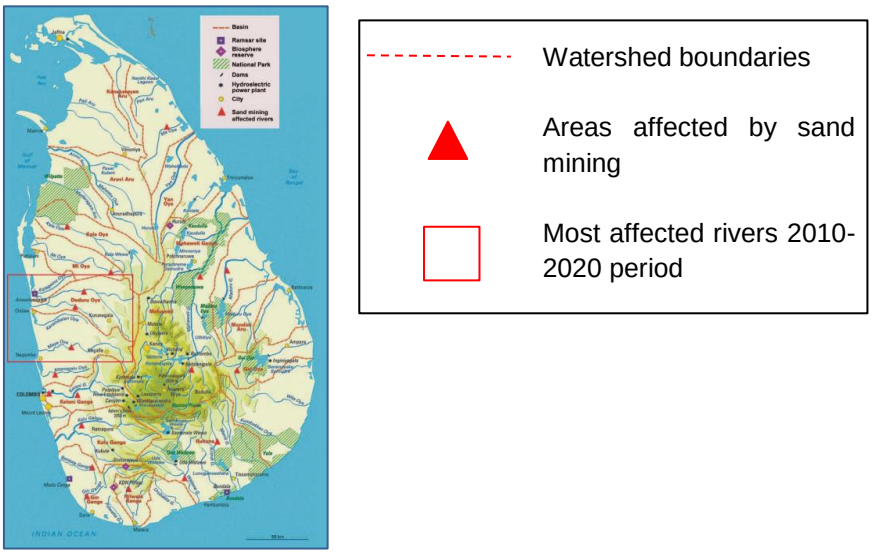


Figure 2.2: Land degradation and sand mining hot spots (Source: Pereira & Ratnayake 2013[22])

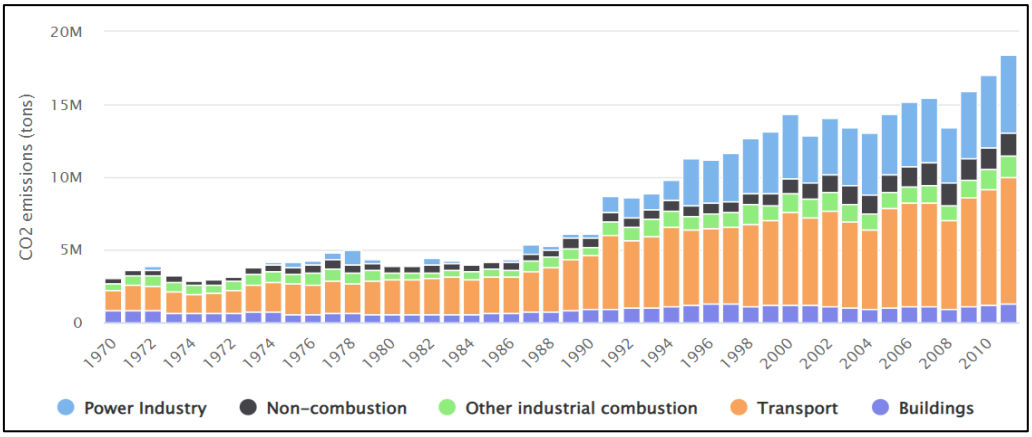


Figure 2.3: GHG emissions Sri Lanka: 1970-2010 (Source: World Bank)

[22] Pereira, K., Ratnayake, R. (2013). Water Integrity in Action: curbing Illegal Sand Mining in Sri Lanka, Berlin, Germany: Water Integrity Network.

Chapter 3: Country vision and strategy for climate change mitigation and adaptation

Sri Lanka adopted the National Climate Change Policy in 2011 with the following objectives: 1) taking adaptive measures to minimize climate change impacts, 2) mitigating greenhouse gas emissions, and 3) promoting sustainable consumption and production[23]. The important implication for the construction industry is that the policy identifies "sustainable consumption and production can significantly address the current and future challenges of climate change". It also highlights that planning of human settlements and land use is a key climate change adaptation approach, and recommends "incorporating nationally appropriate low emission strategies and technologies and appropriate adaptive strategies in human settlement, land use planning, and urban development[24]". In 2016 Sri Lanka adopted the National Climate Change Adaptation Strategy 2016-2025, which identifies human settlements and built-environment as key areas for adaptation interventions.

Sri Lanka's declaration of Intended Nationally Determined Contributions (INDCs) in 2015 set a 2030 target of reducing overall GHG emissions by 14% (20% in the energy sector and 10% in others)[25], which was revised in 2021 to increase the emission reduction target to 14.5% for the period of 2021-2030 from all sectors. The 2021 revision to the NDCs also included: increasing forest cover to 32% and achieving 70% renewable energy in electricity generation by 2030, while attaining Net Carbon Neutrality in electricity generation by 2050[26].

The most pertinent NDC target for the construction sector is the intended 7% emission reduction in the Industry sector[27]. There were many sector-specific NDCs that are pertinent to buildings and housing, where Action Area 7 (Resilience) had the largest share of NDCs[28]. Figure 3.1 gives the distribution of relevant NDCs among the eight Action Areas concerning this report. They are further discussed in Table 7.1 under Conclusions and Recommendations. The upcoming Third National Communication of NDCs is expected to have specific targets for construction.

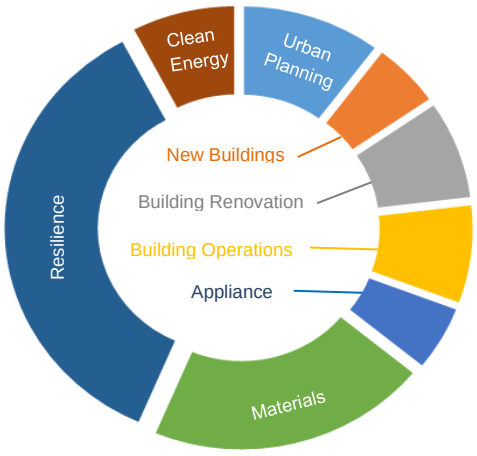


Figure 3.1: Distribution of NDC among Action Areas (source: Author calculations)

There is no adequate review yet of how well the sectors have performed in achieving these NDCs. However, tracking of performance towards Sustainable Development Goals (SDGs) shows that, while having a good overall SDG Index score of 70/100[29], the country is performing poorly in the SDGs pertaining to construction industry sustainability. Affordable Clean Energy (SDG7), Industry Innovation and Infrastructure (SDG9), Rsponsible Consumption and Production (SDG12) and Life on Land (SDG15) were all evaluated as major or significant challenges remaining for the achievement of the SDGs[30]. The construction industry stakeholders therefore, bear a major responsibility in achieving these critical climate and sustainability targets.

[23] Sri Lanka adopted the National Climate Change Policy in 2011- http://www.climatechange.lk/CCS%20Policy/Climate_Change_Policy_English.pdf
[24] ibid
[25] Sri Lanka Second National Communication of NDCs, 2015 - https://unfccc.int/documents/144627
[26] Updated Nationally Determined Contributions, Sri Lanka, 2021 - http://www.climatechange.lk/CCS2021/UpdatedNDCsSriLanka2021.pdf
[27] ibid
[28] Author assessment
[29] Sustainable Development Report – Sri Lanka: Available at https://dashboards.sdgindex.org/profiles/sri-lanka
[30] ibid

Chapter 4: Context and Way-Forward: Resource-Efficient Housing and Buildings Sector

4.1. Action Area 1: Urban Planning

4.1.1. Baseline and Enabling Environment:

Under this Action Area three aspects are covered: National level physical planning, Urban planning and Strategic planning for the Construction Sector. Sri Lanka prepares a National Level Physical Development Plan at regular intervals and the legal framework for national planning is provided by the Town & Country Planning Ordinance (Amended Act - 2000). The first National Physical Planning Policy and the Physical plan was enacted in 2011 and the National Physical Plan 2050, was enacted in 2019[31]. The Plan adopted the principles of sustainable development (17 SDGs) and the development framework provided therein is aligned with UN Land Use- Climate Action Pathway of goal 13: protecting what we have and restoring what we have lost. Under these plans, four urban conurbations, two metropolitan areas, nine major urban service centers, and a series of well-connected secondary and tertiary urban centers have been identified and demarcated for future urban development to provide facilities to approximately fourteen million residents[32]. A prominent share of building construction activities can be expected in the forthcoming decades in these areas.

The existing plan was formulated based on detailed scientific studies, expert stakeholder consultations, comprehensive analysis of trend patterns and future requirements with an over-arching holistic vision. Hence, it is important that the housing and infrastructure development projects and other sectoral development programs comply with the directives and guidance provided therein, in order to achieve climate responsive, economically and technically feasible, sustainable building and construction sector in the near future.

The government which came into power in 2020, initiated another amendment to the National Physical Plan, based on their election political manifesto[33]. These proposals have not been adopted yet and the updating process still continues (in August 2022). Thus, the Plan enacted in 2019 is still valid, unless another enactment replaces it in the near future.

The Urban Development Authority (UDA) is the apex urban planning and development regulatory institution established under the Urban Development Authority Law of 1978 and amendments thereafter. Among many other tasks, the UDA is mandated with the preparation, enactment and implementation of development plans in urban areas. These declared urban areas fall in line with the future urban development trends indicated in the National Physical Plan 2050. Even though, there are 240 ‘urban areas’ declared since 1980s, only forty development plans have been formulated as of 2022[34]. These plans also needed to be updated once in ten years and therefore, the UDA is currently experiencing significant backlog of planning activities. This is a major gap that directly impacts the building compliance and compatibility with the sustainability principles which also raise many social and environmental concerns.

With the growth of the economy, a larger share of the population will inevitably shift to the category of ‘urban’ within the next few decades. Even though the Census of 2012 classified

[31] National Physical Planning Policy & The Plan — 2017-2050 National Physical Planning Department Sri Lanka - National Physical Planning Policy & The Plan — 2017-2050 Available at https://www.nppd.gov.lk/images/National_Physical_Plans/National_Physical%20Planning%20Policy%20and%20The%20Plan%202050.pdf

[32] ibid

[33] *Saubhagye Dekma*- Vistas of Prosperity and Splendor, 2019

[34] Urban Development Authority Sri Lanka – Development Plan 2021-2030 Available at https://www.uda.gov.lk/

18.5% of Sri Lanka's population as 'urban', it is far from the ground reality. Several studies (World Bank[35], UoM[36]) revealed that, irrespective of the type of LGA in the area of residence, at least half of Sri Lanka's population would have reached the threshold of being 'urban' by 2020.

The RE-CCAT analysis of the construction lifecycle stages pertaining to urban planning – "Strategic planning" and "Spatial planning" – showed that spatial planning processes are more developed and stronger in most enabling domains than strategic planning (see Fig.4.1). Strategic planning showed strength in enabling domains such as "Technical resources" and "Process," but was weak in domains such as "Institutional arrangement" and "Stakeholder engagement." Data management was somewhat strong both in Strategic and Spatial planning stages because of the availability of general census and statistics data, but rapidly diminishes in later lifecycle stages.

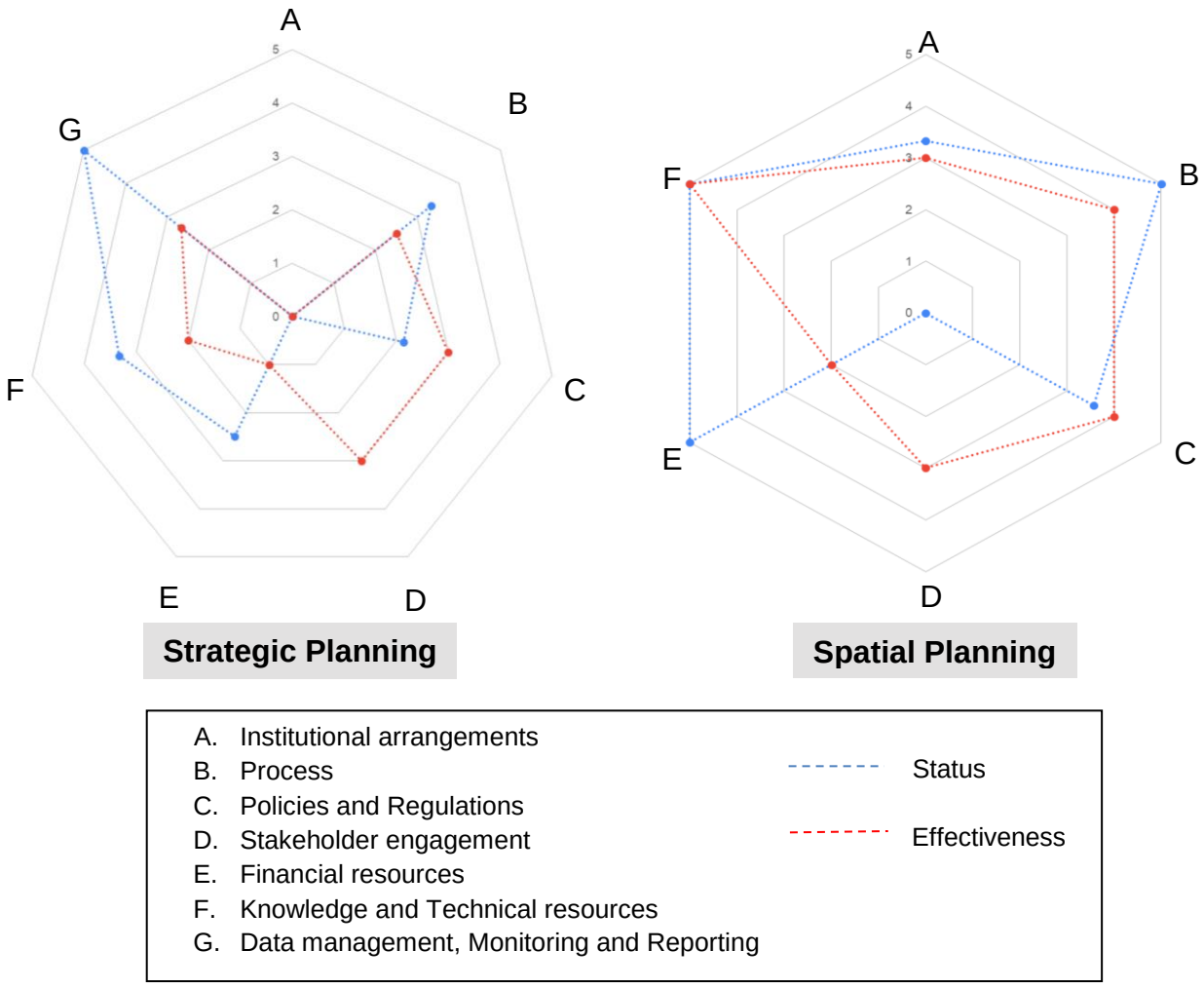


Figure4.1. : RE-CCAT Analysis for stages pertaining to Strategic Planning and Spatial Planning

[35] World Bank Ground - Leveraging Urbanization in Sri Lanka, 2015, Available at https://www.worldbank.org/en/country/srilanka/brief/leveraging-urbanization-sri-lanka

[36] De Silva, M C K, Dharshini G C and Munasinghe J N (2016), *Defining 'Urban' among Urbanizing Rural: the case of Sri Lankan Urbanization*, Proceedings of the 9th Internationla Conference of the Faculty of Architecture Research Unit (FARU) University of Moratuwa, Sri Lanka: pp 288-303

4.1.2. Projection 2050

- By 2050, it is likely that more than 70% of the population in Sri Lanka, will be 'urban'[37]. There will be a rapid increase in demand for urban utilities such as pipe borne water supply, formal drainage, grid-based electricity, municipal liquid and solid waste disposal and many more. At the same time, there will be an increased demand for urban facilities such as recreation spaces, shopping and entertainment facilities, health services, etc.

- This trend is inevitably associated with an upward trend in building construction both to facilitate the transformation expected in 'urban residences' and to accommodate the urban facilities and services.

- This will intensify building material and energy flows for construction activities. Accordingly, resource exploitation (earth, sand, quarried materials, clay and other mineral resources, timber, water), pollution and GHG emissions are likely to increase significantly between 2020-2050. Discussed in detail under Section 4.6.

- Elevated quality of life of people will result in an increased use of modern household and office equipment further increasing energy and carbon footprints of the construction and housing industry. Discussed in detail under Sections 4.2 and 4.3

4.1.3. Challenges and gaps

1. Inconsistencies in the implementation of the National Physical Plan and lack of compliance with the plan in the implementation of projects by different agencies.
2. Absence of Local Area Development Plans (at local government level) for most of the urban areas and the lower capacities in the LGAs to prepare Local Development Plans on their own.
3. Lack of capacity, systems and interest in LGAs to effectively enforce planning and building regulations in the areas under their jurisdiction.
4. Persistent data gaps in the development activities and inadequate coordination among development agencies.
5. The existing definition of an "urban area" is inappropriate for current conditions, resulting in inaccurate classification of LGAs into Municipal, Urban and Pradesheeya-Sabhas.

[37] De Silva, M C K, Dharshini G C and Munasinghe J N (2016), ***Defining 'Urban' among Urbanizing Rural: the case of Sri Lankan Urbanization***, Proceedings of the 9th International Conference of the Faculty of Architecture Research Unit (FARU) University of Moratuwa, Sri Lanka: pp 288-303

4.1.4. Actions and Goals

Table 4.1:Actions and goals for Urban Planning

Challenge/Gap	Action / Goal	Timeframe
Inconsistencies in the implementation of the National Physical Plan	**Action 1.1:** National Planning Department of the Ministry of Finance to check all development projects for their compliance with the NPP, before approval **Action 1.2:** To establish an Independent National Planning Commission to assure the compliance of all major development projects in their implementation	Short term (03-05 years)
Absence of Local level Development Plans for most LGAs	**Action 1.3:** Development of the Institutional Capacities (necessary financial and human resources), planning capabilities (technical and technological requirements) and the core competencies (Urban Planners, Engineers and other expertise) of the LGAs along with strengthening the capacities of the UDA. **Action 1.4:** Establishment of a dedicated Strategic Planning Division in all LGAs (the purpose of which is to prepare, implement, monitor and phase out of the development plans for the respective Local Area)	Short term (within 03-05 years) Short (within 03-05 years for all MCs[38] and UCs) and Medium term (in 10 years - for all other LGAs)
Lack of capacity, systems and interest in LGAs to effectively enforce Planning & Building Regulations	**Action 1.5**: Extend the UDA's web-based development application processing and clearing (On-line approval system) into LGAs as a common platform, shared, audited and managed centrally and locally. **Action 1.6:** Provide Local Authorities with the necessary technical and technological capacities, capabilities and competences to manage geo referenced, regularly updated and effectively managed spatial data infrastructure, in collaboration with the on-going National Spatial Data Infrastructure (NSDI) development project.	Short Term (within 03-05 years- MCs and UCs) and Medium term (within 10 years - other LGAs)
Inappropriate definition of urban areas and resulting classification of LGAs	**Action 1.8:** Provide necessary support to the Department of Census & Statistics to reformulate the definition.	Short term (within 03 years)

[38] MC – Municipal Council, UC – Urban Council

4.2. Action Area 2: New Buildings

4.2.1. Baseline and Enabling Environment:

This section on New Buildings outlines the baseline on existing stock of housing units and the trends in construction of new houses. Between 2000 and 2015, on average 76,500 houses have been added each year to the building stock of Sri Lanka, with an average annual growth rate of 1.8% (2000-2010) and 1.6% (2010-2015)[39]. Aggregate number of non-housing building units added annually has not been estimated. However, it can be assumed that buildings such as hotels and commercial high rise buildings have significantly increased since mid-2000s and especially after the end of the Civil War in 2009. For example, the number of hotel rooms increased from 14,714 in 2010 to 42,750 in 2020[40], and the floor space of commercial high rise buildings (including luxury apartments) increased from 125,752 m2 to 582,345 m2 (2010-2020) with a 36% annual growth rate[41].

The SBC Country Assessment did not come across a comprehensive study on construction practices in Sri Lanka. According to the interviews, most housing units are constructed using conventional materials and methods – eg. masonry, concrete, timber structured roofing. Use of more advanced techniques such as pre-engineered buildings, pre-caste panels and steel structures are used in urban upper-income housing and commercial high-rise buildings. Use of sustainable building techniques or materials are rare.

Construction of new buildings of any scale have to be approved by the relevant Local Government Agency (LGA): Building Permit issued to commence construction and a Certificate of Conformity (CoC) issued at the completion of construction. The Building Permits and CoCs should adhere to the Planning and Building Regulations (PBR) formulated by UDA or the relevant LGA. The current PBR (2020) consider, sustainability aspects such as the land suitability, energy and water conservation, thermal comfort, sustainable usage of materials and cultural sensitivity[42]. However, the interviews indicated that a significant share of buildings throughout the island are still being constructed without obtaining formal approvals. This creates a major barrier for improving quality of construction work, introducing good practices, and knowledge transfer into the lower segments of the sector. It also disrupts the information flow and creates room for corrupt and fraudulent practices.

Sri Lanka has detailed guidelines for forming formal construction contracts. The Standard Bidding Documents published by the Construction Industry Development Authority (CIDA) include the procedures, conditions of contract and specifications for forming and execution of the contract. CIDA also registers and grades construction contractors according to their capacity and specialization[43]. The institutional framework pertinent to construction of new buildings is given in Fig.4.2. More detailed description of the construction industry legislation, policies, stakeholders and regulators are given in Annexes - Table A1 and A3. These agencies and regulations facilitate the systematic regulation of medium to large construction projects. However, the Country Assessment showed that construction of new buildings of smaller scale

[39] Author calculations based on 2012 Housing and Population Census, Sri Lanka
[40] Sri Lanka Tourism Development Authority statistics: https://www.sltda.gov.lk/en/statistics
[41] Condominium Development Authority of Sri Lanka statistics
[42] https://www.uda.gov.lk/attachments/act/2235-54_E.pdf
[43] https://www.cida.gov.lk/

including a majority of houses are constructed by small holder builders and informal craft persons, without a formal contract.

Policies, regulatory provisions and initiatives for constructing sustainable and low carbon buildings are still at an initial stage of development in Sri Lanka. There are two notable Green Building certification programs (i.e. Green Building Council – GBCSL, and Urban Development Authority – UDA Green Building certification schemes). GBCSL program has certified 80+ buildings where a certificate is valid for 3 years. UDA has made Green Building certification mandatory for buildings lager than 400 sq. m (Urban Development Regulations - 2020). There are some initiatives to certify building materials on their sustainability and energy performance, which are further discussed under Section 4.6.

The analysis of the enabling environment for SBC in Sri Lanka using the RE-CCAT tool showed that stronger opportunities for SBC exists in the early stages of the building project life-cycle – eg. Building sector planning and Design stages. Currently, mechanisms and opportunities of SBC are less in Procurement and Construction stages. (see Fig.4.3). As an enabling environment domain, “Knowledge and technical resources” for new building construction was strong in Sri Lanka, where as “Stakeholder engagement” and “Financial resources” were the weakest domains.

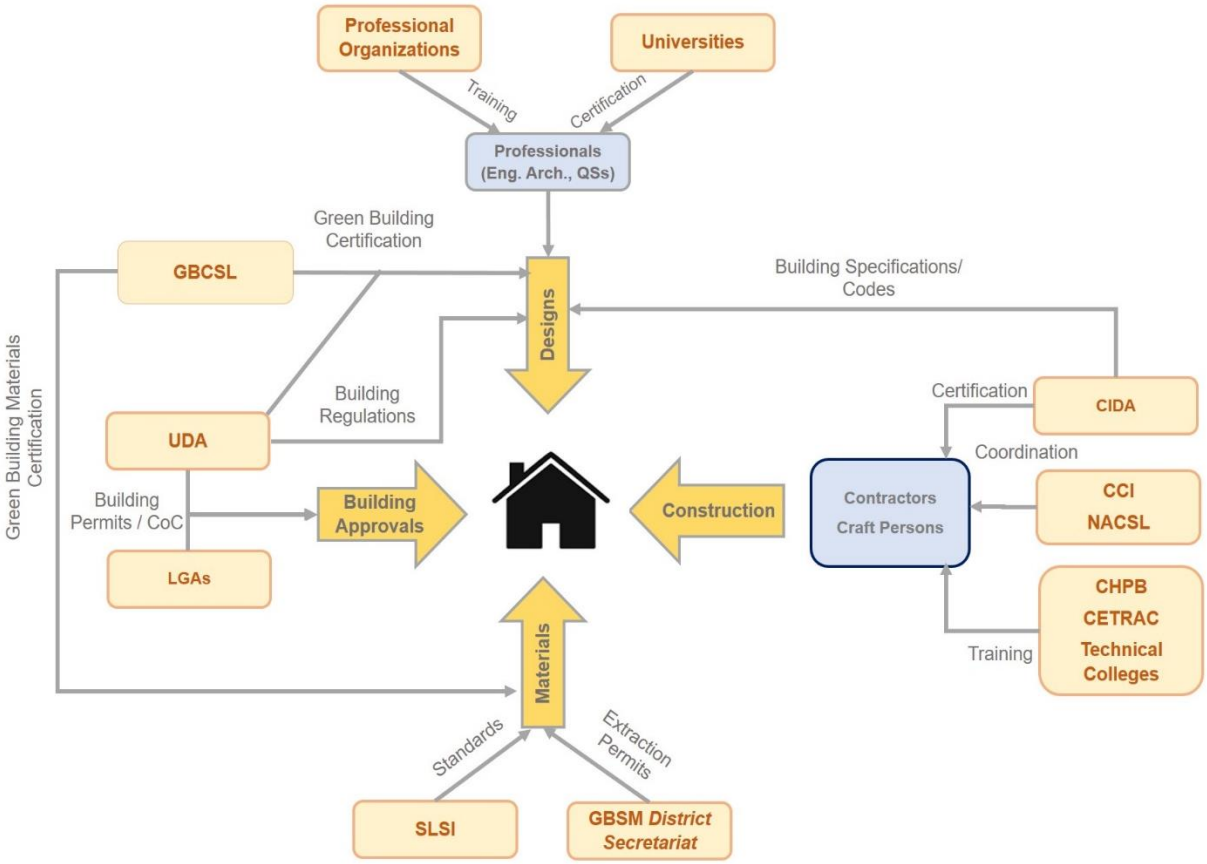


Figure 4.2: Institutional Framework of the Construction Sector – Sri Lanka

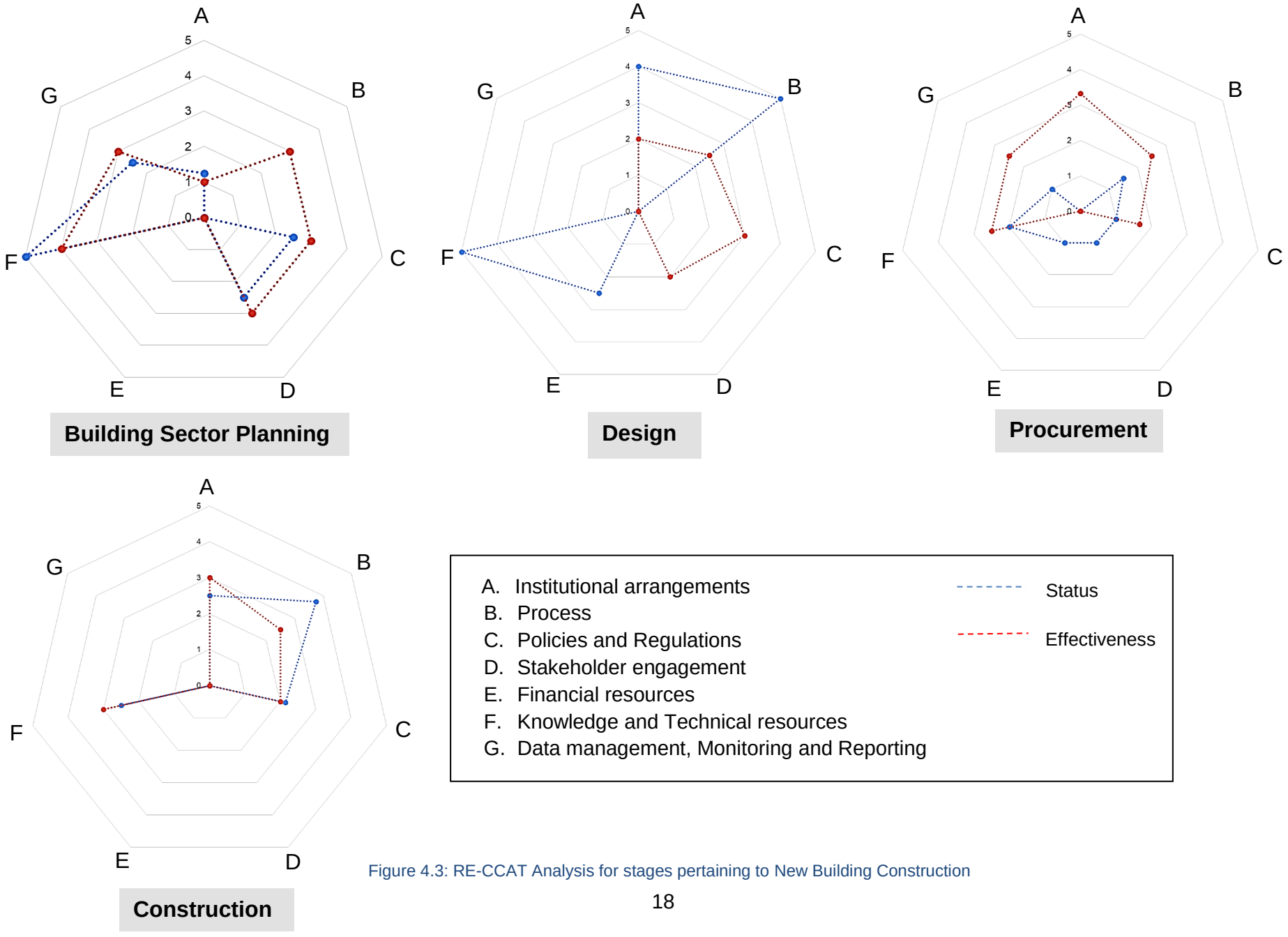


Figure 4.3: RE-CCAT Analysis for stages pertaining to New Building Construction

4.2.2. Projections 2050:

- Population of Sri Lanka as of 2020 was estimated to be 21.4 million. It is projected to peak around 2040 to 22.4 million and start a gradual decrease stabilising around 21.8 million by 2050[44] (See Fig.4.4).

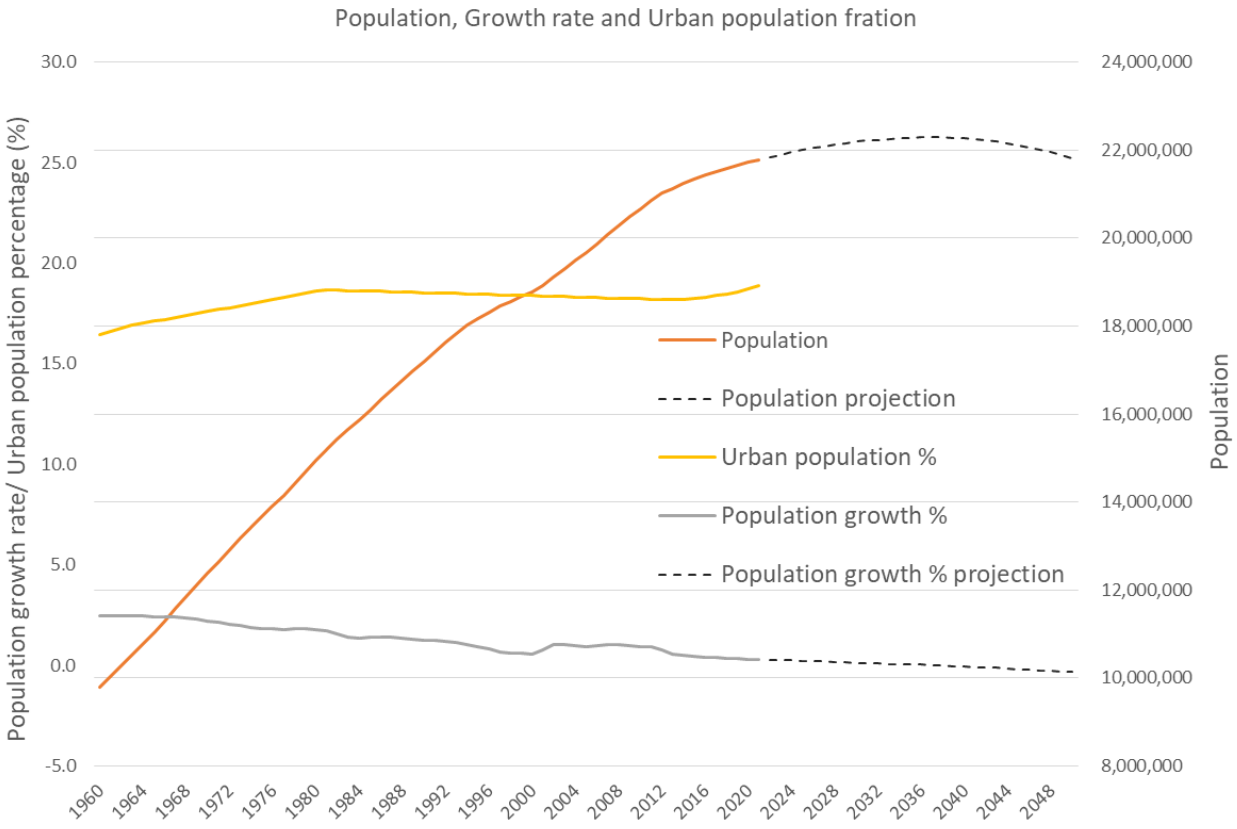


Figure 4.4:Population, growth rate and urban fraction Sri Lanka (Source: Author prepared)

- Sri Lanka had 5,207,740 housing units in 2016[45]. As given below the projected values for number of housing units and persons per house using linear forecast based on the housing surveys of 1981, 2001, 2010 and 2016. Therefore, even by a conservative linear projection around 2.34 million new housing units will be built in the 2020-2050 period (30% decadal increase).

Table 4.2: Housing Predictions Sri Lanka (Source: Author calculations)

	2020	2030	2050	Increase 2020 - 50
Number of housing units	5.2 million	6.4 million	8.2 million	2.3 million
Persons per house	4.2	3.6	2.6	n.a.

[44] Data from Department of Census and Statistics Sri Lanka
[45] Ministry of Housing and Construction (MoHC). 2016. Housing Needs Assessment and Data Survey. MoHC: Colombo, Sri Lanka

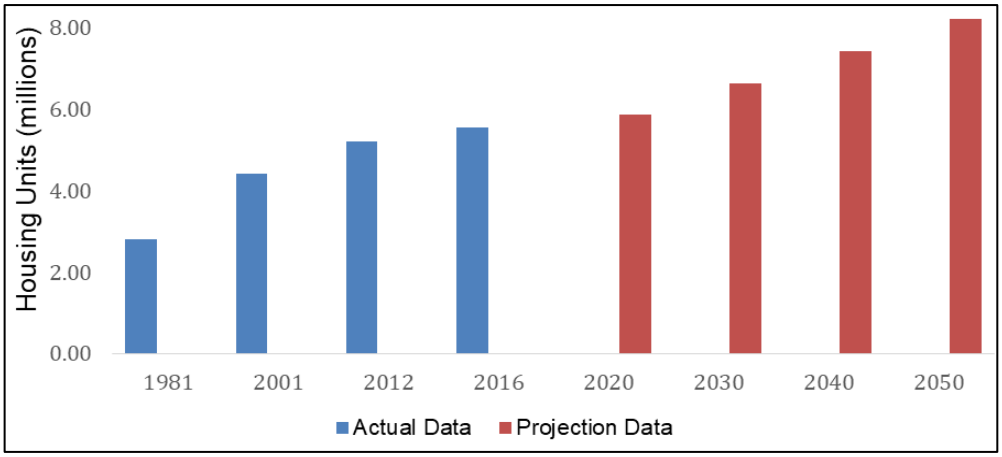


Figure 4.5: Projected increase in number of housing units (Source: Author calculations)

- Sri Lanka emitted an estimated 18.45 million tons of CO2 in 2016. With linear forecasting, this will increase to 21.98 million tonnes in 2030 and 28.46 million tonnes (per year) by 2050. Accordingly, the per capita carbon emission will increase from 1 tonne per person per annum to 1.3 tonnes per person by 2050.

Housing sector CO^2 contribution (2020-2050) = 128 million tons of CO^2 for 2.34 million housing units

(based on average carbon footprint of about 55 tons[46] for a 750 sq. m masonry house - the median house size and common house type according to HIES report 2016[47])

4.2.3. Challenges and gaps:

1. Majority of construction activities in housing is conducted without proper contractual procedures and by informal craft persons.
2. Informal processes makes it difficult to regulate smaller buildings, especially owner built individual houses for quality or construction processes.
3. Prevailing data management on new buildings is disintegrated. The data existing in the form of building permits approvals (at LGAs) is not integrated into a centralized system.
4. Enforcement and implementation of legislation, regulation and policy pertaining to building construction at ground level is poor and uncoordinated.
5. SBC related policies and regulations are at a very initial stage of development. Major improvements are needed.
6. There are no financial incentives for builders or house owners to adopt Green Building or sustainable practices

[46] Based on the 0.8 tons CO2eq/sq. m bench mark
[47] Department of Household Income and Expenditure Survey – 2016 Report available at http://www.statistics.gov.lk/

4.2.4. Actions and goals

Table 4.3: Actions and Goals for New Buildings

Challenge/Gap	Action / Goal	Timeframe
Dominance of informal practices in housing construction Poor monitoring and quality management of smaller projects Poor enforcement of construction related regulations at ground level	**Action 2.1:** CIDA to develop simpler contract documents /codes/guidelines for smaller projects. To be disseminated through LGAs to individual house owners and small-holder builders (for voluntary adaption). **Action 2.2:** Communication and dissemination campaigns for small builders and individual house owners. **Action 2.3:** Review the existing regulatory process and simplify them.	Short Term
Poor data collection on new buildings	**Action 2.4:** Integrate the data on new building permits and CoCs (collected and managed by individual LGAs) into a central data base at the Ministry of Construction or CIDA. **Action 2.5:** Combine the data from utility provision agencies – eg. CEB, NWS&DB and other building related data (eg. borehole data from NBRO) to the central database, making it a one-stop-shop for all housing related information.	Short Term
Inadequacy of SBC / Low Carbon provisions in existing housing/ construction policy and regulations	**Action 2.6:** Revise the CIDA Building Specifications and Conditions of Contract documents to adequately include SBC/Low Carbon provisions in the proposed building code for Sri Lanka. **Action 2.7:** Include SBC/Low Carbon provisions to LGA by-laws related to construction. **Action 2.8:** Setting a 2050 vision for incorporating SBC and Low-carbon provisions to the existing policy and regulations operating under key stakeholders – eg. CIDA UDA	Medium Term Long Term
No incentives for builders or house owners to adopt Green Building / SBC	**Action 2.9:** Develop a Green Financing process for housing, in collaboration with the Ministry of Construction, CIDA, UDA, Commercial Banks, Chamber of Construction Industry, NHDA, GBCSL and UNEP. **Action 2.910:** Explore the feasibility of providing tax rebates by LGAs for individual houses and apartment projects with sustainable and low-carbon features.	Medium Term

4.3. Action Area 3: Building Renovation and Decommissioning

4.3.1. Baseline and Enabling Environment

This section looks at the current status and availability of information on structural maintenance, renovation and decommissioning of houses and residential buildings in Sri Lanka. There was no accessible data on the maintenance or decommissioning aspects of any type of residential buildings – ie. individual houses, low-come housing projects or luxury apartments. Therefore, the information and analysis in this section is mainly based on Key Informant Interviews.

Building maintenance and renovation: Maintenance work of individual houses happens predominantly through small-holder builders and informal crafts-persons[48]. There are no regulations governing renovation or maintenance individual houses. The Common Amenities Board (Amendment) Act of 2003 makes it mandatory to formally manage maintenance of the building through a condominium committee in apartment buildings. However Condominium Management Authority of Sri Lanka does not have a mechanism to monitor this process. Low-income housing schemes are managed by UDA and NHDA. These buildings have a management office on site, and maintained for a limited time period by the government, before handing over to residents' committees. Therefore, there are no reliable data sources on actual scale, or frequency of building renovation activities and the building material demands for them. Non-residential public buildings such as schools and hospitals have maintenance procedures managed by the relevant national or provincial agencies. Comprehensive records are kept by agencies on maintenance work, often at district or local levels. However, there is no mechanism to integrate this data across agencies and make it accessible.

Building demolition and disposal: No formal data exists about the number of buildings fully or partially demolished or the volumes of debris generated in Sri Lanka. Demolition work is done mainly by informal private contractors and unskilled worker gangs (even in most formal contracts), causing noise, vibration and dust pollution. The "Construction Green Guide[49]" (CIDA), and "Technical Guidelines on Building Demolition Work in Sri Lanka[50]" (NBRO) give better practices for safe and environmentally responsible demolition, but are not legally binding. Usually a house in Sri Lanka is demolished or overhauled in about 50 years[51] from construction. Also a large number of buildings are demolished or scheduled for demolition due to slum-eviction and land acquisition for infrastructure projects. According to the UDA, 68,812 low-income families are to be relocated to apartments and their current dwellings demolished in the coming years.[52] Construction of Southern Expressway from Colombo to Galle impacted more than 4000 households in varying degrees.[53] There is no permit requirement to demolish a building or transport the debris, but disposal is bound by solid waste related regulations. Demolition debris is commonly disposed at municipal landfills, by giving a tipping fee to the council. There is also demand for debris from construction projects to be used as filling materials. Illegal dumping of demolition debris for filling of wetlands is also widely reported in the media. Few initiatives have been taken to recycle demolition debris and construction work,

[48] Key informant interviews
[49] Construction Green Guide – Construction Industry Development Authority 2020
[50] Technical Guidelines on Building Demolition Work in Sri Lanka – National Building Research Organization
[51] Key informant interviews
[52] Urban Development Authority - https://www.uda.gov.lk/urban-regeneration-programme.html
[53] Sharni Jayawardena. 2012. Right of Way: A journey of resettlement. Colombo: Center for Poverty Analysis (CEPA)

such as a pilot construction and demolition waste initiative, a pilot recycling plant (COWAM Centre) in Galle[54]. However, these are very small compared to the scale of demolition and construction waste generation.

The analysis using the RE-CCAT tool showed that opportunities for SBC during the Operation and Maintenance (O&M) and Decommissioning phases for the construction project lifecycle were very low in all enabling domains both in terms of current status and effectiveness (See Fig 4.4). The only enabling domain where current status offered some level of opportunities for SBC was in "Knowledge and Technical Resources."

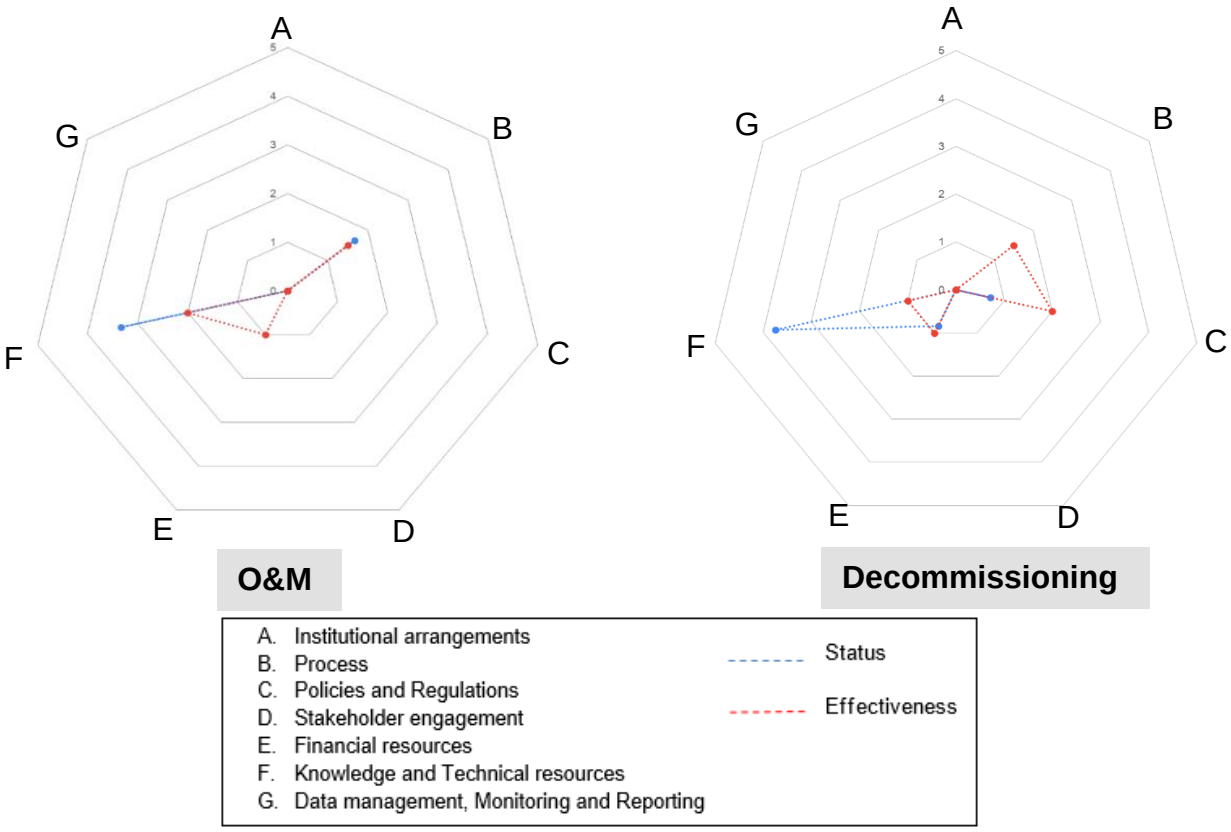


Figure 4.6: RE-CCAT Analysis for stages pertaining to Building Renovation and Decommissioning

4.3.2. Projection 2050

- Lack of data makes it difficult to make any form of reliable projections about resource requirements for structural maintenance and renovation of houses or commercial high-rise buildings. Therefore, carbon emissions due to renovation or maintenance also cannot be estimated in a reliable manner.
- Similarly, it is difficult to estimate the volume of debris generated in demolition. However, based on a 50-year life span expressed by the key informants, it can be assumed that the total housing stock that existed in year 2000 would have undergone full or partial demolition by 2050. Therefore, if we assume a factor of 75% of full demolition; 3,253,284 housing units that existed in 2000 will be demolished by 2050. Based on the median

[54] Karunasena, G., Rameezdeen, R., Amaratunga, D. (2012) 'Post-disaster C&D waste management: The case of COWAM project in Sri Lanka', Australasian Journal of Construction Economics and Building, Conference Series, 1 (2) 60- 71 6

house size of 750 sq ft (sq m), this will generate about 621 million cu m of demolition waste[55] from the housing sector alone (from 2000 to 2050).

- It is difficult to estimate a general value for per unit carbon emission in building demolition (ie. CO^2 emissions per cubic meter of demolition debris generated) as it differs widely according to many factors such as building type and location. However, it is established that an average 35 kg of CO^2 emissions per square foot of a building can be saved by renovating instead of demolishing[56] it i.e. about 30 tons of CO^2 eq. per 750 sq.ft. median house size in Sri Lanka. Therefore, renovating 50% of the 3,253,284 houses to be demolished by 2050 will save 48,799,262 tons of CO^2 eq. 2000-2050.

4.3.3. Challenges and gaps

1. Lack of any reliable data on renovation and demolition of buildings remains the most significant challenge for planning, regulating or policy making.
2. Absence of any regulations applicable to demolition of buildings. Enforcement of construction waste management regulations is very poor, which leads to environmental issues.
3. No circular economy plan for a sustainable/low carbon maintenance and decommissioning regime of buildings.
4. There is a gap in skills both at professional and craft level to implement guidelines for safe demolition of buildings as they have not been published by government agencies.
5. Facilities for recycling of demolition debris are highly inadequate compared to the scale of debris generation and require vast improvements.

4.3.4. Actions and goals

Table 4.4: Action and Goals for Building Renovation and Decommissioning

Challenge/Gap	Action / Goal	Timeframe
Absence of a monitoring/ data collection and regulatory mechanism on renovation or demolition of buildings	**Action 3.1:** Introduce and enforce regulations for demolition of buildings and disposal of construction waste and develop a 2050 vision for a circular economy plan for building maintenance and demolition. **Action 3.2:** Introduce a Green Building certification scheme for building maintenance, renovation and demolition (similar to LEED for Operation and Maintenance). **Action 3.3:** Physical and technical capacity building of LGAs to ensure the new/existing regulations for renovation, demolition and disposal are enforced.	Medium term
Develop professional and craft level skills for safe and sustainable building demolition and recycling debris	**Action 3.4:** Develop awareness and training programs for planning and execution of sustainable and safe demolition and debris recycling for engineers and architects, and craft level training through agencies such as CIDA, NBRO, CHPB, and CETRAC. **Action 3.5:** Introduce standards for materials produced from recycled C&D waste (SLSI) and a grading system for demolition companies (CIDA).	Short Term
Inadequate facilities for construction and demolition waste recycling	**Action 3.6:** Financial support to LGAs to establish C&D waste recycling plants at their waste management facilities **Action 3.7:** Public-Private Partnerships for C&D waste recycling	Medium term

[55] Debris Estimating Field guide 2010 – FEMA Available at https://www.fema.gov/sites/default/files/2020-07/fema_329_debris-estimating_field-guide_9-1-2010.pdf
[56] New Tricks with Old Bricks – BSHF & EHA Available at https://world-habitat.org/wp-content/uploads/2016/03/New-Tricks-with-Old-Bricks1.pdf

4.4. Action Area 4: Building Operations

4.4.1. Baseline and Enabling Environment

This section covers status of energy, thermal comfort and other building services in Sri Lanka and building designs to optimise these services. Located near the equator, Sri Lanka has a tropical climate with high temperature and relatively high humidity levels. The need of having a thermally comfortable living environment is a must in these conditions. Further the wear and tear and maintenance requirements due to humid and dusty conditions is high.

The routine operations in residential buildings include regular cleaning of windows, interior cleaning, painting, and weatherproofing of exterior walls, cleaning of septic tanks, repair and replacement of electrical wiring and fixtures and plumbing operations. In large scale buildings additional operations may take place such as regular servicing of air conditioning systems, safety systems i.e. fire and burglar alarms. At present in Sri Lanka, most operations especially in single houses, are conducted in an informal manner by individual tradespersons, with the exception of services such as air conditioning, fire safety systems and wastewater systems maintenance in high-rise residential buildings. Hence the data availability is low and there is no adherence to specific quality standards.

Sri Lanka Sustainable Energy Authority in their Guideline for "Sustainable Energy Residences in Sri Lanka" highlights the importance of using different "passive design strategies" in building construction which will increase the indoor thermal comfort and reduce the equipment/energy usage, subsequent operation and maintenance requirements. According to the guideline instead of using energy intensive appliances (such as air conditioning systems and fans) different strategies can be used[57]. Design strategies such as orienting the building in correct direction, having sufficient ventilation channels, thermally insulating roofing materials can be used to reduce the hours of usage of these appliances.

Some commercial buildings in particular those related to hospitality industry are using international level certifications such as LEED and EDGE in Sri Lanka, but the practice of using these in the housing sector is very low. Several international studies have shown considerable energy saving can be obtained during occupancy if these guidelines are used during construction[58]. There are two main local Green Building certifications issued under the GBCSL -green certification, and the "Neela Haritha" by the UDA. The middle-income housing projects implemented by the Government has implemented the Neela Haritha standards in their design.

4.4.2. Projection 2050

- No specific studies are available to project the trends in building operations in the future. Current practice of residential building design is more oriented towards outward appearance. Operational aspects, thermal comfort and other services are rarely considered. If this trend continues it can be predicted that the maintenance and service requirements of buildings will keep increasing (e.g. frequent usage of cooling systems,

[57] Code of Sri Lanka energy efficiency building 2020, SLSEA– available at -http://www.energy.gov.lk/images/resources/downloads/draft-eebc-2020.pdf

[58] LEED certified buildings in Sri Lanka -http://www.gbig.org/search/advanced?search%5Bflat_rating_program_ids%5D=Certification&search%5Bplace_ids%5D=694

frequent repairs due to usage of sub-standard products). Effective and efficient building operation and maintenance in terms of cost and environmental impact, could be achieved if sufficient consideration is given at the design and construction stage.

- With a linear estimate of 8.4 million housing units by 2050, the operation and maintenance requirement of buildings will increase. In order to benefit from available space and provide services efficiently the housing units are made smaller. While this will enable the required operations, services and maintenance to be provided efficiently, the lack of effective design considerations might make operation and maintenance activities difficult due to lack of space requiring sophisticated equipment to carry out a task or replacing items/equipment, instead of repair and thus resulting in an increase in carbon emissions related to the activities.
- Another major service that is predicted to expand in the future is the connection of current stand- alone septic tanks into centralized sewer treatment systems in urban areas. Many of the current peri-urban locations are projected to be classified as urban in the coming decades. The environmental costs and carbon emissions of building, operating and maintaining these sewer systems can be minimised if proper design considerations are made now.

4.4.3. Challenges and gaps

1. Incorporating O&M considerations at the design stage is very low, resulting in higher O&M costs during occupancy. Poor coordination between building designers/architects and building operation service providers especially in the housing sector.
2. Lack of skills and expertise in using existing Sustainable Building Design Guidelines (SBDG): both UDA and SLSEA have developed SBDG's with health, comfort and energy efficiency to reduce operation and maintenance cost, but there are few experts and skilled workers capable of implementing these guidelines.
3. Lack of regulatory provisions for residential buildings to use SBDG guidelines.

Actions and goals

Table 4.5: Action and Goals for Building Operations

Challenge/Gap	Action / Goal	Timeframe
Lack of interaction between designers and operation service providers.	**Action 4.1:** Conduct continuous awareness creation on the subject (including integration to syllabi) at different levels and platforms to interact, between various stake holders (UDA, SLSEA, CIDA, Architects Institute) **Action 4.2**: Simple regulations to be developed indicating the involvement of a service provider at design stage (LGA level guidelines).	Short term Medium term
Low regulatory drive for residential buildings to use SBDG guidelines	**Action 4.3**: All houses/residential buildings in urban and peri urban areas to be built following the SBGs (UDA, MC & LGA's).	Medium term

Challenge/Gap	Action / Goal	Timeframe
Low regulatory drive for residential buildings to use SBDG guidelines	**Action 4.4**: Develop guidelines and standards for building operations and maintenance and development of maintenance plans for all types of residential buildings and provide training to non-formal sector service providers on the same. **Action 4.5**: Smart and sustainable building guidelines (SGB) need to be upgraded to account for different types of residential building types (e.g. apartment buildings, attached houses, houses with garden areas and without, houses within limits of LA based services and without LA based services, different climatic zones), with a value assessment tool developed for each type, enabling occupants to compare the life cycle cost versus current cost. Integration of cultural and religious practices together with scientific methods especially in residential buildings is an essential factor in achieving this success (UDA, SLSEA, GBCSL).	Long term
Lack of skills and expertise in using existing sustainable building design guidelines (SBDG)	**Action 4.5:** Sufficient actors/service providers with required knowledge and skill to be trained and made available at LA level to serve building owners, residents. (CIDA through Provincial Engineering Departments) **Action 4.7**: Conduct awareness creation and capacity building programs for building occupants on sustainable and efficient practices of occupancy resulting in energy saving. (SLSEA, Media, Ministry of Environment, SLEMA, SLIA, GBCSL).	Short/ Medium

4.5. Action Area 5: Appliances and Systems

4.5.1. Baseline and Enabling Environment

This section covers the current usage, resource requirements and efficiency of different household equipment and building services systems. Household appliances are used as tools for providing various services required by a household. These include cooking, thermal comfort, water supply, cleaning and entertainment. Most of the appliances use electricity as the main energy source. Biomass although used for cooking purposes only represent a higher share of the domestic energy usage.

Data derived from the national energy balance from 2011 – 2019 reveals that the average electricity usage per meter has been increasing in the country, mainly due to the increase in the number of appliances used in households which is related to the increasing per capita income of the country[59]. It is also important to note that Sri Lanka has achieved reasonable living standards with low energy usage when compared with global and regional averages[60]. Table 6.2 indicates the trend in the increasing number of household connections in Sri Lanka.

Table 4.6: Trends in increasing number of household connections in Sri Lanka - National energy balance 2012-2019

	2011	2012	2013		2016	2017	2018	2019
Domestic electricity demand (GWh)	3928.4	4062.9	4078.3		4810.6	5063.7	5230.9	5523.7
Average electricity price	13.21	15.56	17.93		16.18	16.26	16.29	16.63
Domestic meters	4165738	4391445	4589929		5243433	5425060	5543137	5651452
Units per month per meter	78.57	77.08	74.04		76.45	77.7	78.63	81.44

Considering the increasing trend of electricity usage per meter (household) and the predictions on the impact of global warming, it is evident that the business-as-usual scenario in household energy usage will be of critical concern impacting the balance of trade, energy supply issues and the overall emission targets of the country.

Household appliances and services are mostly regulated as consumer products, looking at the benefits and demand of the individual consumer but in the recent past efforts have been made by the government to regulate the quality and standard of appliances by looking at environmental concerns and energy efficiency[61].

Following table lists out the key regulations/guidelines regarding appliance labelling and standardization in the country:

- The SLSEA has developed energy performance standards for compact fluorescent lamps, fluorescent lamp ballasts, LED lamps, electric motors, refrigerators, room air

[59] Sri Lanka Energy Sector Assessment – Strategy and Road map, available at https://www.adb.org/sites/default/files/institutional-document/547381/sri-lanka-energy-assessment-strategy-road-map.pdf

[60] Consumption based CO2 emissions per capita vs Human development index, available at https://ourworldindata.org/grapher/per-capita-co-emissions-vs-human-development-index

[61] Introducing standards SLSEA, available at https://www.energy.gov.lk/index.php/en/energy-management/introducing-standards

conditioners and computers enabling users to make an informed decision during designing and purchasing[62].

- Sri Lanka ratified the Montreal Protocol in 1989 and completely phased-out high-ODP CFCs in 2008, two years ahead of the schedule. HCFC phase-out is also underway and HCFCs will be phased out of the Sri Lankan market by 2030 [79].
- Sri Lanka Standards Institution - code of practices for setting up biogas plants at household level as a mode of cooking energy production and waste management. SLS 1292 Part 1[63]
- The "anagi" clay pot stove- standardized under: SLS 1475/2013 for Two Pot Clay Cook stoves (TPCCS).[64]
- A practitioner's guide has been developed for rain water harvesting by the Lanka Rain Water Harvesting Forum[65]

There are no strict regulations pertaining to disposal of household appliances, studies conducted by PUCSL has revealed that with the increase in average income of households the number of electrical and electronic appliance usage is increasing drastically, while the lifetime of these appliances is reducing due to changing market demand and trends. Hence the amount of appliance waste coming out of households are increasing[66]. This is a critical area of concern in addition to the increase in energy usage due to household appliances.

4.5.2. Projection 2050

- Based on the prediction in expected number of households by 2050 and the energy usage per meter; the electricity usage in the housing sector (assuming 100% electrification) and using same grid emission factor as in 2019, the figures will be as follows:

Table 4.7: GHG Emissions from Electricity Usage in 2030-2050

	No of Housing units (no)	Average Electricity usage (kWh/month)	Annual electricity usage (GWh/Year)	Related emissions ($kTCO^2e$/ Year)
2030	6,400,000	95	7310	5412
2050	8,200,000	120	11826	8755

- The Study conducted by PUCSL reveals that a house consuming less than 60 kWh/month will have on average 6 electrical appliances, whereas a house consuming between 120-180 kWh/month will have 32 appliances. With the expected increase in the average electricity usage, majority of the houses will be using more than 95 kWh/month by 2030 and more than 120 kWh/Month by 2050 thus resulting in very high increase in the overall electrical appliances used in the country. Based on the business-as-usual scenario.

[62] Appliance Energy Labelling Programme – Sri Lanka Sustainable Energy Authority - http://www.energy.gov.lk/index.php/en/energy-management/labelling-programme
[63] Biogas standards – (SLS 1292) - https://www.slsi.lk/index.php?option=com_slstandards&view=search_standards&Itemid=436
[64] Anagi clay pot Standard– (SLS 1475) - https://www.slsi.lk/index.php?option=com%20%20slstandards&view=search_standards&Itemid=436
[65] Rain Water Harvesting Practitioners Guide for Sri Lanka - http://www.lankarainwater.org/books-and-reports/
[66] Electronic waste management in Sri Lanka, available at http://www.auditorgeneral.gov.lk/web/images/audit-reports/upload/2016/performance_2016/e_waste/Electronic-Waste-Management-in-Sri--Lanka----Performance-and-Environmental-Aiudit-Report_1-E.pdf

- Estimating that by 2030 more than 50% of the houses will be using more than 95 kWh/month and thus using 10 appliances, and in 2050 more than 50% of the houses will be using more than 120 kWh/month and thus using 32 appliances; the increase in number of electrical appliances is given below, along with the resultant electrical/ electronic waste generation (assuming 10% of these items will be discarded annually).

Table 4.8: Average annual discarding Quantity of Appliances

	No of houses using more than average electricity usage	No of Average Appliances	Total increase in Appliances	Average annual discarding Quantity (10%)
2030	3,200,000	10	32,000,000	3,200,000
2050	4,100,000	32	131,200,000	13,120,000

These figures reveal that it will be extremely important for the country to promote and educate the stakeholders in SBC practices to avoid usage of unnecessary appliances through smart design practices in order to achieve NDC and SDG targets and avoid facing an energy supply and waste management crisis.

4.5.3. Challenges and gaps

1. Lack of studies on effective use of appliances (SC&P) practices: there are insufficient local level studies and research carried out to convince the stakeholders that smart design practices will reduce the energy and appliance usage at occupancy stage of a building.
2. Lack of knowledge of the inter linkage between appliance requirement and initial design considerations, and designers not being able to relate to the link between appliance/energy usage during occupancy and initial design considerations.
3. Product standardization and guidelines for performance has been taken up in the country by the relevant regulatory bodies yet lack of resources has limited the application.

4.5.4. Actions and Goals

Table 4.9: Actions and Goals for Appliances and Systems

Challenge/Gap	Action / Goal	Timeframe
Lack of studies on effective use of appliances (SC&P) practices	**Action 5.1:** Conduct research and detailed studies using data specifically from buildings that practiced SBDG pertaining to appliance usage and measure the impact (National Universities, SLEMA)	Short term
Lack of knowledge on interlinkage of appliance requirement and initial design considerations.	**Action 5.2:** Training and capacity building of stakeholders on improving housing design in order to reduce future appliance requirement and energy usage (CIDA, UDA, SLSEA, provincial engineering departments, national universities, SLEMA), use existing guidelines from UDA, GBCSL and SLSEA as starting points. NHDA, UN-Habitat and similar entities to provide knowledge and know how.	Medium term
Product standardization	**Action 5.3** Increase the number of appliances that needs to be energy related and standardized based on importance. **Action 5.4** Increase awareness among stakeholders on using energy efficient standard appliances. **Action 5.5** Develop tools and methods to identify and optimize energy efficient appliances b ased on the type and cluster of building.	

4.6. Action Area 6: Materials

4.6.1. Baseline and Enabling Environment

This Action Area provides the baseline information for building material management in Sri Lanka in aspects such as extraction, manufacturing, usage and disposal. A large variety of vernacular, conventional and advanced building materials are used in the Sri Lankan construction industry. Some of the most commonly used materials include[67]:

Structural material	Ordinary Portland Cement (OPC), river sand, stone/metal for concrete and rip-rap (mainly hard metamorphic rock types such as gneisses), steel reinforcement bars (mild and yield steel, 6mm -16mm diameter)
Wall material	Burnt clay bricks, cement blocks (solid and hollowed)
Roofing and carpentry	Timber (mainly tropical hardwoods and coconut timber), clay roofing tiles, asbestos cement sheets, corrugated galvanized iron (CGI) roofing sheets, zinc-aluminium roofing sheets
Finishing	Plate glass, lime-based paints, emulsion and enamel paints, glazed ceramic floor and wall tiles

Key informant interviews indicated a steady decline of vernacular materials such as wattle and daub (Varichchi) construction, cadjan/palm thatch for roofing, and mud bricks, from the 1980s. However, coconut timber which was a vernacular material has been successfully adapted to modern housing construction, with chemical treatment. Some advanced building materials (eg. concrete related chemicals, advanced adhesives, aluminium sections and toughened glass) have been introduced, but the use is limited to high-value buildings.

There is no central database for sourcing, production, import, and export of building materials. It is extremely difficult to track the supply chain of most building materials. Common building materials are mostly extracted or manufactured in-country (e.g. sand, rock, clay, soil, burnt clay bricks, cement blocks, and clay roofing tiles). Cement, timber, floor/wall tiles, and reinforcement steel are both sourced locally and imported. Materials such as plate glass and almost all advanced building materials are entirely imported. Estimates indicated that sand consumption in Sri Lanka stood at 50 million cubic meters as of 2020[68], cement consumption was about 7-8 million metric tons (2020), of which 66% was imported and timber consumption was around 1.6 million cubic meters per annum (2020) where more than 10% is imported[69].

Price inflation of building materials have been generally high in the last three decades. For example, yearly average price increase between 1990 - 2020 of cement, sand and steel, had been 18%, 118%, 22% respectively[70]. Some periods saw a sharp increase in building materials, where prices were most volatile. Due to the economic crisis 2021-22 price of cement and sand has increased 206% and 77% respectively, in less than 12-months.

Sri Lanka has long standing governance systems for building materials management with multiple government agencies mandated to manage various aspects (see Table A2 for details):

[67] Based on interviews
[68] Construction Industry Development Authority Data
[69] Central Bank of Sri Lanka - Economics and Social Statistics in Sri Lanka – 2020 Report, Available at https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/statistics/otherpub/ess_2020_e1.pdf
[70] Construction Statistics July 2022 - Construction Industry Development Authority

Geological Survey and Mines Bureau (GSMB) – permitting of mineral extraction

Divisional Secretariats – permitting of timber felling and transport

Ministries of Industries and Labour – building material manufacturing

Sri Lanka Standards Institute (SLSI) – quality control and standardisation

Construction Industry Development Authority (CIDA) – preparation of specifications

Central Environmental Authority (CEA) – pollution control

Consumer Affairs Authority – retail sales and product safety

Building material extraction and production has acute environmental degradation issues in Sri Lanka. Principle among them is river sand mining, which has caused impacts such as river bank erosion, sea erosion, ground water drawdown and salinity intrusion, which are particularly catastrophic, and now affecting every major river system[71]. Key informant interviews noted that illegal felling of trees for timber has significantly contributed to the degradation of protected forests and given rise to soil erosion and landslides. Building material manufacturing is also one of the major contributors of GHGs in Sri Lanka. The cement manufacturing alone emits about 3 million tons of CO^2 annually (2019)[72].

Sustainable materials: Compressed Stabilized Earth Blocks (CSEB) have been available for many decades (see Table A5 of Annexes for more details on currently used sustainable materials). Research on sustainable materials is conducted by the NERD Centre, NBRO and in all recognized engineering schools. Interviews showed that there is a growing market trend to use resource efficient building materials and techniques such as pre-cast / prefabricated concrete components. Green Building Council of Sri Lanka has a Green Labelling system GreenSL) for selected types of building materials, considering all stages of material lifecycle in the assessment criteria. CIDA has also published an environmental guide for building materials[73] which helps the construction industry professionals to sustainably select, use and dispose building materials. However, the existing building material standards or the building specifications published by SLSI and CIDA do not consider environmental criteria, which remains a major barrier for mainstreaming sustainable materials.

The RE-CCAT analysis showed that there is much to be improved in all enabling environment domains for building materials management in Sri Lanka. While the existing “Knowledge and Technical resources” and “Policy and Regulations” provided moderate opportunities for SBC, other domains such as “Institutional arrangements” and “Financial resources” remained weak.

[71] Ratnayake, R. Rivers and mining- Boon or Bane? (2008). Available at: http://lankajalani.org/wp-content/uploads/2017/04/RSM-English.pdf.

2[72] 3.4 million metric tons of cement produced in Sri Lanka (2019) multiplied by global average CO^2 emission rate of 0.85 tons of CO per ton of cement produced.

[73] Hettiarahchi M., Van Breda A., Fonseka C., Priyanvada A.K.M., and Amarasekara, S. 2018. Environmental Guide for Construction Materials and Products. Colombo: Construction Industry Development Authority (Government of Sri Lanka). 23 pp

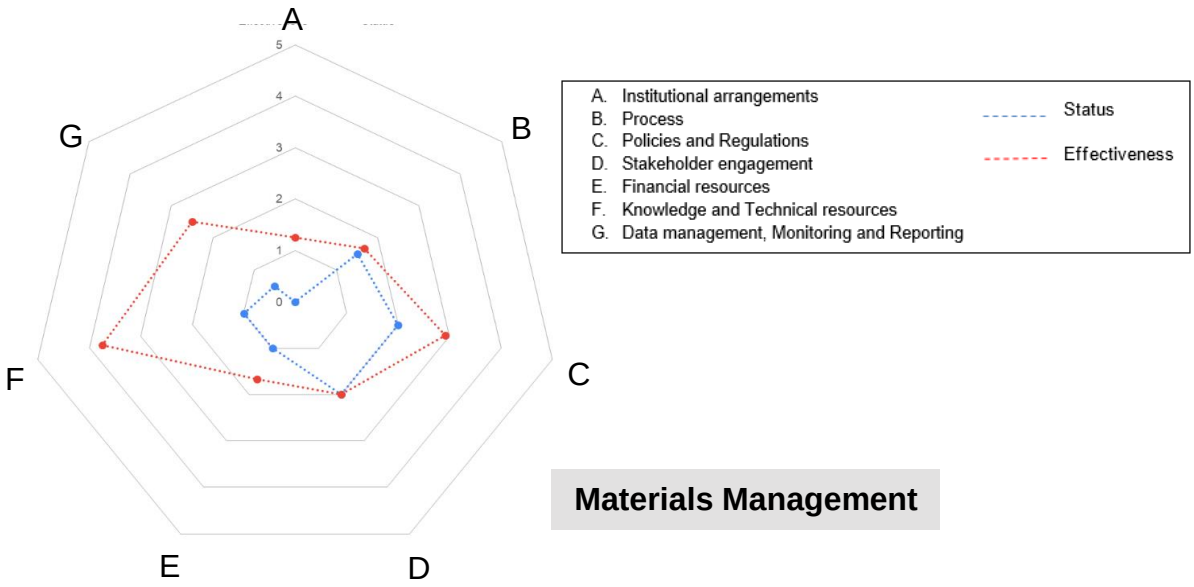


Figure 4.7: RE-CCAT Analysis pertaining to materials management

4.6.2. Projection 2050:

- Very approximate projections could be made on the demand for cement, sand and timber based on past demand. Also projected demand for housing was calculated for the same materials based on the projected increase of housing units 2020-2050 (Table 4.10A). Table 4.10B gives summary of domestic extraction of some common construction minerals including historical extraction data and projections up to 2050.

Table 4.10 A: Materials Projection Data (*Source: Author calculation*)

Material	National demand		Housing sector	
	2020	2050	Demand 2020-2050	CO^2 emissions 2020-2050 (tons x106)
Cement (million mt)[74]	8.5	20.0	23.7	30.4
Sand (million mt)[75]	43.0	100.1	82.5	1.2
Timber (million cu.m)[76]			6.5	7.7
Bricks (million nos)[77]	n.a	n.a	23,750	17.3
Cement blocks (million nos)[38]	n.a	n.a	3,100	8.3

[74] National cement demand for 2030/2050 projected by a linear forecast based on 2000-2019 (Central Bank of Sri Lanka Data). Cement demand for housing calculated based on typical cement requirements for 750 sq. ft. brick and cement block houses. Per brick house – 10.13 tons of cement; per cement block house – 13.58 tons of cement. As per 2012 national census 53% of the houses were brick and 34% were cement block. CO2 values based on EPIC database - https://msd.unimelb.edu.au/research/projects/current/environmental-performance-in-construction/epic-database

[75] National demand of sand was calculated using cement demand as a proxy – sand demand by wt. = cement demand by wt. x 5. Sand demand for housing calculated based on typical sand requirement for 750 sq.ft. brick and cement block houses. Per brick house – 42.5 tons of sand; per cement block house – 37.5 tons of sand.

[76] Sri Lanka Production: Timber: Other Logs, 1997 - 2015 - Department of Census and Statistics Available at https://www.ceicdata.com/en/sri-lanka/production-by-commodity-annual/production-timber-other-logs

[77] Brick and cement block demand based on - 19,187 bricks per750 sq.ft. brick house, 2,500 cement blocks (8 inch/ 4inch) per750 sq. ft. cement block house

Table 4.10 B: Current and projected rates of construction mineral extraction in Sri Lanka (*Source: Author calculations using data from Geological Survey and Mines Bureau – Sri Lanka*)

	Year	Silica Sand (Tonnes)	River Sand (Cubic Meters)	Sea Sand (Cubic Meters)	Lime Stones (Tonnes)	Dimension Stones (Tonnes)	Gypsum (Tonnes)
Actual Data	2005	46,070	N/A	N/A	1,094,919	4,117	548
	2010	67,606	4,829,840	6,741	1,191,629	3,433	104
	2015	65,195	9,330,000	99,148	1,270,065	1,907	1,120
Projection Data	2020	58,738	14,128,881	4,117,416	1,397,947	2,478	2,052
	2025	56,906	17,533,394	6,059,050	1,506,136	2,042	2,781
	2030	55,074	20,937,908	8,000,684	1,614,326	1,607	3,510
	2035	53,242	24,342,421	9,942,317	1,722,516	1,171	4,239
	2040	51,410	27,746,934	11,883,951	1,830,706	736	4,968
	2045	49,578	31,151,448	13,825,585	1,938,896	300	5,697
	2050	47,746	34,555,961	15,767,218	2,047,085	N/A	6,427

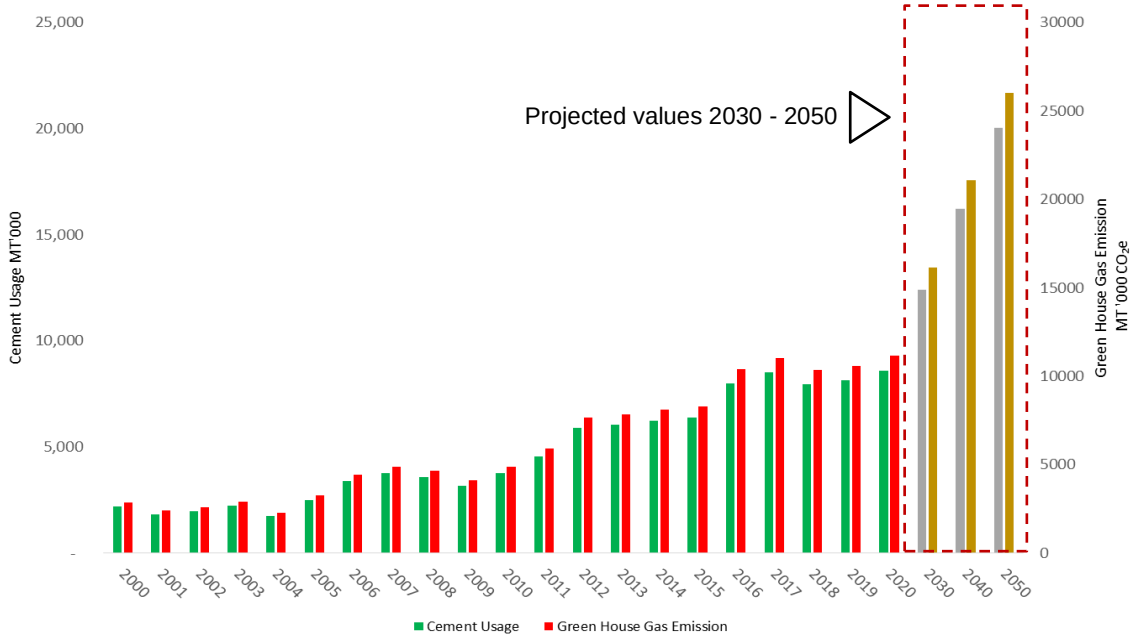


Figure 4.8: Projected increase in cement use (Source: Author calculations)

4.6.3. Challenges and gaps

1. No regular data collection or management process on building material extraction, manufacturing, or trade. Records exist for certain aspects of limited number of materials (e.g. cement imports/manufacturing, sand mining permits, timber production), but they are not integrated into a central database.
2. No mechanism to assess and review the building materials demand, local availability, sustainable extraction rates, import requirements and potential environmental impacts/ carbon emissions. This is a major challenge for systematic planning of building materials management in Sri Lanka, including sustainable and low carbon construction.

3. Though there are some initiatives to introduce, certify and conduct research on sustainable building materials, financial resources and funding should be substantially increased to mainstream these materials.
4. Existing building material standards and building specifications do not adequately cover sustainability criteria and innovative material use.
5. Poor enforcement of regulations to control environmentally harmful and illegal practices related to building material extraction or manufacturing.
6. Lack of awareness and practical experience among end-users (individual house owners, investors) and construction practitioners about sustainable materials, and their use.
7. Lack of financial incentives, high initial investment requirements, poor demand, high competition from conventional materials and regulatory restrictions make it difficult for producers of sustainable and low-carbon materials to enter the market.

4.6.4. Actions and goals

Table 4.11: Actions and Goals for Materials

Challenge/Gap	Action / Goal	Timeframe
No regular data collection/ management process on building material extraction, manufacturing, or trade No mechanism to assess/review the building material demand, availability, and other sustainable concerns	**Action 6.1:** Establish a central database to collate building material related data including mining permits (GSMB Minerals Year Book), timber permits (District Secretariat), and manufacturing/ import/export data (CBSL/ Ministry of Industries). **Action 6.2:** Construction Ministry led committee to annually review material demand, availability, price and environmental issues along with CIDA/GSMB/CEA/NBRO/UDA/ Ministry of Finance. Develop an annual plan for sustainable sourcing and production of building materials.	Short Term Short Term
Existing building material standards and building specifications do not contain adequate sustainability criteria Absence of accepted carbon calculator customized for construction in Sri Lanka	**Action 6.3**: Develop or adapt a carbon calculator for construction work in Sri Lanka **Action 6.4:** CIDA to review the existing building specifications (including the upcoming building code) and incorporate sustainability/low carbon criteria **Action 6.5:** SLSI to review the existing building material standards and incorporate sustainability/ low carbon criteria, in line with international initiatives.	Medium Term Short Term Medium Term
Lack of funding for developing, manufacturing and mainstreaming sustainable building materials, including training at both professional and craft levels.	**Action 6.6:** Government budgetary allocation, exploring external funding sources (including climate finance) and Public Private Partnerships for research and piloting sustainable material. **Action 6.7:** Exploring the possibility of providing tax rebates for local manufacturers of sustainable materials. **Action 6.7:** Communication and awareness campaigns on sustainable / low carbon materials	Medium term

4.7. Action Area 7: Resilience

4.7.1. Baseline and Enabling Environment

This section looks in to the impacts of natural and man-made hazards on residential buildings in Sri Lanka and current provisions to improve built-environment resilience. Sri Lanka experiences many natural and man-made hazards that often turn into disasters driven by community and institutional vulnerabilities. Most commonly experienced hazards in Sri Lanka are: floods, landslides, droughts, cyclones, coastal erosion, lightening, human induced fires and pollution related hazards. According to the INFORM Risk Index, Sri Lanka ranked 97th out of 191 countries with moderate disaster risk levels[78]. For example, 59,000 people were annually affected by river flooding (in 2010), with an annual impact on GDP estimated at $267 million. Average annual direct losses from disasters is approximately $140 million per year (2014)[79]. Development pressures and climate change are both likely to cause an increase in these figures. Sri Lanka is recognized as highly vulnerable to climate change impacts, ranked 100th out of 181 countries in the 2017 ND-GAIN Index[80].

Poor planning and design of buildings is a key contributing factor to disaster vulnerability of communities. Informal buildings and poor maintenance also make the communities more vulnerable to disaster. For example, 2016 flooding in the Kelani river watershed fully or partially damaged more than 4000 houses[81], most of which were in poor maintenance conditions in low-income areas.

The Disaster Management Act (No. 13 of 2005) governs all disaster related issues in Sri Lanka, while the Disaster Management Centre (DMC) overlooks disaster response as well as risk reduction, along with agencies such as Irrigation Department and Coastal Conservation Department. There are disaster Preparedness Plans developed at district, division and village levels. Disaster resilient planning and mainstreaming DRR into development has been identified as an objective of DMC in these plans[82]. The National Building Research Organization (NBRO), in the past three decades, has developed guidelines for built environment resilience, including developing a Hazard Resilient Housing Construction Manual and Guidelines for schools and other public buildings[83]. NBRO is also developing hazard and risk maps for various hazards. NBRO also designates areas with landslide risks as “landslide prone”, and since 2011, any development permits (by Local Governments) in landslide prone areas require concurrence of NBRO.

These are encouraging developments towards planning for built environment resilience in Sri Lanka. However, the mechanisms to implement or enforce these technical guidelines and regulations remain very poor. Lack of provisions to monitor the quality during construction and absence of data about the status, and maintenance of existing buildings makes ensuring built environment resilience extremely difficult.

[78] European Commission (2019). INFORM Index for Risk Management. Sri Lanka Country Profile. URL: https://drmkc.jrc.ec.europa.eu/ inform-index/Countries/Country-Profile-Map
[79] Climate Risk Country Profile: Sri Lanka (2020): The World Bank Group and the Asian Development Bank.
[80] Notre Dame Global Adaptation Initiative – University of Notre Available at https://gain.nd.edu/our-work/country-index/
[81] Sri Lanka: Floods and Landslides - May 2016 – OCHA. Available at https://reliefweb.int/disaster/fl-2016-000050-lka
[82] National Disaster Management Plan - Disaster Management Centre, Available at http://www.dmc.gov.lk/index.php?option=com_content&view=article&id=74&Itemid=236&lang=en#future-upgrading-of-the-plan
[83] Hazard Resilience Housing Construction Manual – National Building Research Organization, Available at https://drive.google.com/file/d/1o3iVz0y4g4c9e2Nj3UdXKR-0_WJfbqtg/view

4.7.2. Projection 2050

- Climate Projections indicate that a temperature rise of 3.2- 3.5°C under RCP8.5 scenario and 0.8-1.2°C under RCP2.6 by the 2090s[84]. This is expected to increase the frequency of extreme storms, flooding and cyclones and thereby the occurrence of landslides. A potential sea level rise ranging from 0.18 – 0.59 m by 2100, compared to the levels at year 2000 is predicted for different climate change scenarios. This would further increase the risk of flooding and coastal erosion.
- What would historically have been a 1-in-100-year flood events, could become a 1-in-50-year or 1-in-25-year events. By the 2030s, number of people annually affected by river flooding is expected to increase up to 85,000, and annual impact on GDP to $338 million[85]. During the period of 2030 to 2045, the total number of people effected by extreme flooding is estimated to be between 900,000 - 1,000,000[86].
- The impacts of extreme heat on buildings in Sri Lanka has not been properly analyzed or estimated. However, extreme temperature levels can lead to expansion cracks and faster deterioration of finishing materials, leading to increased maintenance and demolition requirements.
- Population density in Sri Lanka will peak during the period 2040-2050. This would increase disaster vulnerability in certain densely populated urban areas.
- All the above factors will substantially increase the disaster vulnerability of buildings, especially housing units between 2020 and 2050. However, certain initiatives and factors may contribute to ameliorating disaster vulnerability of housing units e.g. landslide resilient housing program conducted by NBRO where around 20,000 families are to be relocated from high landslide risk areas.

4.7.3. Challenges and gaps

1. The projected increase of extreme weather events and resultant hazards pose a significant challenge to built-environment resilience and safety of occupants and property. Understanding the impact of these extreme events on built-environment needs to be substantially improved.
2. Skills available for effectively implementing the technical guidelines and regulations for resilient building design and construction, is inadequate and needs substantial improvement
3. Lack of construction stage monitoring and absence of data about the state of existing buildings is another major challenge to built-environment resilience.

4.7.4. Actions and goals

Table 4.12: Actions and Goals for Resilience

Challenge/Gap	Action / Goal	Timeframe
Need for improved understanding about the impact of extreme climate events on built-environment	**Action 7.1:** A joint DMC/NBRO/CIDA/UDA/ Universities initiative to assess the climate threats to built-environment in Sri Lanka. Develop an action plan for built-environment disaster resilience, conforming to the National Resilience Action Plan DMC[87]. **Action 7.2:** CIDA/UDA to update urban development and construction regulations to integrate built environment resilience.	Short Term Medium Term
Inadequate skills for effectively implementing the technical guidelines and regulations for resilient building design and construction	**Action 7.3:** Develop a regular training program under CIDA/CHPB to improve awareness and skill to ensure built-environment resilience in design and construction, targeting engineers, architects, technicians and crafts persons. Include it in University / Technical College curricular.	Short Term

[84] Climate Risk Country Profile: Sri Lanka (2020): The World Bank Group and the Asian Development Bank
[85] ibid
[86] ibid
[87] Disaster Management Centre – Emergency Response Plans Available at https://www.dmc.gov.lk/index.php?option=com_content&view=article&id=86&Itemid=245&lang=en

4.8. Action Area 8: Clean Energy

4.8.1. Baseline and Enabling Environment

The action area on Clean Energy covers the current status of clean energy usage in residential buildings in Sri Lanka and provisions to convert to clean energy. Basic household needs such as preparation of food, access to water, decent living environments, health, and educational services are dependent on the availability of energy, mainly electricity. However with the interlinkage of energy with fossil fuels and ever-increasing usage of such energy directly results in an increase in global warming. Thus designing, planning, and constructing the built-environment, particularly in the housing sector, to reduce the requirement of energy usage while achieving better services and higher living conditions is of prime importance. Further, the same spaces being effectively used to generate and harness renewable energy is critical if the world is to achieve a net-zero status by 2050 while successfully achieving the SDGs.

The overall energy supply in Sri Lanka is a mix of renewable energy and fossil fuels. Key indicators of energy usage in Sri Lanka are given below, based on the Sri Lanka energy balance published by the Sustainable Energy Authority of Sri Lanka for the year 2019[88].

Table 4.13: Energy Supply in Sri Lanka

HH, Comm, Other (PJ)	2015	2018	2019
Biomass	125.2	81.8	82.7
Petroleum	15.8	25.2	25.7
Electricity	28.3	34.3	36.2
Total	169.3	141.3	144.6

The electricity demand is 24% of the household energy demand, whereas 57% of the demand is supplied from biomass which is mostly used for cooking purposes. Household and commercial sectors together are the predominant user of energy in the country closely followed by the transport sector. The energy usage in the household and commercial sectors is dominated by the cooling and heating energy requirement which is mainly supplied through biomass[89]. Existing policies and regulations related to improving RE and EE in household energy usage and demand.

Energy Tariff (penalizing excessive usage)	The energy tariff is set based on usage blocks, a lifeline limit of 60 units is given a special subsidy. The other usage blocks are categorized as (60-90, 90- 120, 120 – 180 & above 180)[90] and the unit rate is increased by the usage blocks with an effort to discourage high electricity usage. The decision is further rationalized with the argument that excessive electricity usage (demand) is met through electricity produced from fossil fuel based thermal plants hence a higher rate is applied for the supply of this excess demand.
Solar roof tops	The Government policy to promote renewable energy has allowed households to install solar panels on the rooftops and benefit from using the national grid as a virtual storage. Three options **i.** Net metering (setting off household usage from the national grid against the amount generated from the solar roof top, no financial transactions involved). **Ii.** Net accounting (setting off the household usage from national grid against units generated from solar roof top and being able to receive a monetary sum for the excess generation from CEB). **Iii.** Net plus (receiving money from CEB for the number of units generated from the Solar roof top system)[91].

[88] Sri Lanka Energy Balance - 2016, Sri Lanka Energy Balance - 2017, Sri Lanka Energy Balance - 2019
[89] Sri Lanka Energy Balance -2019, available at https://www.energy.gov.lk/images/energy-balance/energy-balance-2019-lg.pdf
[90] https://www.pucsl.gov.lk/electricity/consumer/tariff-and-charges/
[91] https://www.pucsl.gov.lk/electricity/consumer/domestic-solar-power/

4.8.2. Projection 2050

- The country's electrical energy generation is shifting towards a fossil fuel base due to the ever-increasing demand. As Sri Lanka has reached the maximum of its hydroelectric generation potential, the targets of increasing the renewable energy share in the electrical energy supply will depend on solar, wind, and other non-conventional sources. Thus, it is important to consider the potential to generate electrical energy using renewable sources at the household level (using housing infrastructure) as the land/space available for setting up systems to harness renewable energy is reducing.
- As presented in table 4.7 under action area 4.5 on appliances and systems, the household energy usage will increase up to 7000 GWh by 2030 and 11000 GWh by 2050. The change in climate conditions will require additional energy to provide thermal comfort requirements by cooling. If the number of households with a small window type air conditioner for 1 room will increase by another 100,000 (less than 2% of the total number of households in SL by 2030) the electricity demand per day will increase by 600 MWh.
- The country under its NDC obligations, aims to install 2000 MW of solar PV by 2030. Integrating housing and related building design to accommodate solar roof tops and solar hot water systems together with sufficient infrastructure and upgrading of the national electricity grid will enable achieving this target.
- Further, following SBDG advice will enable successfully integrating biogas systems, rainwater harvesting systems and biomass stoves in to housing units thus contributing to increase the RE share generated and used at household level and reducing the energy requirement for water pumping.

4.8.3. Challenges and gaps

1. Connecting Solar roof tops to the Grid: the current capacity of the national grid does not facilitate setting up roof top solar systems in certain areas. Even in areas where there is capacity, regulatory barriers (such as not being able to integrate one meter with different roofs) has slowed the process of adding RE supply in to the grid.

2. Controlling energy demand through smart design has been limited due to lack of knowledge and incentives provided to house owners who are using SBDG's, to consider the initial investment required.

3. Cooking energy demand shifts from biomass to fossil fuels as household income level rises, generally , the shift in the energy ladder will be from biomass to kerosene, to LPG and finally to electricity. However in urban areas, irrespective of the income capacity, low income households are compelled to use kerosene or LPG due to the compact nature of houses and lack of ventilation.

4. Lack of financial tools and support for house owners to make Investments in using residential infrastructure for renewable energy generation (Solar PV/ Hot water, Bio gas).

4.8.4. Actions and goals

Table 4.14: Actions and Goals in Clean Energy

Challenge/Gap	Action / Goal	Timeframe
Controlling energy demand at Household level through demand management	**Action 8.1:** Educate stakeholders on the benefits of using SBDG, provide financial and other incentives (tax relief, priority in approvals – LA level), and enforce guidelines provided by SLSEA. Enable NDC targets to be achieved on demand management	Medium / long term
Increasing solar PV and water heating roof-top systems.	**Action 8.2** Provide regulatory support to allow using roofs of different buildings under same meter (power wheeling) CEB/ PUCSL	Short term
Lack of financial and other tools as support for house owners to make investments	**Action 8.3**: Make available financial and other tools such as loans, easy payment schemes tax concessions for house owners, to enable making initial investments required for setting up RE based energy generation/energy saving systems at home including Biogas, Biomass stoves, Rainwater harvesting. (Treasury, commercial banks)	Medium term

Chapter 5: Cross-cutting challenges

The Country Assessment showed that there are major challenges in all eight Action Areas pertinent to Sustainable Building Construction in Sri Lanka – ie. Urban planning, New Buildings, Existing Buildings, Building Operations, Appliances and Systems, Materials, Resilience, and Clean Energy. These challenges also vary according to the phases of the construction lifecycle. The same challenges were further highlighted by the RE-CCAT analysis. Six challenges were recurrently observed in all eight Action Areas which threatened an effective shift towards SBC policies and practices or weakened the effectiveness of existing ones.

5.1. Lack of strategic level planning and inter-agency coordination

Currently there is no process for developing overarching strategic plans for the construction sector in Sri Lanka. This remains a major barrier to the paradigm shift needed to improve SBC as there is no central platform to guide decision-making processes for improving sustainable housing and construction in the country. Also, coordination among agencies for a concerted shift towards sustainability in the construction sector remains weak.

5.2. Weak enforcement of regulations

There are strong environmental protection regulations and construction related regulatory procedures in place that can contribute towards sustainable and low-carbon construction. However, their enforcement has been weak, undermining their effectiveness. Specific SBC-related regulations and policies (eg. UDA's Green Building certification for all buildings > 400 sq.m.) are relatively new and their effectiveness in implementation is yet to be understood. Overall, there is a need to strengthen the enforcement of existing regulations and policies pertaining to all Action Areas discussed in this report.

5.3. Lack of community participation and engagement opportunities for disadvantaged groups

There are acute disparities in stakeholder engagement in all aspects of the construction sector. Powerful government stakeholders are well consulted in the planning and design stages of major construction projects through established mechanisms, in both state and corporate-driven projects. Consultation processes are weaker in the latter stages of the construction life cycle. Engagement of the community in general and especially vulnerable groups (eg. women, elderly, persons with disabilities, ethno-religious minorities) is very poor at all stages of the construction life-cycle. Some provisions are there for community engagement during the project approval stage of major development projects through the Environmental Social Impact Assessment (ESIA) process and requirements in donor-funded projects. These consultations are for projects in general, not specific to building design or construction. Inclusive strategies are required in all aspects and lifecycle phases i.e. planning, building design, construction and building operations.

5.4. Inadequate resource allocation

There is a vast gap between the financing, human resources, and other inputs required for the urgent shift towards SBC. The current level of resource allocation by the state or private entities are not adequate to make this shift. Apart from small-scale initiatives budgeted under sub-projects of government agencies, there are no dedicated budget allocations for SBC. Private sector investment in SBC is sporadic and insignificant. Currently there are no direct incentives provided by the government to encourage private sector companies to invest in SBC. This deficiency was observed in all eight Action Areas, however resources for SBC were comparatively better in "Urban planning" and "Clean energy.

5.5. Lack of SBC related capacity and skills

There is an acute lack of awareness and skills for SBC at artisan/tradesman level (eg. masons, carpenters, electricians). Most of the skills at this level are stil acquired through informal education, where former traditionally sustainable practices have largely disappeared and modern awareness of sustainability has not yet developed. The existing vocational training programs do not focus on SBC. At the professional level (e.g. civil engineers, architects, energy consultants, environmental engineers and sustainability consultants) SBC / low-carbon design knowledge and skills are developing. Most engineering and architecture programs at the university level offer sustainability and environmental management-related modules. There are also professional level programs on SBC related topics offered by professional organizations and private companies. However, a lot still remains to be done to bring the sustainability skills to the level required for an effective shift towards SBC.

5.6. Poor monitoring and data management

Monitoring and documenting is one of the least developed aspects of the construction industry in Sri Lanka, compared to industries such as transport or plantations where there are, thorough state regulated processes for data collection and management. The challenge of monitoring and documenting is aggravated by the large informal sector of the construction industry. There is no mechanism available currently to monitor any of the sustainability aspects of the eight Action Areas of this report. Lack of data remains a major barrier to policy level decision-making towards SBC.

Based on these cross-cutting challenges, and the specific actions proposed for the eight Action Areas we have identified over-arching policy, planning and management recommendations for different enabling domains for SBC. The recommendations are described in Table 6.1 in the next section.

Chapter 6: Conclusions and Recommendations

The SBC Country Assessment showed that Sri Lanka has mature policy regimes for the governance of construction, energy and environment, with key governing bodies and legislation being in operation for more than 40 years. Sustainability has been adopted in principle and formally introduced to policy documents in these areas since 2000s. Climate Change governance is still nascent but has grown considerably in the last decade.

However, as discussed in detail in the "Context and Way-Forward" section, there are many significant challenges that cumulatively pose a roadblock to an effective shift towards SBC in Sri Lanka. These challenges and current opportunities for SBC are varied across the eight Action Areas considered in this report and also manifest more sharply in certain stages of the construction life cycle. Fig.6.1 gives a qualitative assessment of the overall SBC opportunities for the eight Action Areas.

Figure 6.1: Overall SBC opportunities in different Action Areas and Enabling Domains (source: Author assessment)

Opportunities for SBC in Action Areas: Action Areas such as "Urban planning," and "Clean energy" showed certain promising initiatives towards SBC in recent times. However, areas such as "Building renovation and decommissioning," "Materials" and "Building operations" require vast improvements.

Opportunities for SBC in the Enabling Domains: "Knowledge and Technical Resources" is currently the strongest enabling domain in the Construction Industry for SBC. Domains such as "Policies and Regulations," and "Institutional arrangement" provided some positive prospects. "Stakeholder engagement", "Data management" and "Financing" were the weakest domains. Fig.6.1 gives a qualitative assessment of the overall support for SBC provided by each domain.

Climate adaptation and mitigation: The need for Climate Change adaptation and mitigation in the Construction sector had been identified at a higher strategic level through NDCs. Few promising initiatives in green building and household energy efficiencies have been implemented. However, no concrete policy, planning or regulatory mechanisms are in place to address Climate Change in the Construction sector.

Following cross-cutting challenges were identified across the considered Action Areas and throughout the different stages of the Construction Lifecycle:

- Lack of strategic level planning
- Inadequate laws and regulations and weak enforcement
- Lack of community participation and engagement opportunities for disadvantaged groups
- Inadequate resource allocation
- Lack of SBC related capacity and skills at the vocational level
- Poor monitoring and data management

To overcome these cross-cutting challenges and achieve the specific actions proposed by for the Action Areas, we propose the overarching 2050 Vision for SBC in Sri Lanka, elaborated in the policy, planning and management goals given in Table 6.1. These goals are based on specific actions identified in the "Context and Way-Forward" section. They are descriptive rather than prescriptive and open to interpretive adaptation by the policymakers.

A potential timeline for achieving these goals are presented visually in Fig.7.1. "Roadmap towards 2050". Table 7.1 gives how the specific actions proposed under each Action Area relates to Sri Lanka's NDCs (as per 2021 update)[92] and SDGs.

Vision 2050 for Sustainable Building Construction in Sri Lanka

"By 2050, housing and construction in Sri Lanka are socially inclusive, environmentally sustainable and carbon neutral"

[92] Updated Nationally Determined Contributions 2021 – Ministry of Environment Available at http://www.climatechange.lk/CCS2021/UpdatedNDCsSriLanka2021.pdf

Table 6.1: Policy, Planning and Management goals to achieve Vision 2050 for SBC in Sri Lanka

Enabling Domain	Recommendation
Institutional arrangements	Establish a **National Alliance for SBC (NA-SBC)** led by apex state agency such as CIDA and represented by national agencies, private sector, local governments, NGOs/Civil Society, professional organizations and educators. Objectives of the NA-SBC: 1. Assess the baselines and set national SBC goals (including achieving relevant NDCs) 2. Coordinate among stakeholders to mainstream SBC in building construction 3. Streamline policies/regulations/standards pertaining to construction to achieve SBC goals 4. Develop a 2050 Circular Economy plan for the Construction Industry
Process	Formally **mandate the apex state agency** leading the National Alliance for SBC to monitor the progress of SBC goals and coordinate with other related agencies, along with financial provisions for monitoring, data management and coordination. Include **specific Construction Industry targets to NDC** targeting the next revision of NDCs and upcoming National Communications. Meet all construction NDC targets by 2050.
Policies and Regulations	**Incorporate SBC goals** based on the specific Actions/Goals identified in this report into the existing “National Policy on Construction”, “Construction Industry Act” and other relevant Acts and Policies. All **building specifications and standards to include sustainability** and climate criteria by 2050 Ministry of Construction or CIDA to conduct a national level **assessment of regulatory barriers** for implementing SBC, achieving NDCs and mainstreaming sustainable materials. Remove all barriers by 2050.
Stakeholder engagement	**Strengthen the Community Engagement, and Gender and Social Inclusion** provisions within the existing National Policy for Construction and Construction Industry Act in consultation with relevant government agencies and civil society groups. **Build capacity** in construction related state agencies and LGAs to expand Community Engagement
Financial resources	NA-SBC to prepare a **Financing Plan for SBC**, including proposals for the national budget, international funding agencies and highlighting areas with opportunities for Public-Private Partnership (PPP).
Knowledge and Technical resources	Formulate a **National Action Plan for improving awareness, skills development and capacity building** for SBC and Climate resilience in the construction industry (through NA-SBC).
Data management, Monitoring and Reporting	Establish **a central database** under CIDA/ Ministry of Construction to collate and manage data on all aspects of construction – supported by the NA-SBC partners. CEA and Climate Change Secretariat to develop a **mechanism to monitor construction related sustainability parameters and NDCs.**

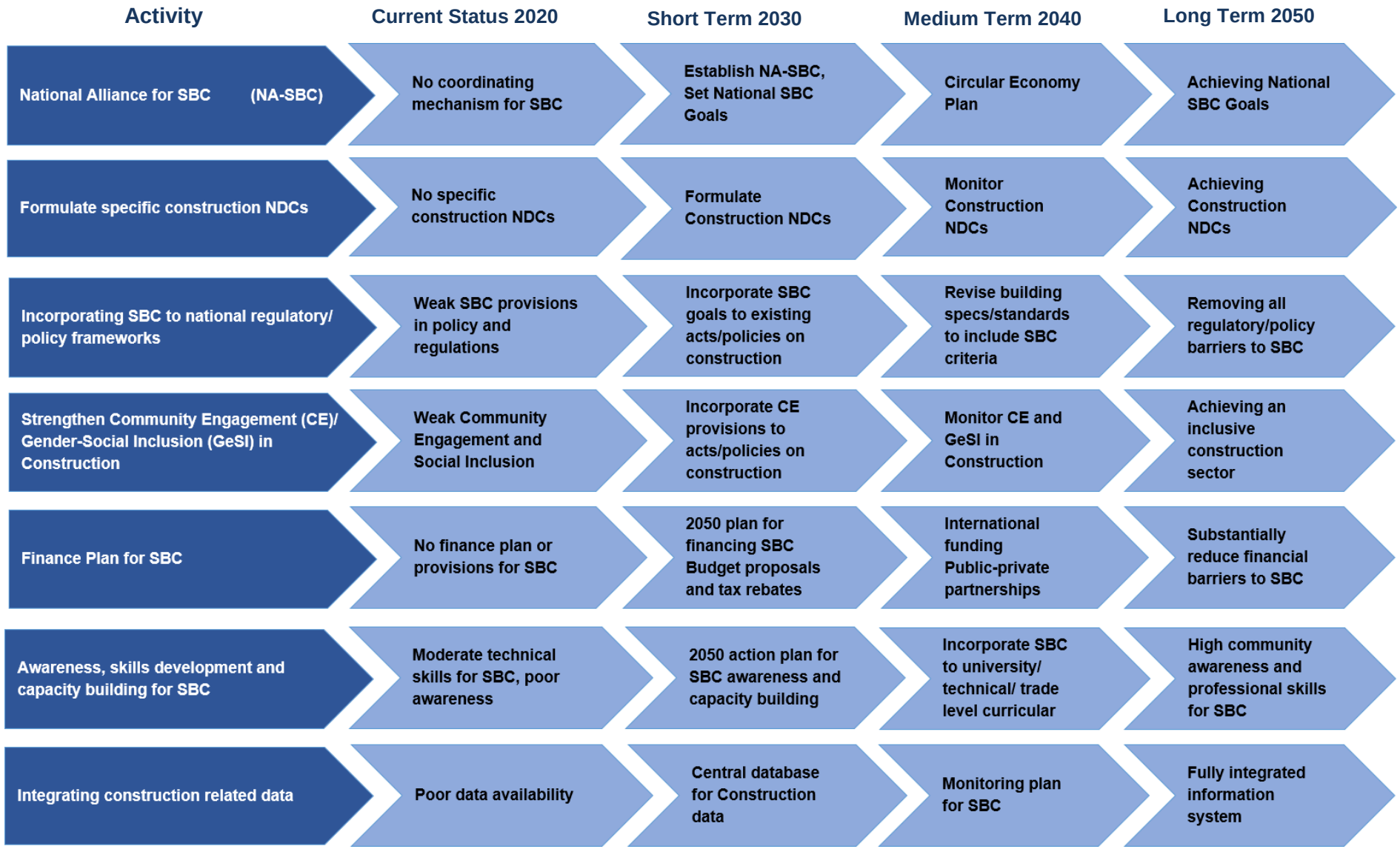


Figure 6.2: SBC Roadmap towards 2050

Table 6.2: Proposed Actions/ Goals relevant to NDCs and SDGs

Relevant NDC Sectors – 1. Energy (electricity), 2. Energy (transport), 3. Industry, 4. Waste management, 5. Forestry, 6. Urban Planning and Settlements

SDGS – 1: No Poverty 2: Zero Hunger 3: Good Health and Well-being 4: Quality Education 5: Gender Equality 6: Clean Water and Sanitation 7: Affordable and Clean Energy 8: Decent Work and Economic Growth 9: Industry, Innovation and Infrastructure 10: Reduced Inequality 11: Sustainable Cities and Communities 12: Responsible Consumption and Production 13: Climate Action 14: Life Below Water 15: Life on Land 16: Peace and Justice Strong Institutions 17: Partnerships to achieve the Goal

Action Area	Specific Actions / Goals	Relevant NDC Sectors (2021 Update)	Relevant SDGs
Urban Planning	**Action 1.1.** National Planning Department to check all development projects for their compliance with the NPP	6	11
	Action 1.2. Establish an Independent National Planning Commission to assure the compliance of all major development projects at their implementation	6	11
	Action 1.3. Develop institutional, planning capabilities and the core competencies of the LGAs and UDA.	6	11
	Action 1.4. Establish a dedicated Strategic Planning Division in all LGAs, with community engagement.	6	5,10,11
	Action 1.5. Extend the UDA's web-based development application processing and clearing into LGAs as a common platform.	N/A	9, 10
	Action 1.6. Provide Local Authorities with necessary capacity to effectively manage data with the on-going National Spatial Data Infrastructure (NSDI) development project.	6	9, 11
	Action 1.7. Provide necessary support to the Department of Census & Statistics to reformulate the definition.	N/A	11
New Buildings	**Action 2.1.** CIDA to develop simpler contract documents / codes / guidelines for smaller projects.	N/A	9
	Action 2.2. SBC communication and dissemination campaigns for small builders and individual house owners.	6	5,9,10,11,12,13
	Action 2.3. Review the existing regulatory process and simplify them, with community consultation.	N/A	5,9,10
	Action 2.4. Integrate the data on new building permits and CoCs (collected and managed by LGAs) into a central data base at the Ministry of Construction or CIDA.	6	9
	Action 2.5. Combine data from utility provision agencies e.g. CEB, NWS&DB and other building related data to the central database.	6	6,7,9,10
	Action 2.6. Revise CIDA Building Specifications and Conditions of Contract documents to adequately include SBC/Low Carbon provisions.	3,4,5	9,11,12,13
	Action 2.7. Include SBC/Low Carbon provisions to LGA by-laws related construction, with community engagement (especially women and underrepresented groups)	3,4,5	5,9,10,11,12,13
	Action 2.8. Setting a 2050 vision for incorporating SBC and Low-carbon provisions to the existing policy and regulations, with community consultation (especially women and underrepresented groups)	3,4,5	9,11,12,13
	Action 2.9. Develop a Green Financing process for housing and construction	3,4,5,6	9,11,12,13
	Action 2.10. Explore the feasibility of providing tax rebates for individual house and apartment projects with sustainable and low-carbon features.	3,4,5	9,11,12,13

Action Area	Specific Actions / Goals	Relevant NDC Sectors (2021 Update)	Relevant SDGs
Building Renovation and Demolition	**Action 3.1.** Introduce and enforce regulations for demolition of buildings and disposal of construction waste	4	11,12,13,15
	Action 3.2, Introduce a Green Building certification scheme for building maintenance, renovation and demolition	3,4,5	11,12,13
	Action 3.3. Physical and technical capacity building of LGAs to enforce regulations for building renovation, demolition and disposal.	N/A	11,12,13,15
	Action 3.4. Develop community awareness and training programs for planning and execution of sustainable and safe demolition and debris, including targeted programs for women and underrepresented groups.	4	10, 11,12,13,15
	Action 3.5. Introduce standards for materials produced from recycled C&D waste (SLSI) and a grading system for demolition companies (CIDA).	3,4,5	11,12,13,15
	Action 3.6. Financial support to LGAs to establish C&D waste recycling plants at their waste management facilities	3,4,5	11,12,13,15
	Action 3.7. Public Private Partnerships for C&D waste recycling, including non-profit and community organisations (representing women and underrepresented groups)	3,4,5	5,10,11,12,13,15
Building Operations	**Action 4.1.** Conduct continuous awareness creation on the building operations at different levels and platforms	1,3	6,7,12,13
	Action 4.2. Develop simple regulations indicating the involvement of service providers at the design stage (LGA level guidelines).	1	10,6,7,12,13
	Action 4.3. All houses/residential buildings in urban/peri urban areas to be built following SBGs.(UDA, MCs, UCs)	1,3	6,7,12,13
	Action 4.4. Develop guidelines and standards for building operations and operations plans for all types of residential buildings and provide training to non-formal sector service providers	1	6,7,12,13
	Action 4.5. Upgrade the sustainable building guidelines (SGB) to be smart taking in to account different types of residential buildings	1	6,7,12,13
	Action 4.5. Train sufficient actors/service providers with required knowledge and skill at LGA level to serve building owners	1	10,6,7,12,13
	Action 4.7. Awareness and capacity building programs for occupants on sustainable end efficient practices of building operations, including targeted programs for women and underrepresented groups.	1	5,10,6,7,12,13
Appliances and Systems	**Action 5.1.** Conduct research and detailed studies using data specifically from buildings that have practiced SBDG and measure the impact.	1	7,12,13
	Action 5.2. Train and build capacities on improving housing design in order to reduce future appliance requirements and energy usage	1	7,12,13
	Action 5.3. Increase the number of appliances that need to be energy related and standardized based on importance.	1	7,12,13
	Action 5.4. Increase awareness among stakeholders on using energy efficient standard appliances, including targeted programs for women and underrepresented groups.	1	7,12,13
	Action 5.5. Develop tools and methods to identify and optimize energy efficient appliances based on the type and cluster of building.	1	7,12,13

Action Area	Specific Actions / Goals	Relevant NDC Sectors (2021 Update)	Relevant SDGs
Building Materials	**Action 6.1.** Establish a central database to collate building material related data	3,4,5	9,11,12,13,15
	Action 6.2. Review material demand, availability, price and environmental issues of building materials annually by a Construction Ministry led committee and develop an annual plan for building materials management.	3,4,5,6	9,11,12,13,15
	Action 6.3. Develop or adapt a carbon calculator for construction work in Sri Lanka	3,4,5	9,11,12,13
	Action 6.4. Review the existing building specifications and incorporate sustainability/ low carbon criteria by CIDA	3,4,5	9,11,12,13,15
	Action 6.5. Review the existing building material standards and incorporate sustainability/ low carbon criteria by SLSI , .	3,4,5	9,11,12,13,15
	Action 6.6. Explore Government budgetary allocation, external funding sources (including climate finance) and Public Private Partnerships for research and piloting sustainable material.	3,4,5	9,11,12,13,15
	Action 6.7. Explore the possibility of providing tax-rebates for local manufacturers of sustainable materials	3,4,5	9,11,12,13,15
	Action 6.8. Conduct communication and awareness campaigns on sustainable / low carbon materials, including targeted programs for women and underrepresented groups.	3,4,5	5,9,10,11,12,13, 15
Built-environment Resilience	**Action 7.1.** Assess climate threats to the built-environment in Sri Lanka through a multi-stakeholder initiative and develop an action plan for built-environment disaster resilience, with community consultation (especially women and underrepresented groups)	3,4,5,6	5,10,11,13
	Action 7.2. Update urban development and construction regulations to integrate built environment resilience by CIDA and UDA, with community consultation (especially women and underrepresented groups)	6	5,10,11,13
	Action 7.3. Develop a regular training program under CIDA/CHPB to improve awareness and skills to ensure built-environment resilience, including targeted programs for women and underrepresented groups.	6	5,10,11,13
Clean Energy	**Action 8.1.** Educate stakeholders on the benefits of using SBDG, provide financial and other incentives for using SBDG's , enforce guidelines provided by SLSEA, including targeted programs for women and underrepresented groups.	1	5,9,10,11,12,13
	Action 8.2. Provide regulatory support to allow using roofs of different buildings under same meter (power wheeling) CEB/ PUCSL	1	9,11,12,13
	Action 8.3. Make available financial and other tools such as loans, easy payment schemes, tax concessions to house owners for setting up RE based energy	1	9,11,12,13

Acronyms

CAA - Consumer Affairs Authority
CBD - Convention of Bio-diversity
CCISL - Chamber of Construction Industry of Sri Lanka
CEA - Central Environmental Authority
CEB - Ceylon Electricity Board
CIDA - Construction Industry Development Authority
CIOB - Ceylon Institute of Builders
CoC - Certificate of Conformity
CPD - Continuing Professional Development
CSEB – Compressed Stabilised Earth Blocks
DMC - Disaster Management Centre
DS - Divisional Secretariats
EEBC - Energy Efficiency Building Code
GBCSL - Green Building Council of Sri Lanka
GDP - Gross Domestic Product – GDP
GHG - Green House Gas
GII - Gender Inequality Index
GIS RS – Geographic Information Systems Remote Sensing
Global ABC - Global Alliance for Building Construction
GN - Grama Niladhari
GSMB - Geological Survey and Mines Bureau
HDI - Human Development Index
ICC - International Construction Consortium (Pvt) Ltd
LEED - Leadership in Energy and Environmental Design
LGA - Local Government Agencies
NBRO - National Building Research Organisation
NCCAS - National Climate Change Adaptation Strategy
NCP - National Construction Policy
NDC - Nationally Determined Contributions
NERD Center – National Engineering Research and Development Center
NHDA - National Housing Development Authority
O&M - Operation and Maintenance
PBR - Planning and Building Regulations
RE-CCAT - Resource Efficiency Country Construction Assessment Tool
RE - Renewable Energy
EE - Energy Efficiency
SBC-CA - Sustainable Building Country Assessment Sri Lanka
SBDG - Sustainable Building Design Guidelines
SCP - Sustainable Consumption and Production
SDG - Sustainable Development Goals
SL - Sri Lanka
SLSEA - Sri Lanka Sustainable Energy Authority
SLSI - Sri Lanka Standards Institute
TPCCS - Two Pot Clay Cook Stoves
UDA - Urban Development Authority
UNEP - United Nations Environment Programme
UNOPS - United Nations Office for Project Services
USD - U.S. Dollar
WWF - World Wildlife Fund

Annexures

Table A1: Institutions and Roles

No	Institution name	Description	Responsibilities
1	Construction Industry Development Authority (CIDA)	Construction Industry Development Authority (CIDA) is the leading organisation in the construction sector of Sri Lanka, whose mission is to provide strategic leadership to the sector by ensuring dynamic and professional industry services through national construction policies, regulations, capacity building, industry development, and promotion of quality standards to meet the requirements of sustainable national development.	• Recommend strategies for the development of the Construction Industry and assist in their implementation. • Regulate registration and grading of construction contractors. • Promote professionalism of consultants and coordinate activities of professional bodies and assist in the formation of similar bodies in the Construction Industry. • Promote/Facilitate export of construction industrial services by undertaking overseas contracts. • Provide advisory services to the Construction Industry. • Review human resource requirements of the industry and assist in the provision of training facilities. • Promote the advancement of the skills and expertise of personnel and professional bodies in the Construction Industry. • Promote/undertake research on matters related to the Construction Industry. • Promote Quality Assurance and productivity in the Construction Industry. • Promote and grant assistance to the development of industries related to the Construction Industry. • Undertake or assist any other activity for the promotion of the Construction Industry.
2	Sri Lanka Land Development Corporation	Sri Lanka Land Development Corporation (SLLDC) was established under the Colombo District (Low Lying Areas) Development Board Act No. 15 of 1968, mandated with low land areas and other lands declared under the Act. SLLDC is supported by staff of engineers in a variety of engineering specialties, including civil, mechanical, electrical, and chemical engineering, architects, quantity surveyors and related specialists in the legal and financial fields. The Corporation has the tools, machines, and resources connected to the construction, drainage, and reclamation sectors.	• To reclaim and develop every development area declared by order under section 2 of the amendment to the SLLDC Act No. 15 of 1968. • To ensure flood free habitat and improve the environment by rehabilitating, creating and maintaining pollution free inland water bodies • To undertake consultancy work on drainage design, land filling and other related areas and establishing a Bench Mark of high standard for the industry. • To improve and maintain the quality of services and add value to customer's needs in particular and to the community at large"
3	Urban Development Authority	The Urban Development Authority (UDA) was established under UDA Act of 1978 to promote integrated planning and implementation of economic, social and physical development of certain areas declared as urban development areas. At present, the Urban Development Authority is committed to achieve the vision 'Towards a Planned, Sustained and Adored Urbanization'	• Carrying out integrated planning and physical development within declared areas and coordinating and implementing related programs of development activities and services. • Formulating and Implementing capital investment promotion programs • Formulating and implementing an urban land use policy • Developing environmental standards and prepare schemes for

No	Institution name	Description	Responsibilities
		and the mission to 'Promote integrated planning and implementation for the economic, social, environmental and physical development of the declared Urban Development Areas. The Urban Development Authority is equipped with necessary systems and tools, modern technology and efficient and effective strategies as well as proficient and contented human resources with an emphasis to provide improved services and key development outcomes into the future.	environmental improvements • Carrying out buildings, engineering and consultancy operations in connection with the development of urban areas • Planning and executing projects in pursuance of development plans • Completing approved development projects • Acquiring and disposing immovable or movable property for urban development of the country • Preparing, implementing housing improvement projects and removing undeserved settlements and development of the land which undertake resettlement of the said settlements in declared urban areas • Preparing, coordinating, implementing and monitoring development planning proposals and projects for the government institutions and government representing agencies. • Providing technical planning service for other government institutions
5	The Central Environmental Authority	The Central Environmental Authority (CEA) was established on 12th August 1981, under the provision of the National Environmental Act No. 47 of 1980, with the objective of integrating environmental considerations into the development process of the country. The CEA was given wider regulatory powers to maintain environmental quality, control pollution and protect sensitive ecosystems under the National Environment (Amendment) Acts No. 56 of 1988 and No. 53 of 2000.	• To prevent or minimize the release of discharges and emissions into the environment from prescribed (industrial) activities in compliance with national discharge and emission standards. • To develop an approach to pollution control that considers discharges from prescribed (industrial) processes to all media (air, water, land) in the context of the effect on the environment. • To contain the burden on industry, in particular by providing guidance on pollution control for polluting processes. • To ensure that the system responds flexibly both to changing pollution abatement technology and to new knowledge such as cleaner production, waste minimization • Conduct Environmental Impact Assessment (EIA) • Provide Environmental Recommendations • Scheduled Waste Management Licensing

No	Institution name	Description	Responsibilities
6	Green Building Council	The Green Building Council of Sri Lanka is a consensus-based not for profit organization with diverse and integrated representation from all sectors of the property industry, environment and academia. This was established with a joint effort by the professional institutions of architects, engineers, structural engineers, town planners, quantity surveyors, university academics, construction industry leaders, environmentalists and business leaders. Their aim is to transform the Sri Lanka construction industry with green building practices and to fully adopt sustainability as the means by which their environment thrives, economy prospers and society grows to ensure the future wellbeing of Sri Lanka	• Rate Buildings based on the Sustainable Features via Green Rating System • Rate materials and Products based on the sustainable and eco-friendly manufacturing and features via Green Labelling System
7	Department of Buildings	The Buildings Department was established in 1969 after the abolition of the then Public Works Department. From the very inception, this department was considered as the sole authority and the advisory body in the field of building works. It was called upon to provide expert advice on building works to the government and semi-government institutions in the implementation of their building programs. The functions of the Department were broadly set out in the financial regulations and various Treasury Circulars. However, these functions have taken different forms with time, and were modified to suit the requirements of client organizations, changes in the Building Industry, and also to be in keeping with government policies, which were introduced from time to time. The role played by the Department in the national development and in the preservation of the public building assets is commendable. The execution of work was handled by the 27 District Engineer's offices, which were coordinated by 9 Superintending Engineer's office extended throughout the Island. The total permanent staff was over 5000.	• Life time Technically / Financially Accountable. • Designs for complete building needs by accredited professionals. • Adhere to all rules, regulations, quality, and safety standards. • Highly accurate scope specially developed utilizing past experience. • Assure quality, safety by scrutiny, concur designs, documents of other service providers. • Manage contracts. • Ensure value by experienced professional project management services, • Assistance in hassles of management audit. • Assistance in contractual litigations.

Table A2: Construction Related Governance Processes

Processes	Descriptions	Actors
Authorization of construction work.	Construction of new buildings of any scale have to be approved by the relevant Local Government Agency (LGA): Building Permit issued to commence construction and a Certificate of Conformity (CoC) issued at the completion of construction. The Building Permits and CoCs should adhere to the Planning and Building Regulations (PBR) formulated by UDA or the relevant LGA. Historic buildings require approval from the Department of Archaeology.	LGAs UDA Historic buildings Department of Archaeology
Environmental Impact Assessment (EIA)	As per the provisions of "National Environment Act (of 1980)" larger building projects deemed a Prescribed Project under the "Gazette No. 772/22 of 24.06.1993" should go through EIA (or Initial Environmental Examination – IEE) process. Project Approval is carried out by authorized Project Approval Agency (PAA) under the concurrence of the Central Environmental Authority (CEA). A developer or building owner is in doubt whether their proposed project would be a Prescribed Project and about the relevant PAA , can forward the application to CEA.	CEA Relevant PAA
Regulation of building material extraction	All mineral extractions are regulated by the Geological Survey of Mines Bureau under the "Mines and Minerals Act (of 1992)" which issues permits for extraction and transport of minerals. Some mineral extraction permits require concurrence of other relevant agencies (eg. Irrigation Department concurrence for sand mining). Timber felling and transport are permitted by the Divisional Secretariats (DS) under concurrence of Forest Department (FD).	GSMB DS FD
Regulating social environmental impacts at construction sites	Environmental impacts at site are regulated by the relevant environmental regulations for air pollution, water pollution, noise and vibration declared under the provisions of the National Environmental Act (of 1980) operated by CEA. Any other inconvenience or damage caused neighbours or public due a to a construction project can be addressed under Public Nuisance Regulations, if a complaint is lodged to the CEA or the Police.	CEA Police
Building Materials Manufacturing	Building material manufacturing is governed by the provisions of the "Factories Ordinance" operated by the Ministry of Labour and the environmental regulations (declared under the National Environment Act f 1980) and the Environmental Protection Licence (EPL) process operated by the CEA and LGAs (Gazette Notification No.1533/16 dated 25.01.2008). All factories should be registered under The Commissioner of Labour and periodically inspected for industrial safety by District Factory Inspecting Engineers. All manufacturing facilities should also periodically obtain an EPL issue by CEA or the relevant LGA based on their scale.	Ministry of Labour Labour Department CEA LGAs

Processes	Descriptions	Actors
Registration and grading of construction companies and consulting firms	Construction Industry Development Authority (CIDA) registers all businesses, professionals and trades-persons involved in the construction industry. However CIDA registration is not mandatory to operate in the industry. CIDA also grades construction companies according to their capacity, finances and scale of operations and monitors the performance of construction contractors.	CIDA
Accreditation of Professionals	Accreditation of construction professionals (engineers, architects, surveyors, quantity surveyors, valuers) comes under the purview of relevant professional organisations (eg. The Institution of Engineers, Sri Lanka -IESL). Professional organisation review and accredit the courses of study that would be recognised in the country, and also certify individuals as “Chartered” professionals. It is mandatory by law to have the Chattered status to perform certain functions as construction professional in the industry.	The Institution of Engineers Sri Lanka Sri Lanka Institute of Architects Institute of Quantity Surveyors Sri Lanka The Surveyors Institute Sri Lanka Institute of Valuers of Sri Lanka
Certification of crafts persons	Trades/Crafts persons are certified by multiple agencies in Sri Lanka including Technical College network, Univotech University, Construction Equipment Training Centre (CETRAC). CIDA registers crafts person and maintains a database. However, CIDA registration or any certification is not mandatory to work as a trade/crafts person in the construction industry.	CIDA Technical College Network CETRAC

Table A3: Policies and Regulations

No	Policy / Legislation / Regulation	Description	Sustainability features
1	National Policy on Construction	The National Policy on Construction applies to the construction industry as a whole, including both the public and private sectors. The Policy outlines the Ministries' major functions and responsibilities in the operational context. The Policy also coordinates activities with Ministries to ensure that their operations are run smoothly.	The policy recognizes the overall importance of sustainable development and proper environmental management in the construction sector. In the section NPC 3 the policy says – "Promote sustainable economic growth of the construction industry with special attention to the design and development of disaster resilient, energy efficient and environmentally sustainable buildings, structures and construction practices."
2	Construction Industry Development Act no. 33 2014 -	Construction Industry Development Act provides for the development of the construction industry in Sri Lanka; to regulate, register, formalize and standardize the activities of the construction industry; to provide for the establishment of the national advisory council on construction; the establishment of the construction industry development authority; and the establishment of the construction industry development fund and the fund of the construction industry development authority; to provide for the establishment of the national advisory council on construction; to provide for the establishment of the national advisory council on construction; to provide for the establishment of the national advisory council on construction; to protect public safety in Sri Lanka's construction industry; and for matters related to or incidental thereto	The act is to provide strategic leadership to the stakeholders of the construction industry to stimulate sustainable growth, reform, and improvement of the construction sector through the authority. In addition to that, the duty of authority is to promote sustainable growth of the construction industry with special attention to the design and development of energy efficient buildings and structures
3	Urban Development Authority (UDA) Act no. 41 1978 and Regulations	Urban Development Authority (UDA) Act 41 of 1978 established UDA as the apex body of urban planning and regulating in Sri Lanka. Under the Act UDA is mandated to declare "Urban Areas" and formulate urban development and building regulations to govern town planning, urban design and construction.	UDA introduced the "Green Rating" for proposed projects to promote and encourage sustainable development through construction of environmentally friendly buildings. From year 2017 all Government and Semi Government new buildings need to obtain "Green Building Certification" by UDA. However Other buildings also can get the "Green Building Certification" from the UDA, to ensure that a building is environmentally friendly.
4	The National Physical Planning Policy (Recurrent – every 5 years)	The National Physical Planning Policy and the National Physical Plan are the two main documents that encourage and regulate integrated land planning in Sri Lanka. Further, The National Physical Planning Policy and Plan's goal is to create an integrated land use and infrastructure framework that will allow Sri Lanka to maximize its natural resources and strategic location in South Asia. The Act also allows provisions for UDA to undertake projects for urban renewal and regeneration.	Key Element No.3 - The National Physical Planning Policy and National Physical Plan have the fundamental goal of ensuring future growth and development which are environmentally, economically, and socially sustainable and feasible. Protecting delicate environments, limiting urban development, fostering and preserving social cohesion, improving travel efficiency, and bolstering the economy are all part of this. Principle 4.8 - Ensure the sustainable management, treatment and disposal of solid waste and sewerage.

No	Policy / Legislation / Regulation	Description	Sustainability features
			Principle 6.6 Encourage the sustainable use of offshore resources
5	Town and Country Planning Ordinance –	The Ordinance authorizes the formulation and implementation of a National Physical Planning policy; the formulation and implementation of a National Physical Plan with the goal of promoting and regulating integrated planning of economic, social, physical and environmental aspects of land in Sri Lanka; to provide for the protection of natural amenities, the conservation of natural environment, buildings of architectural and historic interest, and places of natural beauty.	No sustainability provisions
6	National Environment Act No. 47 1980	An act to establish a central environmental authority, to provide for the authority's powers, functions, and duties, and to provide for the protection and administration of the environment, as well as things related to or incidental to it.	Encourage, co-ordinate and carry out strategic planning in environmental protection and management
7	Sri Lanka Sustainable Development Act, No. 19 of 2017	An act to provide for the creation and execution of a national policy and strategy for sustainable development in Sri Lanka; the establishment of a sustainable development council and other matters related to or incidental to the foregoing.	An act to set its own national goals, guided by global ambition but taking into account national interests and circumstances, and incorporate the seventeen Sustainable Development Goals into national planning processes, policies, and strategies in ongoing economic, social, and environmental processes.
8	National Disaster Management Act no 13 2005	This act is to protect the people of Sri Lanka's lives and property, as well as the environment, from the consequences of catastrophic disasters by preparing a national strategy and plan, as well as appointing centrally coordinated bodies and institutions to carry out such policy and plan	No sustainability provisions

No	Policy / Legislation / Regulation	Description	Sustainability features
9	Megapolis and Western Province Development Master-Plan	The Western Megapolis Master Plan is envisioned and conceptualized as a sensible grand strategy for attaining two critical interdependent transformations necessary in Sri Lanka's progress toward becoming a 'High Income Developed Country.' It discovers major regions of utilization in non-living materials such as sand to check the supply and demand of sand for building activities in the region, as well as environmental impact assessment due to construction activities in Sri Lanka, from the perspective of the construction sector.	
10	Code of Practices for Energy Efficiency Buildings Sri Lanka	The Ceylon Electricity Board created the first Energy Efficiency Building Code (EEBC) in Sri Lanka in 2000.	It has implemented energy efficient design and/or retrofits in commercial buildings, industrial facilities, and large-scale housing schemes to allow for minimal energy consumption during design, construction and maintenance without compromising the building's function or the comfort and health of occupants.
		The EEBC (2000) was a significant catalyst for the Sri Lanka Sustainable Energy Authority to design a new code for energy efficient buildings by analyzing and updating the existing EEBC to account for evolving technologies and current society needs.	It has also established criteria and minimum standards for energy efficiency in commercial building design and/or retrofits, as well as criteria for determining compliance. It also advises on how to encourage designs that are more energy efficient than the minimum requirements.
11	Sri Lanka Sustainable Energy Authority Act No. 35	Sri Lanka Sustainable Energy Authority Act established the Sri Lanka Sustainable Energy Authority, to develop renewable energy resources, to declare energy development areas, to implement energy efficiency measures and conservation programs, to promote energy security, reliability, and cost effectiveness in energy delivery and information management and to repeal the Energy Conservation Fund Act, No. 2 of 1985 and to provide for matters connected with or incidental to the foregoing.	Provide technical and financial assistance for sustainable energy consumption of the buildings and premises.

Tables A4: Housing Programs and Best Practices

No	Housing Program Example	Image and description	Agent, actors or policies.	Sustainability approaches
1	Middle Income Housing Project - Elliot Residencies - Borella	The overall project consists of 400 Housing Units. The contract was awarded to Access Engineering PLC. Project Duration is 2017 - 2023	Urban Development Authority	• Waste Management facilities with separate service life • Proper Rain water harvesting • Electric Vehicle charging facilities • Solar PV Systems for Common Area Lightning
2	Middle Income Housing Project - Crescendo Apartments - Malabe	The overall project consists of 256 Housing Units. The contract was awarded to ICC (Pvt) Ltd. Project Duration is 2021 - 2022	Urban Development Authority	• Central Gas System • Sewer Treatment Plants • Waste Management facilities with separate service life • Electric Vehicle charging facilities • Proper Rain water harvesting
3	Middle Income Housing Project - Central Residencies Phase I	The overall project consists of 504 Housing Units. The contract was awarded to Sanken Builders. Project Duration is 2017-2022	Urban Development Authority	• Central Gas System • Sewer Treatment Plants • Waste Management facilities with separate service life • Electric Vehicle charging facilities • Proper Rain water harvesting
4	Middle Income Housing Project - Central Residencies Phase I	The overall project consists of 314 Housing Units 314. The contract was awarded to Tudawe Brothers (pvt) Ltd.. Project Duration is 2021-2023	Urban Development Authority	• Central Gas System • Sewer Treatment Plants • Waste Management facilities with separate service life • Electric Vehicle charging facilities • Proper Rain water harvesting
5	Middle Income Housing Project - Citadel Apartments - Anuradhapura	The overall project consists of 135 Housing Units. The contract was awarded to Sathuta Builders (pvt) Ltd. Project Duration is 2021-2022	Urban Development Authority	• Central Gas System • Sewer Treatment Plants • Waste Management facilities with separate service life • Electric Vehicle charging facilities • Proper Rain water harvesting

No	Housing Program Example	Image and description	Agent, actors or policies.	Sustainability approaches
6	Middle Income Housing Project - Urban Crescent Residencies - Bloemendhal	The overall project consists of 210 Housing Units. The contract was awarded to Edward and Christie. Project Duration 2021-2022	Urban Development Authority	• Central Gas System • Sewer Treatment Plants • Waste Management facilities with separate service life • Electric Vehicle charging facilities • Proper Rain water harvesting
7	Middle Income Housing Project - Green Arcade Housing Project - Kottawa	The overall project consists of 135 Housing Units. The Contract was awarded to Sathuta Builders (pvt) Ltd. Project Duration is 2017-2022	Urban Development Authority	• Central Gas System • Daily Waste management facilities • Sewer Treatment Plants • Solar System for common areas
8	Homes not Houses Project	Funded by the European Union, jointly implemented by Habitat for Humanity and World Vision Lanka, the 'Homes not Houses Project' is expected to benefit more than 215,250 internally displaced people in the Northern and Eastern Provinces of Sri Lanka. Seeking to serve the most vulnerable families displaced by the civil war, the project has committed Euro 14.7 million towards providing returnee families with permanent and affordable housing solutions, social infrastructure and livelihood protection.	Habitat for Humanity	• Introducing the beneficiaries to appropriate construction materials such as Compressed Stabilized Earth Blocks (CSEB) and Earth Concrete Blocks (ECB), • Utilizing the land usage plans to equip homeowners to identify and efficiently avail resources from their own land to increase family income such as making informed decisions about placement of perennial crops, seasonal crops, home-garden and livestock rearing
9	Indian Housing Project – Central and Uva Provinces	In response to a major housing need in the Central and Uva Provinces, the Government of India initiated the Indian Housing Project in the Central and Uva Provinces to make a significant contribution to the sustainable resettlement of at least 4,000 plantation worker families in newly created cluster villages or small townships, under the auspices of the Ministry of Hill Country, with new villages, Infrastructure and community development. The Indian Housing Project in the Central and Uva Provinces is an extension of the Government of India's overall commitment of constructing 50,000 houses in Sri Lanka.	Habitat for Humanity	• Beneficiaries are encouraged to provide in-kind contributions of labour and building materials towards the construction efforts in order to save costs.

No	Housing Program Example	Image and description	Agent, actors or policies.	Sustainability approaches
10	Indian Housing Project – East	The Indian Housing Project is a housing construction project funded by the Government of India and implemented through a Memorandum of Understanding (MoU) with the Government of Sri Lanka (GOSL) initiated in 2012. In 2016, Habitat for Humanity Sri Lanka successfully completed the construction of 3,713 new houses and repair of 46 houses for Internally Displaced Persons (IDPs) in Trincomalee and Batticaloa as part of Phase 1 of the Indian Housing Project funded by the Government of India. Consequent to the completion of Phase 1 of the Indian Housing Project, Habitat for Humanity Sri Lanka was awarded the construction of 270 homes in Batticaloa as part of Phase II of the Indian Housing Project in the Eastern Province. Habitat Sri Lanka commenced the construction of 270 homes in Batticaloa in September 2017 and was subsequently, awarded an additional caseload of 131 homes in Batticaloa. Phase 11 of the Indian Housing Project was completed by the end of 2018.	Habitat for Humanity	• The unique approach adopted encourages homeowners to take ownership of the design and construction of their own homes, utilizing the extensive orientation and training given by the implementing agencies on basics of construction, technical aspects and house lifecycle management. Habitat Sri Lanka's Technical Officers regularly visited the construction sites and assisted beneficiaries to source good quality building materials and supervised skilled labour.
11	Kalutara Housing Project	The Kalutara Housing Project was initiated in August 2017 to construct 37 homes for low-income families in Kalutara District. The selected beneficiary families originally lived in small one-bedroom temporary wooden structures with limited protection from adverse weather conditions, intruders and provided minimal privacy for the girl child.	Habitat for Humanity	• Designed to include disaster resilient features to minimize the risk of future disasters such as floods, in accordance with the standards of the NBRO
12	Kegalle Housing Project	Habitat for Humanity Sri Lanka partnered with Alwaleed Philanthropies in an initiative to rebuild the lives of families affected by landslides caused by Cyclone Roanu, in May 2016. Together with the Government of Sri Lanka, District Secretariat of Kegalle and Divisional Secretaries of Aranayake, Yatiyantota and Deraniyagala, 80 families were identified as key beneficiaries for the rebuilding initiative. Alwaleed Philanthropies has supported Habitat for Humanity's work over the past years including the earthquakes in Ecuador, Japan and Nepal and a cyclone in Vanuatu. Alwaleed Philanthropies has come forward to support Habitat for Humanity Sri Lanka's initiative by providing a LKR 80 Million (USD 545,200) grant to construct 80 homes for victims of the landslides.	Habitat for Humanity	• Designed to include disaster resilient features to minimize the risk of future disasters such as land slides

No	Housing Program Example	Image and description	Agent, actors or policies.	Sustainability approaches
13	Brandix Housing Project	Following the severe floods caused by Tropical Storm Roanu in Sri Lanka in May 2016, Habitat for Humanity Sri Lanka (HFHSL) partnered with Brandix Lanka Limited to help rebuild lives of those affected by the disaster. This collaboration aimed at reconstructing and repairing homes of twenty-two employees of Brandix Lanka Ltd., that were completely or partially destroyed following the floods located in various parts of the island. HFHSL was assigned the task of implementing the project by managing the construction and repairs of these homes while the project was funded solely by Brandix Lanka.	Habitat for Humanity	• Designed to include disaster resilient features to minimize the risk of future disasters such as floods
14	Disaster resilient model houses - Landslide Resilient House at Agalawatta	National Building Research Organization (NBRO) operating under the vision of creating a safer built environment has extended its studies on disaster resilient construction. As its initial phase, the main focus of these studies was on housing sector after considering the frequency of natural disasters and severity of damages on houses caused by them. NBRO recommends incorporating disaster resilient features into housing construction when sites are located in localities prone to disasters such as floods, landslides, high wind, and tsunami or in areas having expansive soil. In this context, the Human Settlements Planning and Training Division of NBRO initiated a program to construct disaster resilient model houses in disaster prone areas with the consent of the Ministry of Disaster Management. In this project, disaster resilient features are showcased in hazard prone areas through model houses to enhance awareness within the community on disaster resilient construction.	NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as land slides
15	Disaster resilient model houses - Flood Resilient House at Millaniya		NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as floods
16	Disaster resilient model houses - Tsunami Resilient House at Beruwala		NBRO	• Designed to include disaster resilient features to minimize the risk of Tsunami Impacts
17	Disaster resilient model houses - Flood Resilient House at Bingiriya		NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as floods
18	Disaster resilient model houses - Flood and High wind Resilient House at Mundalama		NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as floods

No	Housing Program Example	Image and description	Agent, actors or policies.	Sustainability approaches
19	Disaster resilient model houses - Landslide Resilient House at Bulathkohupitiya		NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as land slides
20	Disaster resilient model houses - Flood Resilient House at Tissamaharama		NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as floods
21	Disaster resilient model houses - Landslide Resilient House at Katuwana		NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as land slides
22	Disaster resilient model houses - Flood Resilient House at Baddegama		NBRO	• Designed to include disaster resilient features to minimize the risk of future disasters such as floods

Tables A5: Summary of some emerging sustainable materials in Sri Lanka

No	Material Name	Description	Sustainable Features	Disadvantages	Responsible Organization	Status	Cost Effective
1	Compressed Stabilized Earth Blocks	Cement stabilized earth blocks are used as an alternative building material for burnt clay bricks and cement sand blocks. This is an appropriate and cost-effective wall construction material as most of the generally available sandy soil and gravel soil can be used for manufacturing these blocks. Soil can easily be extracted and easily processed for production of these blocks. Soil is mixed in certain proportions of cement (5-10%) for producing and unlike normal clay bricks, burning is not necessary. Unlike for cement sand blocks river sand is not necessary for earth blocks. Hence, low energy consumption and low environmental pollution or degradation occurs with the production of these blocks.	Solution for sand crisis Environmentally friendly green product and problems related to sand mining, defrosting and clay mining are not present. Higher thermal comfort. 15%-50% cost can be saved (according to availability of soil) Creating new employments	Problems may occur if the method/technique is incorrectly used Man power requirement is dependent upon the type of soil	State Ministry of Rural Housing and Construction & Building Materials Industries Promotion	In Use	Average Effective
2	Bamboo	Bamboo is a fast-growing plant that thrives in tropical regions like Sri Lanka. It is frequently used in Sri Lanka for temporary buildings, such as walls, screens, and cladding. It is not a popular building material for permanent structures despite its remarkable structural properties, good availability and ability grow quickly. One set back of bamboo its quick decay compared to timber. However, examples worldwide show that bamboo, when properly treated is as durable as timber, and used for a variety of modern construction uses.	Easy workability. Can be used for both permanent and temporary construction. Extraordinary physical characteristics, and suitable for all types of structures and constructions. Non-polluting Carbon foot print is much less compared to most other materials for similar purposes	They require preservation Bamboo shrinks much more than timber.	Industrial Development Board - lankaboo.lk	In Use	Very effective

No	Material Name	Description	Sustainable Features	Disadvantages	Responsible Organization	Status	Cost Effective
			Can be used in combination with large variety of other material, including as reinforcement for steel.	Bamboo should be sufficiently treated against insect or fungus attack for durability.			
				Structural reliability of joining bamboo is questionable.			
3	Durra Boards	Durra Boards are currently regarded as one of the top Sri Lankan sustainable building products, converting paddy straw into an environmentally beneficial, adaptable, and multipurpose building panel known as DURRA. DURRA panels will aid the environment in any project because they are green, light weight, sound resistant, and heat insulated. They come in a variety of lengths and may be rendered with a variety of designs and finishes. Because of the various benefits a single panel might offer, DURRA may be used for many modular, acoustic, and heat insulating requirements of the project to provide turnkey solutions for the construction sector	Fire Resistance		International Construction Consortium - ICC	In Use	Average Effective
			Impact Resistance				
			Sound Insulation				
			Thermal Insulation				
			Strength and Self-supportive				
			Natural Non-Toxic Glue				
4	Mud Concrete Bricks	Mud concrete bricks have the least impact on the environment and keep homes cool. They are also the cheapest and easiest to get rid of once a property has been demolished. Mud concrete bricks are manufactured from the same soil as conventional mud bricks, but with the addition of gravel and sand for added strength. The researchers examined the carbon footprint of each of the four walling	recyclable	easily damaged	State Ministry of Rural Housing and Construction & Building Materials Industries Promotion	Rare in Use, In Research	Yes
			non-toxic				
			healthy form of building construction	high weight			
			low embodied energy				
			high thermal mass	not good thermal insulators			

No	Material Name	Description	Sustainable Features	Disadvantages	Responsible Organization	Status	Cost Effective
		materials and discovered that mud concrete bricks were the most environmentally benign to manufacture and dispose of. Mud concrete bricks are common in other tropical countries, although they are relatively new in Sri Lanka. They are popular because they are simple to produce and thus inexpensive.	Good Sound Insulator Can be used for the concrete mixes In Sri Lanka, mining river sand will be very limited in the future due to environmental issues so this is the only alternative for the sand crisis				
5	Manufactured Sand (M-Sand)	Manufactured sand, produced with crushing withered or had rock can serve as a substitute for River sand. The use of artificial sand has increased as a result of the scarcity of good grade river sand for construction. Another benefit for using M-Sand is its accessibility and low cost of transportation. Because manufactured sand is made from hard granite rocks, it can be easily obtained in a nearby	It is well graded in the required proportion. It does not contain organic and soluble compound that affects the setting time and properties of cement,	Due to its smooth and angular textures, leads to more water and cement requirement to achieve the expected workability, thereby increase in overall costs.	CA Crushing	In Use	Yes

No	Material Name	Description	Sustainable Features	Disadvantages	Responsible Organization	Status	Cost Effective
		location, lowering the expense of shipping from a distant watersheds.	M-Sand is obtained from specific hard rock (granite) using the state-of-the-art technology, to obtain the required quality of sand	If M Sand contains a large number of micro fine particles, it can affect the strength and workability of concrete.			
6	Rammed Earth	In Rammed Earth construction, compacted and stabilized earth is used to directly cast walls instead of bricks or blocks. In Sri Lanka single-story structures with adequately robust walls with a thickness of 160mm – 300mm have been built using this technique, conserving both soil and cement. Cement levels of 6 percent -10 percent can be employed in laterite soils with high sand content (40 percent - 60 percent) and even hard lumps. If steel moulds are used in casting, smooth surfaces can be produced that enables the removal of plaster from the walls. This reduces the need for cement sand mortar as there are no bed joints, thereby reducing sand usage, saving money and benefiting the environment.	a four-hour fire resistance rating	Poorly installed, it will radiate heat all night	NBRO	In Use	Yes
			non-toxic nature				
			not require additional waterproofing				
			moisture resistant	Materials with high thermal mass are not good insulators			
			highly durable				
7	Micro concrete Roofing Tiles	The most common roofing materials in Sri Lanka are clay tiles and cement fiber sheets. Clay tiles have environmental issues, such as clay mining and a lack of high-quality clay for tile production. Indoor thermal comfort is one of the environmental concerns with cement fibre sheets. Micro Concrete roofing tiles is an alternative to the aforementioned two roof covering materials (MCR tiles). These are made with 1:2 or 1:3 cement and aggregate mixtures, with 3-6 mm	Offer more value for money.	Relatively poor thermal insulation	Samson Rajarata Tiles (Pvt) Ltd	In Research	Yes
			Are highly durable – they have the life of concrete.	Not air and insect proof. Higher costs			
			Are lighter than other roofing tiles – they require less understructure.				
			Can be easily installed.	Leakage cannot be easily detected from the inside			
			Can be colored to user’s preference.				

No	Material Name	Description	Sustainable Features	Disadvantages	Responsible Organization	Status	Cost Effective
		chips included in addition to sand. These tiles can even be hand moulded for low-income construction. A commercial producer provided raw material quantities for tile production.	Reduce heat gain.	Changing tiles from the inside is difficult			
			Do not make noise during rains.	Unmanageable space between tiles and ceiling			
			Do not contain asbestos fibres.				
8	Precast Concrete Panels (Slabs and Walls)	Reinforced concrete slabs and walls are popular in Sri Lanka, due to a paucity of excellent quality timber. Traditional solid slabs and concrete walls built to BS 8110: Part 1: 1997 have various flaws, including inefficient concrete use, the need for formwork and falsework, and reinforcement requirements based on crack control rather than flexural behavior when sustaining mild loads. In order to reduce labor and material costs, an innovative pre-cast reinforced concrete panel (slabs and walls) technique was created. This technique uses pre-cast beams spaced at 1.5 m intervals to support 75 mm thick pre-cast slabs, reducing the need for formwork and falsework. The use of less concrete and steel reduces embodied energy and saves 40–50% on costs. The embodied energy is calculated for a 3.6 m x 3.0 m panel that will require 24 pre-cast slab panels.	Wastage of material is less	High Initial Investment	International Construction Consortium - ICC	In Use	Very Effective
			Energy usage is less				
			Installation time is very low	Transportation Issues			
			Resistance to noise	Sensitive Connection Works			
			Mitigating the urban heat-island effect	Difficult to modify the structure			
			Indoor environmental quality				
			Air infiltration	Handling Difficulties			
			Fire and natural disaster resistant				