Circular Built Environment
Highlights from Asia
Policies, Case studies and UN2030 Agenda Indicators

Countries considered:
China, India, Indonesia, Nepal, Pakistan and Sri Lanka

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One Planet Network

The One Planet network has been formed to implement the 10-Year Framework of Programmes on Sustainable Consumption and Production (SCP), which supports the global shift to SCP and the achievement of SDG12. The One Planet Network acts as an enabler bringing actors from all regions to pool their expertise, resources, innovation and commitment towards a shift to more sustainable modes of production and consumption. The network comprises of six programmes: Sustainable Buildings and Construction, Sustainable Public Procurement, Sustainable Tourism, Consumer Information for SCP, Sustainable Lifestyles and Education and Sustainable Food Systems Programme.

Sustainable Buildings and Construction Programme

The Sustainable Buildings and Construction Programme (SBC) aims at improving the knowledge of sustainable construction and to support and mainstream sustainable building solutions. Through the programme, all major sustainable construction activities can be brought together under the same umbrella. The work involves sharing good practices, launching implementation projects, creating cooperation networks and committing actors around the world to sustainable construction. The goal is to promote resource efficiency, mitigation and adaptation efforts, and the shift to SCP patterns in the buildings and construction sector. The SBC work in 2021-2022 focuses on circularity and responsibly sourced materials.

Circular Built Environment Highlights

SBC has published regional reports on the state of play for circular built environment in Africa, Asia, Europe, Gulf Cooperation Council countries, Latin America and the Caribbean, North America, and Oceania. In addition to regional outlooks, a global report has been produced to summarise and compare the state of play regarding circularity in different regions. A crucial role of the reports is not only to provide a benchmark but also recommendations on how to move forward towards a sustainable and circular built environment.

These highlights from Asia provide a deep dive on circular built environment in China, India, Indonesia, Nepal, Pakistan and Sri Lanka presenting good practice case studies covering different life cycle stages and impact categories. Most important sustainable development goals and indicators for circularity from the UN2030 Agenda for Sustainable Development were identified through a survey. The results were compared between high and low Human Development Index countries and validated in a stakeholder interview.

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List of acronyms and abbreviations

APAC	Asia Pacific Accreditation Cooperation
ADB	Asian Development Bank
AIIB	Asian Infrastructure Investment Bank
ASEAN	Association of Southeast Asian Nations
BAU	Business-as-usual
BECP	Building Energy Code of Pakistan
BEE	Bureau of Energy Efficiency
BIM	Building Information Management
BMDI	Building Materials Directory of India
BMTPC	Building Materials and Technology Promotion Council
C&D	Construction and Demolition
CBDC	Construction Business Development Council
CBDIC	Construction Business Development & Implementation Committee
CBE	Circular Built Environment
CBO	Community-based organisations
CFC	Chlorofluorocarbon
DHPS	Demonstration Housing Projects
ECBC	Energy Conservation Building Code
EIA	Environmental Impact Assessment
EPD	Environmental product declarations
ESL	energy standards and labelling
FDI	Foreign Direct Investment
FYP	Five-year plan
GBCI	Green Building Council Indonesia
GDP	Gross domestic product
GHG	Greenhouse gas
GHTC	Global Housing Technology Challenge
GLS	GreenSL Labelling System
HCFC	Hydro-chloro-fluoro Carbon
HDI	Human Development Index
HVAC	heating, ventilation and air conditioning
IDR	Indonesian Rupiah
IEA	International Energy Agency
IFC	International Finance Corporation
INR	Indian National Rupees
ISO	International Organisation for Standardisation
LCA	Life Cycle Assessment
LKR	Sri Lanka Rupee
LTS	Long-term strategy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MoHURD	Ministry of Housing and Urban-Rural Development
NDC	Nationally Determined Contributors
NDRC	National Development and Reform Commission
NEECA	National Energy Efficiency & Conservation Authority
NPR	Nepalese Rupee
OECD	Organisation for Economic Co-operation and Development
PKR	Pakistani Rupee
SACEP	South Asia Co-operative Environment Programme

SCP	Sustainable consumption and production
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable development goals
SHGC	Solar heat gain coefficient
TPD	Tonnes per day
TSM	Technology Sub Mission
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USD	United States Dollar
VLT	Visible light transmission
VOC	Volatile Organic Compounds
WBCSD	World Business Council for Sustainable Development
WBG	World Bank Group
WCEF	World Circular Economy Forum
WHO	World Health Organisation

Executive Summary

Asia has emerged as the world's largest regional economy and its rise to global significance is evident from its growing production and consumption pattern. Rapid urbanisation and industrialisation in the region have increased the material and energy consumption in the built sector over the years and has become one of the largest contributors to GHG emissions and generation of construction and demolition (C&D) waste. Following the severe slow down due to the outbreak of COVID-19 pandemic in 2020, Asian construction sector is bound to recover this year.

Countries in Asia region show their own diversity when it comes to integrating circularity in built sector in their national policies. With countries such as China and India becoming the new global manufacturing hubs, significant efforts are being made towards green energy transition. However, the management of C&D waste still remains a challenge in these countries. On the other hand, countries such as Nepal and Sri Lanka are still in their infant stages of adopting circular economy and plenty of work needs to be done in this sector.

The section on Circular Economy Initiatives assesses in detail the present policy landscape in the context of circular built environment. Several country-level commitments have been made especially in China, India and Sri Lanka; however, their implementation needs strengthening. It is imperative to close the loop at all stages to truly adopt and follow circular economy principles. Some countries, for instance, China has followed this approach to an extent by enforcing laws for the industrial sector, whereas, its buildings sector policies are largely voluntary certification driven. India has made notable progress in bringing out policies on both demand- and supply-side. However, enforcement and implementation challenges of all building-level policies can be largely attributed to the fact that buildings lie in the purview of the state governments. Sri Lanka and Indonesia have been actively pursuing their commitments to climate change.

Stakeholders of the built environment play a crucial role in transforming the linear economy into a circular economy. The stakeholder's map showcases the potential actors that can bring this change. Interviews and consultations were carried for the collection of good practice case studies from the selected six countries at various life cycle phases including design, construction, manufacture, operation, and deconstruction. The classification of environmental and social impacts along with new businesses and green jobs will be seen in the section corresponding to the case studies.

These cases also highlight the Sustainable Development Goals (SDGs) that are the blueprint to achieve a better and more sustainable future for all. Further, the SBC programme network is building an SDG-based indicator matrix by means of a global survey targeting experts and network participants, who have given priority to SDGs 11, 12, 13 and 9. While respondents from Asia have prioritised the same goals, they have also prioritised a greater number of SDG indicators for higher Human Development Index (HDI) and lower HDI countries. High HDI countries show higher importance for SDG7: Energy, SDG3: Health and SDG17: Global Partnerships compared to lower HDI countries. Lower HDI countries show higher importance for SDG6: Water and Sanitation, SDG4: Education, SDG5: Gender Equality and SDG15: Halt Biodiversity Loss. While the circular economy is not explicit in the 2030 Agenda, SDGs actually may provide a global pathway to guide policies, actors and initiatives towards circularity at different geographical and institutional levels. In the consultation done with the group of experts at regional level it was recommended that correlation of secondary SDGs and Indicators variation in the two groups should be more focused and need further studies at the country level.

The country-level assessment points towards specific gaps in achieving circular economy goals in the true sense. However, the overall challenge of implementation of the policies persists. The transition towards a circular built environment requires stakeholders to adapt or change their role in the value chain (Thelen, 2021). Identifying the facilitators, constraints, and opportunities to transform the linear built environment to the circular built environment requires a review of existing and upcoming policies, interviews with industry leaders, and consultation with stakeholders and professionals. The components of the circular built environment are already emerging. Nevertheless, there are barriers that must be addressed to mainstream circularity in the built environment. Through the study, the detailed barriers and recommendations are identified at the three changing roles of the stakeholders: supply side, facilitators and demand-side. The specific recommendations will act as a way forward in implementing circularity in the

1. Introduction

Over the years, the built environment has become a major consumer of natural resources. The built environment, consuming almost half of the world's resources extracted every year and responsible for a massive environmental footprint, is a fundamental sector in the transition from a linear to a circular economy (Arup, 2016).

Asia contains some of the most populated and fastest-growing cities of the world. Tokyo, Japan, Delhi, India, and Shanghai, China, are the largest cities and the most densely populated. While the cities are expanding, most Asian population is not moving to megacities. This is also the reason why many cities are also witnessing a population decline or flatline resultant of the saturation (World Economic Forum, 2016).

Some countries, for instance Japan and China, maybe capacitated to deal with urbanisation in the years to come. However, both cities are facing challenges due to induced stress on the existing built infrastructure. This has led to a rise in issues around pollution, water scarcity, increasing temperatures, and infrastructure management.

The resources in the Asia region are strained and under threat largely due to the impacts of climate change, urbanisation, and rising demand. Resource consumption patterns have often followed a linear trend and the availability of resources has endured this approach so far. The decarbonisation commitments in the built environment are growing; however, there is a need to upscale and leapfrog to achieve the Paris Agreement Goals.

COVID-19 has a significant impact on the global construction industry and construction activities have dropped by 10–25% compared to 2019 (Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme, 2020). This change was witnessed in the Asian markets, particularly China, with construction growth seen in the region at 4.4% per year (down from 5.1% per year from 2014-19). As economies open post lock-downs, there is a need to 'build back better' aiming at decoupling economic growth from resource consumption.

The circular economy concept offers an opportunity to adopt and switch to a sustainable consumption and production pattern. There is a need to utilise materials, products and components in repetitive loops, maintaining them at their highest possible intrinsic value. This would also lead to designing more durable products and materials that can be repaired, refurbished, reused and disassembled. The process will maintain components and their materials at the highest useful purpose, as long as feasible, minimising resource waste.

The report aims to provide a deep dive into the state of play for the circular built environment in China, India, Indonesia, Nepal, Pakistan, and Sri Lanka. It presents good practice case studies covering different life cycle stages, and impact categories emphasising on the sustainable development goals and indicators for circularity from the UN2030 Agenda indicators identified through a global survey. The study identifies barriers and provides recommendations on the way forward. There is a consensus that the current production and consumption patterns of society need to be radically transformed in order to be compatible with a carbon- and resource-constrained future.

2. Significance of this work

Asia is the largest continent and the fastest urbanising region in the world with associated trends of escalating material and energy intensity in building construction. The continent shows disparities among the various countries in terms of population, area, urbanisation, economy, and geo-climatic conditions. The built environment is responsible for the majority of global greenhouse gases and raw material extraction. The signs of climate breakdown are the most visible symptom of environmental damage caused by human actions, revealing the realistic cost of linear growth (Circle Economy, 2019). Building construction is one of the major sectors, which makes a significant contribution to the regional economy of Asia and has the potential to create new value and economic growth from the transition towards a circular economy. Most developing countries in Asia are expected to follow the trends of developed countries of the world in the use of steel, glass, and concrete. China and India are the fastest-growing economies in the world, which makes it even more essential to study the building and construction trends in Asia to further develop a roadmap for a sustainable, resilient, and circular built environment.

Highlights from the Asia report provide a deep dive into the fast-growing Asian economic countries; China, India, Indonesia, Nepal, Pakistan, and Sri Lanka. Implementing the transition from a linear to a circular economy in these countries will require a joint effort by stakeholders from all sectors. There is a need to address the existing and new policy instruments adapted within a comprehensive policy framework to infuse signals and incentives that promote the circular economy and resource efficiency. Asian people, rooted in their age-old practices, have been reusing, renovating, sharing, and upscaling products in what is now seen as advanced models of the circular economy. Therefore, it becomes important to understand the circularity trends at a global, regional, and country-level focusing the current scenario of building and construction industry, policies and initiatives, and impact on the built environment. A crucial role of this report is not only to provide a benchmark but also recommendations on how to move forward towards a sustainable and circular built environment. This report further builds on the in-depth analysis of the policies, platforms, and initiatives in the context of circular economy in the built environment of the selected countries examined at different life cycle phases including manufacturing, design, construction, operation, and deconstruction.

The significance of this work is not only to deep dive into the selected six countries and address the state of the play for circularity in the built environment but also to provide a way forward to bring out robust, credible, and critiqued circularity recommendations against relevant SDGs and life-cycle considerations across the various phases of the built environment in Asia to forge a sustainable future.

3. Built Environment and Circular Economy in Asia

3.1 Global Perspective

Currently, around 55% of the global population resides in urban areas, which is further expected to grow to 68% by year 2050, adding approximately 2.5 billion people. This growth can be attributed to rapid urbanisation, migration of people from rural to urban areas, economic growth concentrated in and around urban centres, and the rising purchasing power of people (UN, 2018). Around 90% of this increase will take place in Asia and Africa exclusively. Alone, India, China and Nigeria will comprise 35% of the estimated growth of the global urban population between 2018 and 2050. It is projected that India will have 416 million urban dwellers, China will have 255 million urban dwellers, and Nigeria will have 189 million urban dwellers. There were

5.6 billion people in urban areas in 2015, nearly twice that of 1975 and their building footprint increased to 0.5 million km² which is a 20% increase since 2000 (European Commission, n.d.). It is estimated that if this rising trend of population in urban areas continues, the global urban land cover will increase by 1.2 million km² by 2030, thrice that of the land area in 2000 (Seto, et al., 2012). Around 230 billion m² of projected new construction will double the current global floor area by 2060 (UNEP & IEA, 2017). With a consumption of 50% of steel and 3 billion tonnes of raw materials, the construction sector is considered to be the largest consumer of raw materials and other resources globally (World Economic Forum, 2016). Rapid urbanisation has increased extraction and production of raw materials such as sand (for concrete and mortar), soil (for clay bricks), stone (for aggregates) and limestone (for cement) exponentially.

This has a significant ecological footprint as it has led to consumption of energy at high level, GHG emissions and generation of C&D waste. In 2019, the construction and buildings sector accounted for approximately 35% of total final energy use globally and contributed nearly 38% to global energy- and process-related annual GHG emissions (United Nations Environment Programme, 2020). The global final energy consumption for building operations in 2019 was 130 EJ (United Nations Environment Programme, 2020). Urbanisation and twofold increase in the built surface area by 2050 will lead to the building's final energy demand to increase by 50% as compared to the levels in 2015, under business-as-usual scenarios (Graham, 2019).

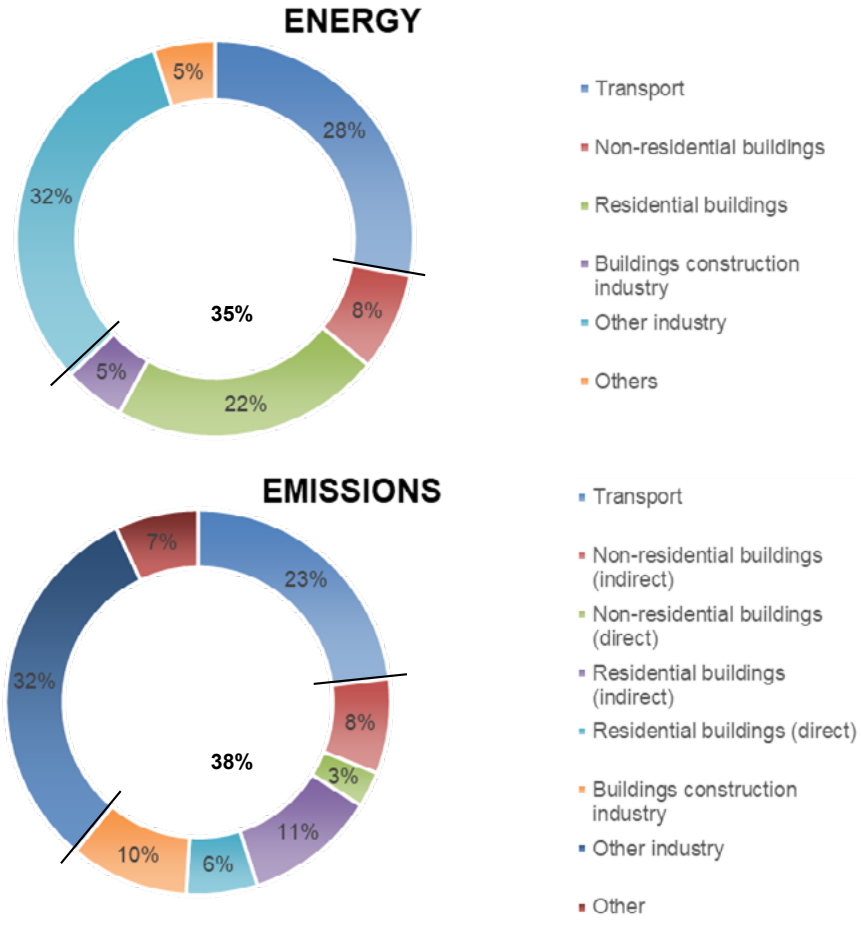

Figure 1: Share of buildings and construction final energy and GHG emissions globally in 2019

(United Nations Environment Programme, 2020)

The construction industry is responsible for a significant amount of C&D waste. The building sector's C&D waste represents around 20% to 30% of total solid waste generated globally, out of which 70% to 80% is concrete and masonry (Malik & Gupta, 2018). Reuse and recycling C&D waste remains low in the sector. It is estimated that C&D waste materials take up over 4,300 acres at a depth of 50 ft, resulting in over 3 billion yd² of landfills each year (Spiegel, 2019).

Managing such a huge chunk of waste is a challenge for any country. However, countries like Germany, France, Japan, Hong Kong, Taiwan, Belgium, Denmark, United States of America, Belgium and Denmark are reusing their C&D waste to some extent. Other developing nations such as Australia, Western Europe, USA have progressed considerably in adopting C&D waste management system. However, major C&D waste producing countries such as China, India, Indonesia, Malaysia, Thailand, Gulf States, Brazil, Mexico are still in their nascent stage in adopting the C&D waste management system.

Figure 2: Annual C&D waste generation in various countries (in tonnes)

(Building Materials & Technology Promotion Council, 2018)

It is estimated that the construction industry uses around two-fifths of the world's energy and materials flow, one-quarter of global wood harvest, and one-sixth of freshwater reserves. It contributes 13–30% to total waste generated globally. The share of C&D waste in total solid waste stream can be very high and vary among different countries. For example, in Europe it was 25–30% in 2016, in Hong Kong it was 23% in 2014, in the United Arab Emirates it was 80% in 2010, and in Singapore it was 59% in 2011 (Turkyilmaz, 2019).

The effect of Covid-19 pandemic has been seen far and wide globally. The pandemic has impacted all economic, commercial and social activities. The building and construction industry too has been hit by this crisis. Most countries across the world have experienced a slowdown in the construction sector as lockdowns led to temporary suspension to protect the health of the workers and the global recession created a decline in the demand for new buildings. As a result, the construction industry across the globe incurred huge losses that had an effect on the world economy. The transportation system also was affected by the pandemic, which resulted in disruption in the supply of raw materials. Many construction companies laid off their workers as they faced financial recession.

From USD 11,217.4 billion in 2019, the global construction market witnessed a decline to USD 10,741.2 billion in 2020 (WBOC, 2021). With operations resuming by the end of 2020, the construction industry has shown signs of recovery since the beginning of 2021 and is expected to reach a market size of USD 13,572.4 billion in 2024. Countries in the Asia Pacific region (APAC) have emerged as a major construction market owing to the increasing construction activities in China, India and various South-east Asian countries due to technological advancement and ease in government regulations and policies. This is despite the region experiencing huge decline in the construction market in 2020 owing to lockdowns across various countries. The world was again hit by the second wave of the pandemic during the second quarter of 2021, due to which the construction sector experienced some disruptions. But most of the construction companies were found to be resilient and prepared this time as the construction sector had started witnessing strong recovery prior to the second wave of the pandemic and pace of execution had crossed the pre-Covid levels.

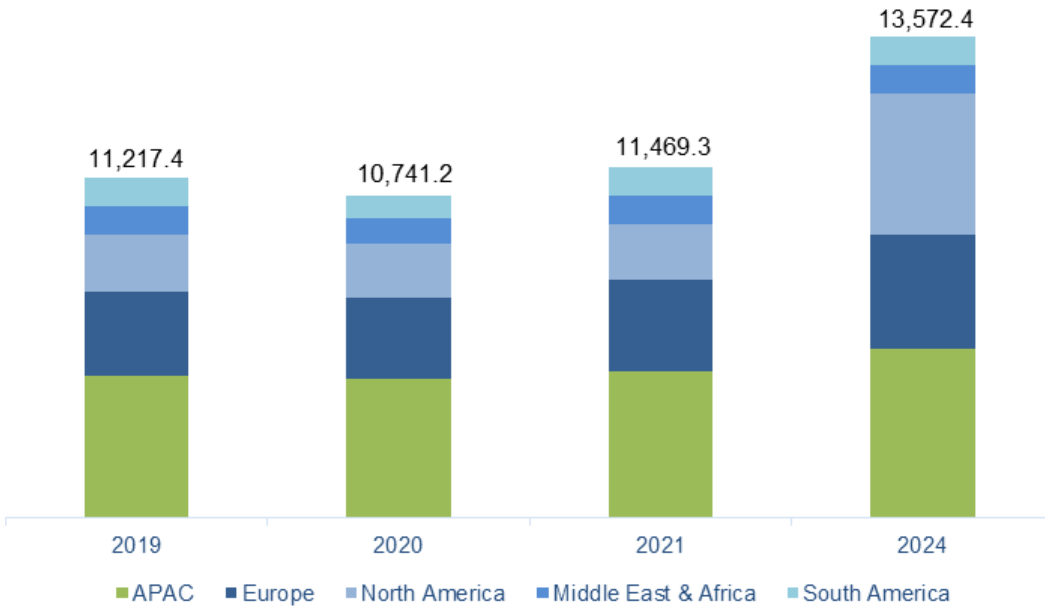

Figure 3: Impact of Covid 19 on construction industry in different regions (USD Billion)

(Markets and Markets, 2021)

3.2 Regional Perspective

Asia is the largest of the seven continents, covering 30% of the total land mass of the Earth. About 60% of the world population lives in the continent (World Population Review, 2021), extending from polar regions to the equator comprising mountain systems, plateaus, plains, steppes and deserts, freshwater systems, seas and oceans. The continent shows huge variations among the various countries in terms of population, area, urbanisation, economy and geo-climatic conditions.

Countries such as India, China, Indonesia, and Pakistan are the most populous countries in Asia with India and China having vast landcover, while Nepal and Sri Lanka covering smaller land mass with lesser population. China and Indonesia score high in Gross National Income (GNI) per capita. For the year 2020, it was USD 17,200 and USD 11,750, respectively. On the other hand, countries such as Nepal and Pakistan have low GNIs of USD 1190 and USD 1280, respectively (The World Bank, 2021). It is estimated that by 2030, Asia will contribute roughly 60% of the global growth. The bulk of that growth will come from the rapidly industrialising

and developing markets of China, India and South-East Asia (Yendamuri & Ingilizian, 2019). Meanwhile countries such as Indonesia are set to grow their labour forces significantly, leading to a rise in per capita disposable income. However, Asian countries such as Sri Lanka and Nepal are still dominated by primary sector activities such as agriculture and are expected to have a slow transition to the industrialised sectors.

Asia is gifted with a variety of natural resources such as dense forests, vast reserves of minerals and natural gas and soil type, which help in the economic development of the region. Given its dependence on natural resources and agriculture sectors, the Asian region, including Pacific, as compared to other regions has become more vulnerable to climate change risks. As global warming becomes one of the most significant challenges to economic development, the Asian region has emerged on the frontline of climate change. Six of the ten largest economic loss events in 2019 that occurred in the region were caused by extreme precipitation (typhoons or monsoons).

Out of the various other reasons, the impact of built environment on our resources, contributes significantly to global greenhouse gas (GHG) emissions. In 2018, 27% of the total final energy consumption and 24% of the total process and energy-related CO_2 emissions were accounted in ASEAN, China and India (Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme, 2020).

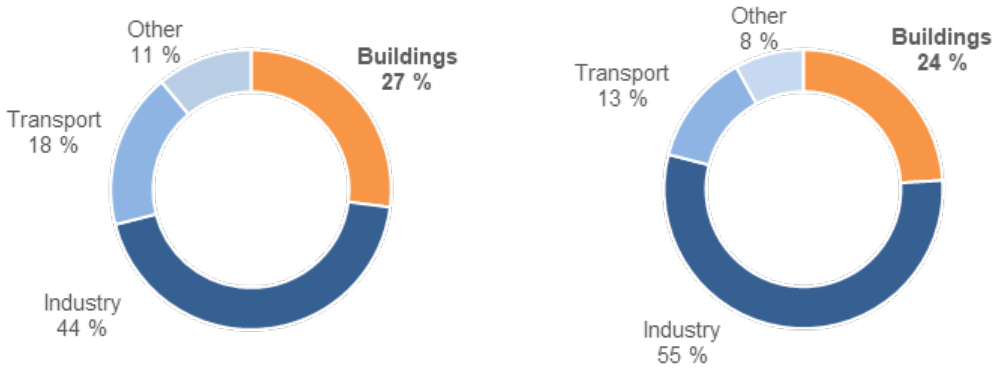

Figure 4: Share of buildings final energy and GHG emissions in ASEAN, China and India in 2018

(Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme, 2020)

To lower the impact of the built environment and forge a sustainable future, there is a need to transform the linear built environment into a circular built environment. Asian countries have already realised the potential of this model in strengthening their economies and have started developing regulatory measures and integrating them into their national policy frameworks to ensure a circular economy and closed loop systems. Countries such as China have adopted regulation on circular economy since 2009 and India enacted an e-waste law in 2016. However, there are other countries such as Nepal and Sri Lanka still in nascent stages of adopting circular economy models.

It should be mentioned here that since ancient times, the circular economy model has been a part of their culture in most of the Asian countries. Asian people, rooted in their age-old practices, have been reusing, renovating, sharing and upscaling products in what is now seen as advanced models of circular economy. These energy and resource-efficient traditions and practices strengthen many national development strategies. For example, since 1997 Thailand has adopted a national sufficiency economy philosophy in its development plans. First advocated

by the late King Bhumibol in 1974, this philosophy, with each National Economic and Social Development Plan, has gained prominence in its application to production processes, from agriculture to cement manufacturing (Sartori, 2016/17).

Owing to the increasing construction activities in China, India, and other Southeast Asian countries, the Asia Pacific region has emerged as a major construction market in the last decade. This has been possible due to factors such as government norms, regulatory policies and technological advancements driving the construction industry in this region. However, it is to be highlighted here, and as already mentioned, that the ongoing novel coronavirus outbreak has had a significant impact on developing countries in 2020, especially on South-Asian economies. Continuous lockdowns in the region has resulted in huge decline in the construction market.

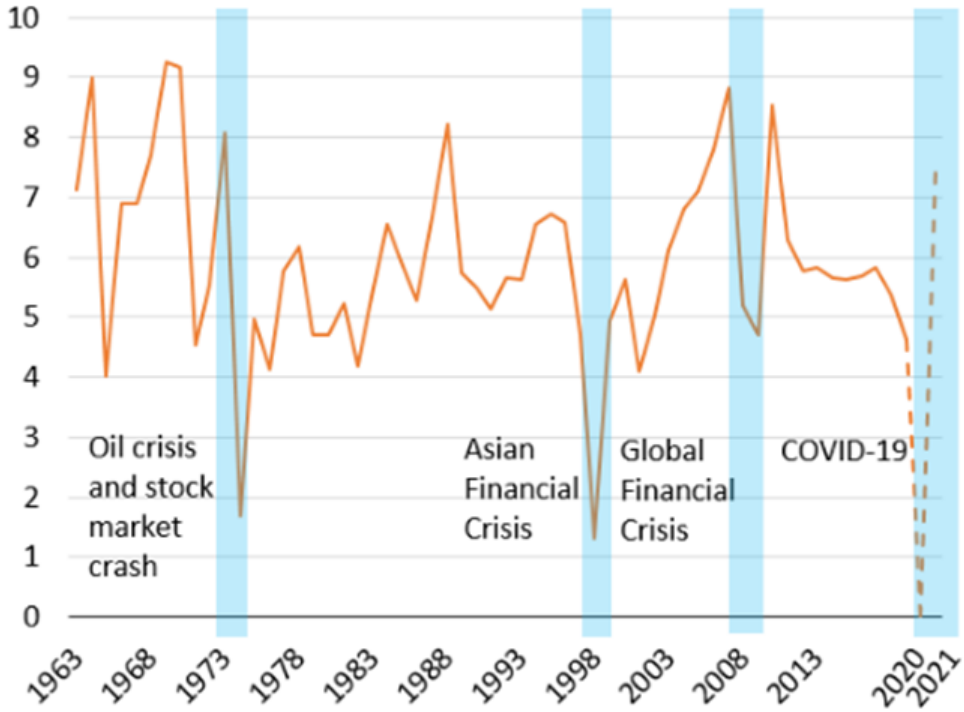

Figure 5: Real GDP growth in Asia region (in %)

(Rhee, 2020)

But fortunately, recovery from the pandemic crisis has strengthened in developing Asia further. Countries have started to bounce back after a severe economic slowdown in 2020, although the overall recovery has been inconsistent. Growth in most regional economies strengthened in the latter part of 2020. Trade and manufacturing have recoiled, payments have been resilient, and policy support remains robust. Growth in 2021 is expected to be strongest in East and South Asia, driven by China and India, and more moderate in Central and Southeast Asia. Developing Asia is projected to grow by 7.3% in 2021, higher than normal due to the comparison with a weak 2020. Growth is expected to be moderate to 5.3% in 2022 (Asian Development Bank, 2021). Assuming that renewed COVID-19 outbreaks are brought under control, domestic demand and economic activity will continue to strengthen this year and the next. Progress on vaccine rollouts and recovering regional as well as global demand are expected to consolidate the growth momentum. However, the main risks to the estimates made could be the new virus outbreaks and spread of coronavirus variants or delays in procuring and administering vaccines.

3.2.1 Country Perspective: China

Scenario of Building and Construction Industry

Out of the three sectors of economy (primary, secondary and tertiary) in China, the secondary sector is the most important one consisting of industry contributing to 40% of GDP and construction contributing to 9% of GDP (FXEmpire, 2021). In 2016, both under construction and completed built up areas reached 12.6 billion m^2 and 4.2 billion m^2, respectively (Zhu, 2018). The value-added output of the construction industry reached USD 830 billion in 2017, compared to only USD 2.07 billion in 1978 (Trade Commissioner Service, 2019). Due to rapid population growth in China's urban areas, it is expected that by 2040, population will double, creating substantial demand for new housing and infrastructure.

COVID-19 caused a massive slowdown with the Chinese economy declining to -6.8%, a positive change was seen from quarter 2 of year 2020. The economy reached a record 18.3% in quarter 1 of year 2021, followed again by a slowdown of 7.9% growth in quarter 2. This was due to the slowdown in factory activity, higher raw material costs, and new waves of COVID-19 outbreaks in some regions, all putting a stress on the recovery momentum.

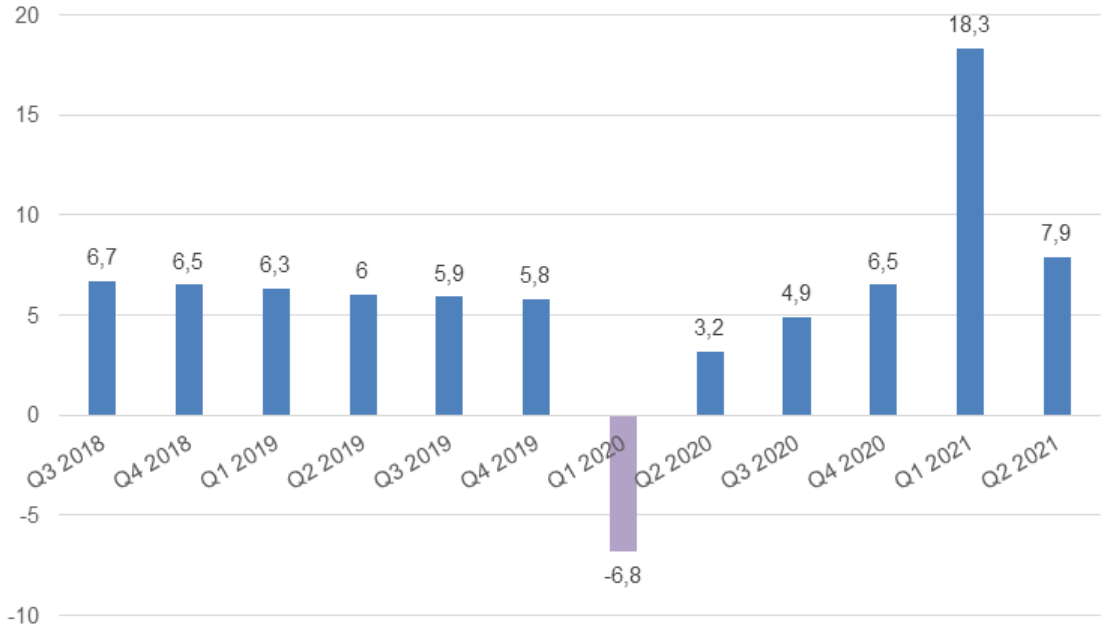

Figure 6: China GDP annual growth rate July 2018 – June 2021

(Trading Economics, 2021)

After facing a decline of 17.5% in quarter 1 and 1.9% in quarter 2 in 2020, the construction industry's value-add started to grow by 2% from quarter 3 (Kwok, 2021). GDP from construction industry increased to 33,335 Chinese Yuan Hundred Million (CNY HML) in the second quarter of 2021 from 12017 CNY HML in the first quarter of 2021.

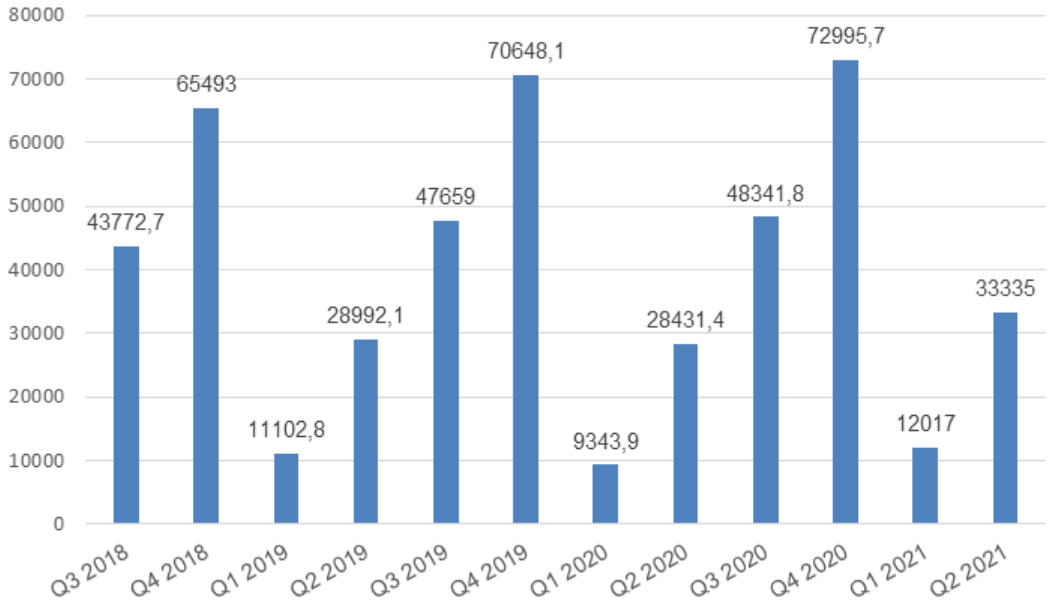

Figure 7: China GDP from construction July 2018 – June 2021 (in CNY HML)

(Trading Economics, 2021)

Policies and Initiatives

For the construction industry, there are several rules and regulations issued by the Ministry of Housing and Urban and Rural Development (MOHURD) and its local counterparts which are responsible for the administration and supervision of construction activities, in addition to the People's Republic of China (PRC) Construction Law.

To control emissions from the built environment sector, promote low-carbonised urbanisation, construction of green buildings and the application of renewable energy in buildings, improve energy efficiency of building and the quality of building construction, intensify energy conservation transformation for existing buildings and promoting the reutilisation of building wastes, China has developed a number of policies such as adopting mandatory energy efficiency codes for urban residential and commercial buildings and promoting voluntary energy-efficiency codes for rural residential buildings through financial incentives. China's 13th FYP included targets for improving building energy-efficiency standards and retrofitting, including targets to achieve a 65% energy-efficiency level compared to 1980 and retrofit 500 million m^2 of existing residential floor space. In 2018, more than 2.5 billion m^2 of urban and commercial floor space was green-building certified, while China has also launched its Near Zero-emission Buildings Standard in 2019. China's long-awaited 14th Five Year Plan (14th FYP), published in March 2021, included 2025 energy- and carbon-intensity reduction targets, as well as a mid-point non-fossil share target to achieve its NDC (Climate Action Tracker, 2021).

In September 2020, China announced its intention to become carbon neutral before 2060 and, in December, followed up with proposed new NDC target updates, strengthening its previous non-fossil share and carbon intensity targets, while adding a new renewable energy capacity target.

Impact of Building and Construction Industry on the Environment

The total building energy consumption of China increased from 310 million tonne of coal equivalent (tce) in 2001 to 860 million tce in 2015. In the National 10th Five-Year Plan of China i.e., during the period 2001–2005, the building energy consumption increased by 11.9%. This increase of building energy consumption slowed down in the National 11th Five-Year Plan of 2006–2010 to 5.3% and in the National 12th Five Year Plan of 2011–2015 to 5.5%. This can be attributed to the country's various building energy-efficiency initiatives launched by national and local governments in 2005–06. This included energy retrofits for existing buildings, promoting green building and low-energy building development and compulsorily energy-efficiency improvement programme for large-scale public buildings.

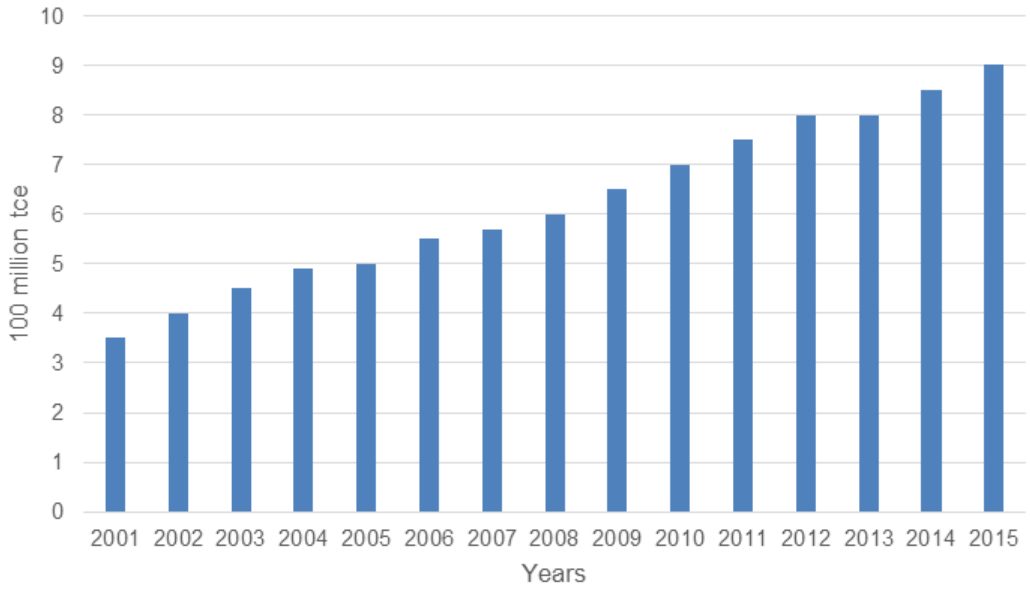

Figure 8: Total building energy consumption in China 2001–15

(Zhang, et al., 2019)

Construction and demolition waste management is a serious challenge in China as it generates high volumes of waste while the recovery rate remains low with most of it ending up on conventional landfill or dumping sites. According to data from MOHURD, the volume of overall construction waste in China has reached 2 billion tonnes every year and is now increasing by 10% annually (Wu, et al., 2017). C&D waste in China consists of concrete (48%), brick and block (21%), ceramics (10%), and other materials (21%). Given the scale of the problem, China's current C&D waste recycling rate of 5% is extremely low, most of which is reused for road gravel rather than re-entering the construction industry. Meanwhile, the dumping of toxic C&D waste causes soil, water and air pollution – the dust generated during transportation of C&D waste to landfill is one of the major sources of $PM_{2.5}$ air pollution in urban areas.

3.2.2 Country Perspective: India

Scenario of Building and Construction Industry

The construction industry contributes 8% to India's GDP. India is projected to become the world's third largest construction market by 2022. As per the economic survey 2017–18, India will require USD 4.5 trillion by 2040 for the development of infrastructure. FDIs in the construction development sector (townships, housing, built-up infrastructure, and construction development projects) and construction (infrastructure) activities stood at USD 25.93 billion and USD 23.99 billion, respectively, between April 2000 and December 2020 (Construction Placements, 2021). It is estimated that India's construction industry will continue to flourish because of increased demand from the real estate and infrastructure projects. The housing and township development sector has received USD 24.7 billion till 2017 through the Foreign Direct Investment (FDI) route (Goldstein Market Intelligence, 2020). Various factors such as the current scenario of infrastructure that is inadequate to sustain the urban population, new urban development mission by government and partnership agreements between urban local bodies and foreign players are further expected to boost the growth of the Indian construction industry. By 2030, Indian real estate sector is expected to reach a market size of USD 1 trillion with its expected contribution to the country's GDP to be approximately 13% by 2025 (Make in India, 2021). As the urban population of India continues to grow and is projected to become 50% of the total population by 2050, the demand for real estate and infrastructure is expected to increase (Central Public Health and Environmental Engineering Organisation, Ministry of Housing and Urban Affairs, Government of India, 2018).

After facing a big slump in quarter 2 of 2020 by 24.4% when the coronavirus crisis hit the economies hard across the world, the Indian economy rose at a record 20.1% year-on-year in quarter 2 of 2021. This was slightly higher than market forecasts of 20%, amid a low base effect from last year and despite a second wave of COVID-19 infections and localised lockdowns.

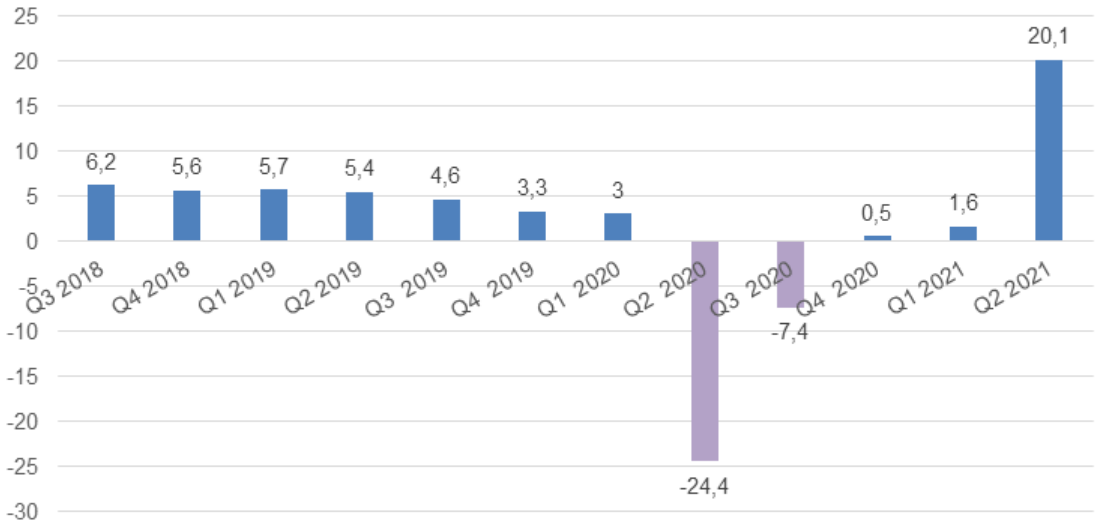

Figure 9: India GDP annual growth rate July 2018 – June 2021

(Trading Economics, 2021)

GDP from construction in India decreased to Rs 2212.56 Indian National Rupees (INR) billion in the second quarter of 2021 from Rs 3175.14 INR billion in the first quarter of 2021. The highest contribution in quarter 2 of 2021 was from the construction sector with 68.3%, followed by manufacturing sector at 49.6%, trade, hotels, transport and communication at 34.3%, mining at 18.6%, utilities at 14.3%, the farm sector at 4.5%, and the financial and real estate sector at 3.7%.

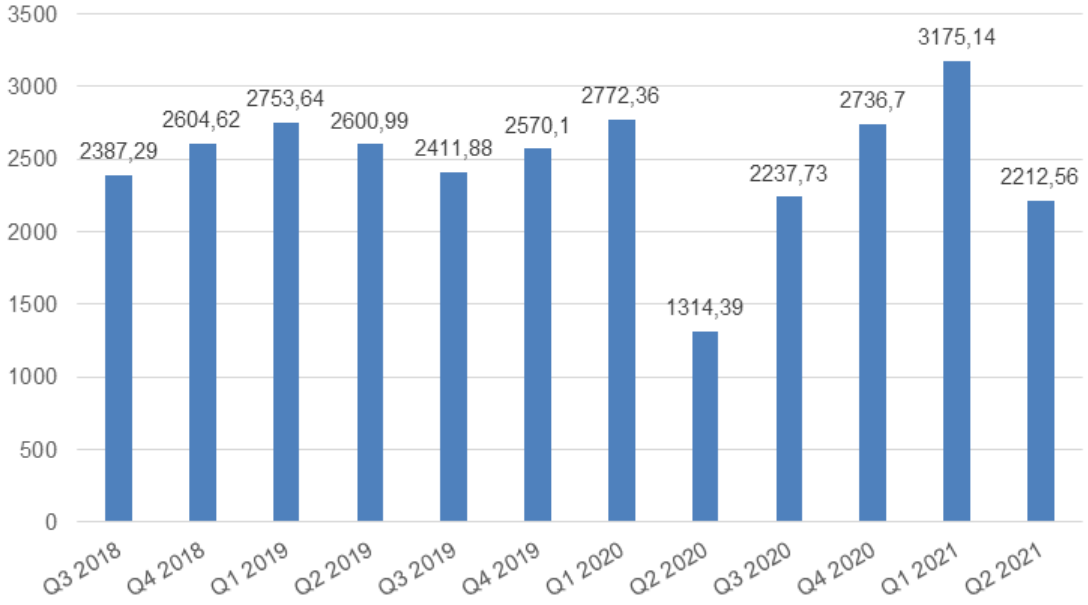

Figure 10: India GDP from construction July 2018 – June 2021 (in INR billion)

(Trading Economics, 2021)

Policies and Initiatives

Residential and commercial buildings in India account for nearly 30% of total electricity consumption and the use is expected to increase to 48% by 2042 (NRDC, ASCI, CEEW, IIPHG, SEWA and TERI, 2020). Thirteen states have notified the Energy Conservation Building Code (ECBC) with four states including a detailed compliance programme and five states incorporating the ECBC into their state by-laws. Over 225 commercial buildings have been certified under BEE's Star Rating Programme (BEE, 2019). India ranks third in the world for Leadership in Energy and Environmental Design (LEED) certification with more than 1400 LEED-certified buildings, including schools, hospitals, offices, residential buildings, and more (Sonja Trierweiler, GBCI, 2020).

As far as meeting its NDC targets are concerned, India has made significant progress while staying committed to meeting its climate goals under the Paris Agreement. Against the targeted emission reduction of 33–35% by 2030, India has already achieved emission reduction of 28% over 2005 levels. At this rate it is estimated to exceed its NDC commitments before year 2030 (Ministry of Power, 2021).

India unveiled one of the largest stimulus packages in the world, in response to the economic crisis that emerged due to COVID-19 pandemic, equating to a share of around 11% of the country's GDP in 2019. India's overall COVID-19 recovery stimulus package mainly supports activities related to industries likely to have a large negative impact on the environment (for

example, increasing the use of fossil fuels and unsustainable land use). However, India's most recent stimulus of year 2021 is more climate-friendly, with two-thirds of the resources targeted towards a green recovery, including roughly USD 3 billion in battery development and solar PV.

Impact of Building and Construction Industry on the Environment

It is projected that among all regions of the world, the fastest growth in buildings energy consumption through 2040 will occur in India. Delivered energy consumption for residential and commercial buildings in India is expected to increase by an average of 2.7% per year between 2015 and 2040, more than twice the global average increase.

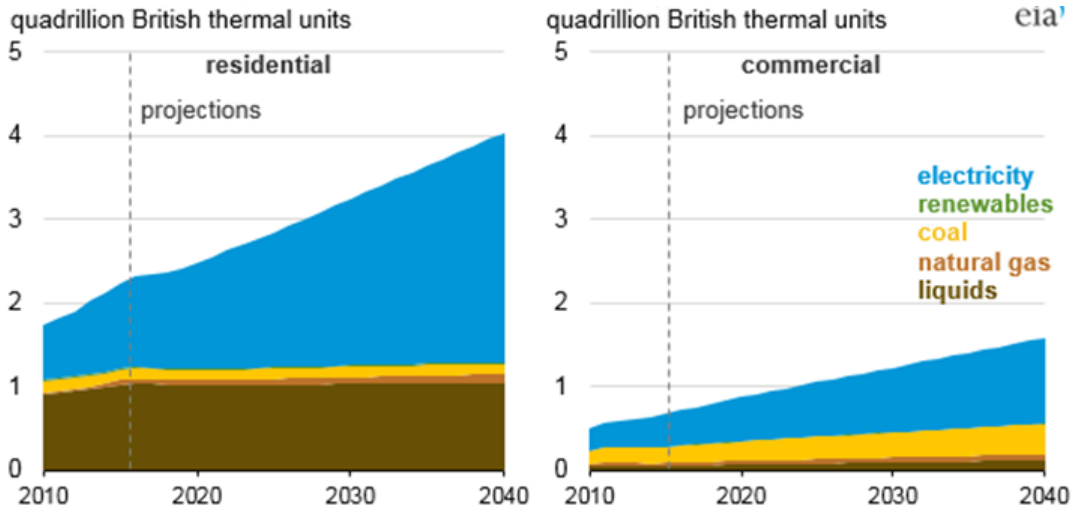

Figure 11: India building energy consumption by fuel, 2015 – 40

(Hojjati, 2017)

As far as C&D waste generation is concerned, India generates an estimated 150 million tonnes of C&D waste every year. But the official recycling capacity is less, i.e., 6 500 tonnes per day (TPD) – just about 1%. The unofficial estimates of the total waste generated in India is three-five times more than the official estimate. By 2017, 53 cities were expected to set up recycling facilities to recover material from the waste; only 13 cities have done it till now (Roychowdhury, 2020).

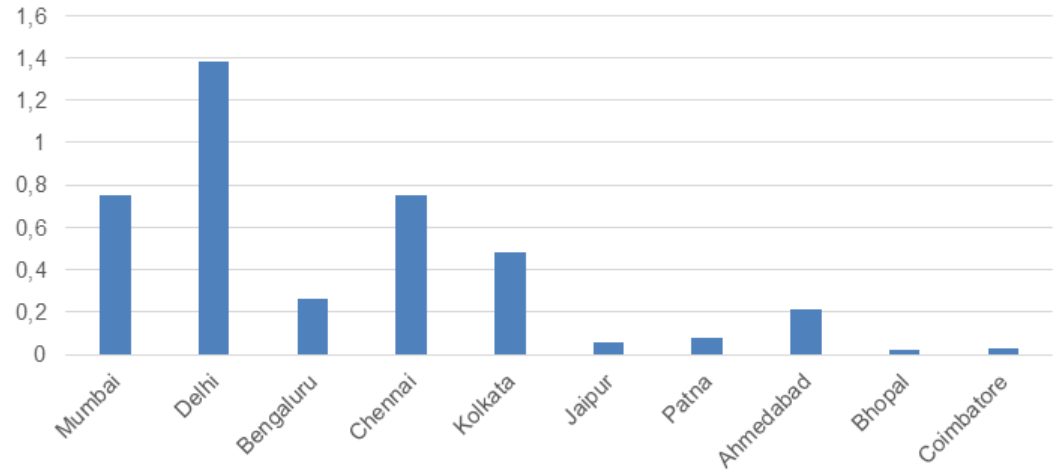

Figure 12: Annual C&D waste generation in major Indian cities (in million tonnes/annum)

(Malviya & Kumar, 2021)

3.2.3 Country Perspective: Indonesia

Scenario of Building and Construction Industry

Indonesia is one of the top Asian countries for construction market growth. The building and construction sector is one of the prominent sectors supporting the economic growth in the country. Infrastructure projects in Indonesia are the key to boost the construction sector in the country. The flourishing construction sector made the Indonesian economy in 2017 grow by 5.01%, and the GDP by 10.38%, higher than the preceding years. Indonesia's construction sector is growing at 7–8%/year.

In 2018, the total construction projects market in the country, excluding oil and gas sector, is predicted to be worth USD 32.2 billion. Annual per capita cement consumption in Indonesia stands at around 200 kg.

Impact of COVID-19

In the second quarter of 2021, Indonesia's economy expanded by 7.07%, rebounding sharply from a marginally revised 0.71% contraction in the previous quarter. Both household consumption (5.93% versus – 2.22% in quarter 1) and fixed investment (7.54% versus – 0.23% in quarter 1) rebounded while external demand contributed positively to the GDP, as exports jumped by 31.78%, while imports rose at a softer 31.22%. On the production side, output grew mainly for transportation and warehouse (25.10%), accommodation and food services (21.58%), mining (5.22%), manufacturing (6.58%), construction (4.42%), wholesale trade, retail (9.44%), communication (6.87%).

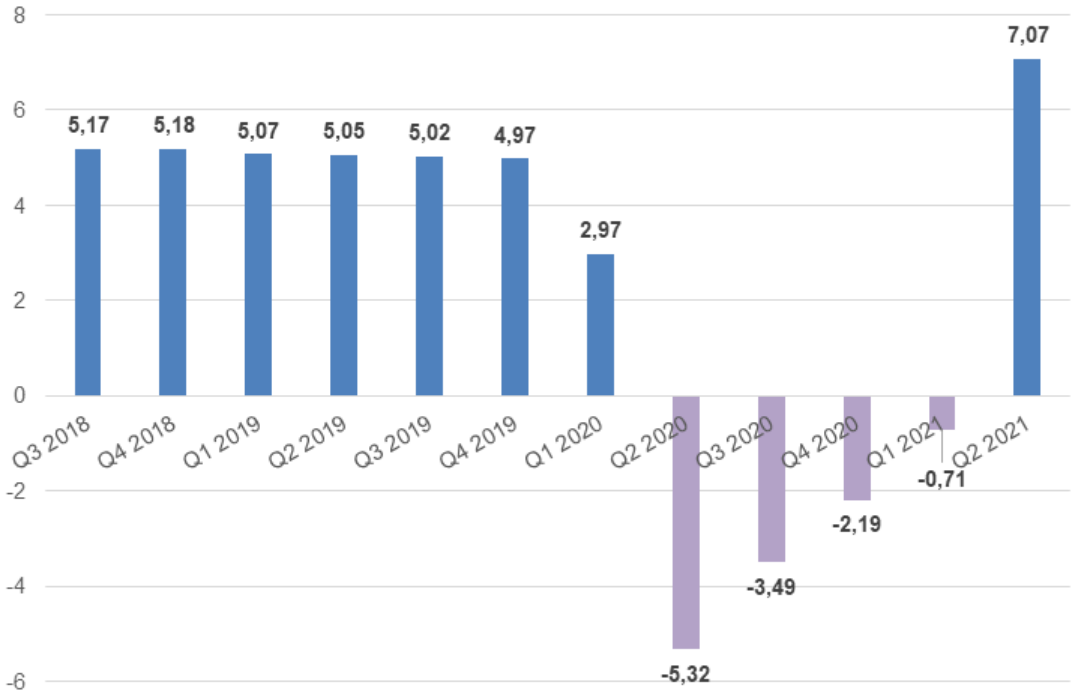

Figure 13: Indonesia GDP annual growth rate July 2018 – June 2021

(Trading Economics, 2021)

GDP from construction in Indonesia decreased to 264,663.70 Indonesian Rupiah (IDR) billion in the second quarter of 2021 from 271,471.40 IDR billion in the first quarter of 2021.

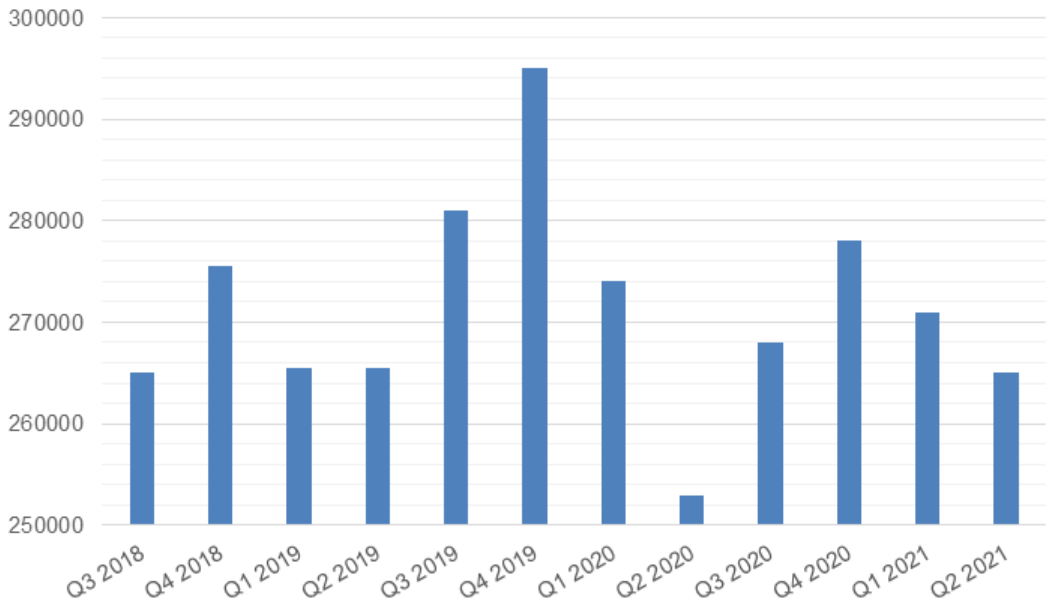

Figure 14: Indonesia GDP from construction July 2018 – June 2021 (in IDR billion)

(Trading Economics, 2021)

Policies and Initiatives

Construction industry has for long been the backbone of Indonesian economic and social development. The political reform of 1998 put Indonesia into a new governance paradigm, which, in turn, also affected practices of the construction Industry. The New Construction Law revoked Law No. 18 of 1999 regarding Construction Services (the 'Previous Construction Law') and introduced several changes and new provisions related to construction services in Indonesia.

On July 22, 2021, Indonesia submitted its updated NDC, confirming its existing 2030 targets. Indonesia again commits to an unconditional 29% reduction in emissions below a business-as-usual (BAU) scenario, and a conditional 41% reduction in emissions below the same BAU. The updated NDC links to the long-term strategy (LTS), submitted on the same day. Indonesia opens the door to setting a net-zero target, and presents a pathway compatible with doing so by 2060 in its LTS.

The growing middle-class energy demand means a continued relevance of the building sector in Indonesia. Emissions per capita in the building and construction sector have more than tripled since 1990. To mitigate the impacts of growing demand, the Indonesian government has set targets to reduce the total final energy consumption in the buildings sector (both commercial and housing) by 15% compared to a BAU by 2025 (Climate Action Tracker, 2021).

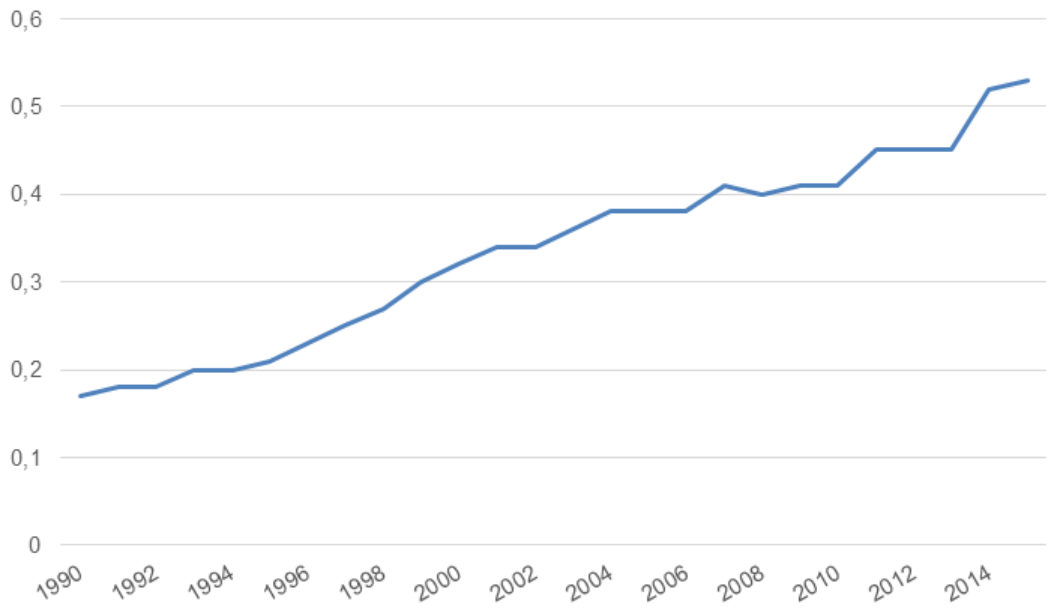

Figure 15: Building emissions intensity per capita in Indonesia (in tCO_2/cap)

(Climate Action Tracker, 2021)

Impact of Building and Construction Industry on the Environment

Building emissions in Indonesia occur directly (burning fuels for heating, cooling, etc.), and indirectly (grid-electricity for air conditioning, appliances, etc). Buildings represent a 4% share of direct CO_2 emissions and 16% share of electricity-related CO_2 emissions (Institute for Essential Services Reform, 2020).

Building-related emissions per capita are far from the G20 average of 1.48 tCO_2 and stands at 0.48 tCO_2. However, the five-year trend (2014–19) shows the scale of emissions per capita is increasing (14.01%) in Indonesia, which is more than the G20 average (1.82%) representing the growth of electricity consumption and coal in the power mix in the country.

3.2.4 Country Perspective: Nepal

Scenario of Building and Construction Industry

Nepal's construction sector is said to contribute about 10–11% to its GDP and uses about 35% of the government budget. It is estimated that it provides employment to about 1 million of people. Nepal is in the process of rapid infrastructure development. In the last two decades, there has been considerable progress in the construction industry in Nepal and is in the process of rapid infrastructure.

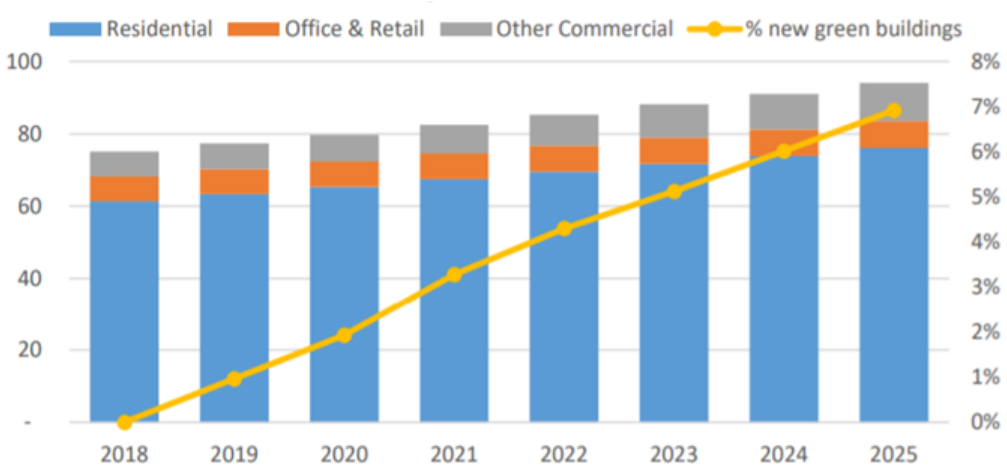

Figure 16: Projections for building stock in Nepal (in million m²)

(IFC, 2018)

Nepal like other Asian countries was also hit by the pandemic. In 2020, Nepal's real GDP decreased by around 1.88% compared to the previous year.

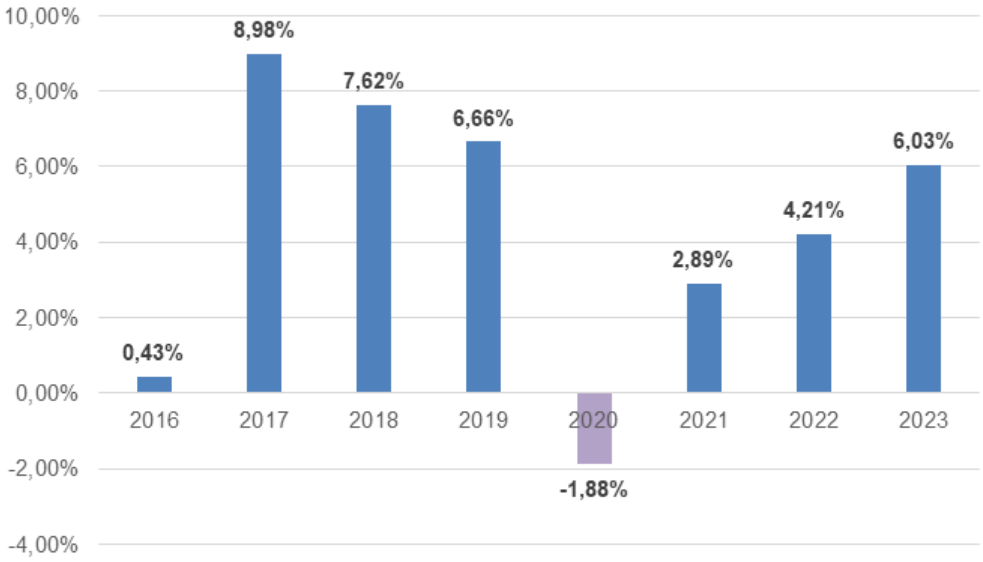

Figure 17: Nepal GDP annual growth rate 2016 – 2023

(Statista, 2021)

GDP from construction in Nepal decreased to 54,499 million Nepalese Rupee (NPR) in 2019 from 54,669 NPR million in 2018.

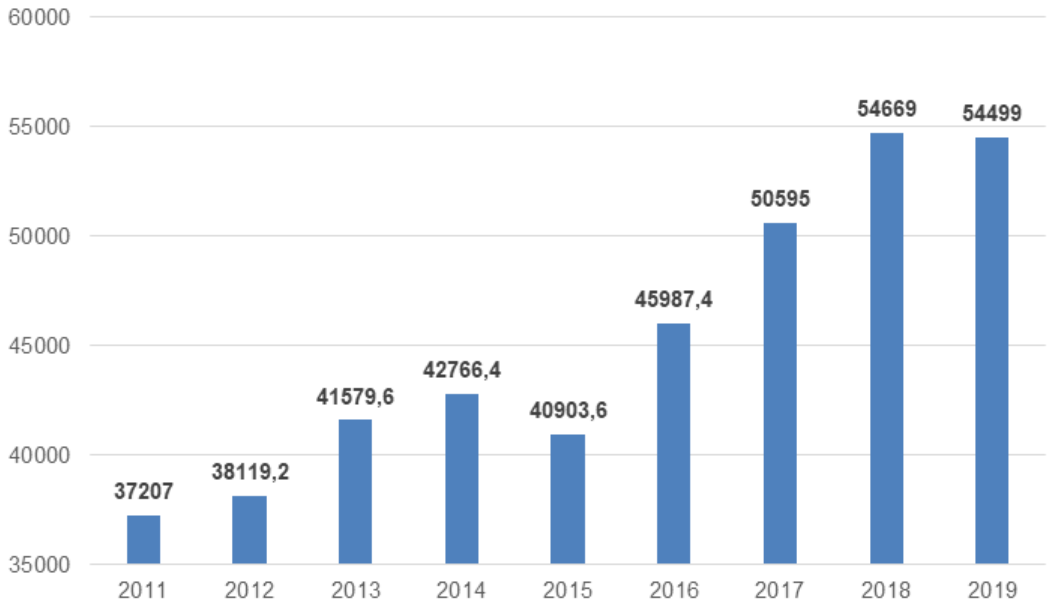

Figure 18: Nepal GDP from construction 2011– 2019 (in NPR million)

(Trading Economics, 2021)

Policies and Initiatives

The First Five Years Development Plan of Nepal was created in 1956 which gave a boost to the country's construction activities. The Industrial Resolution, 1957 adopted by the government of Nepal declared construction as the 'Priority Sector' industry (Baral, 2009). As the priority sector, construction firms enjoy income tax holiday along with other tax concessions for seven years from the date of incorporation, a more liberal depreciation rate, capitalisation of pre-investment expenditure, provision of foreign exchange facilities, etc.

Realising the need for enhancement of the construction industry, Construction Business Act 2055 was promulgated and came into force from year 1999 (Baral, 2009). This is an effort to institutionalise and systematise the construction sector. The act has defined the procedures and requirements relating to issues and renew of license and classification of and obligations of construction entrepreneurs. The Act has established Construction Business Development Council (CBDC) under the chairpersonship of the Minister for Physical Planning and Works and Construction Business Development & Implementation Committee (CBDIC) under the chairpersonship of Joint Secretary (technical) designated by the Ministry for Physical Planning and Works. These are both regarded as the apex institutions to develop the Nepalese construction industry. Establishment of the CBDC and CBDIC is the important step taken by the government to promote the construction industry of the country.

Nepal has initiated several activities to reduce climate hazards and build resilience, help climate vulnerable communities to cope with climate-change impacts, and reduce impacts of climate change on its people, property and natural resources. One of the mitigation actions includes building codes, which has provisioned for at least two trees in home gardens, rainwater harvesting and solar lights in urban homes. Nepal in its drive for reconstruction in the post-earthquake situation will strive to promote greener, smarter and better homes as guided by the National Reconstruction Authority.

Impact of Building and Construction Industry on the Environment

Nepal does not have its own reserves of gas, coal or oil. Although its most significant energy resource is water, less than 1% of the potential 83,000 megawatts of hydropower is currently harnessed. Energy consumption by the residential sector is found to be highest (80.36%) in the country followed by industrial and transport.

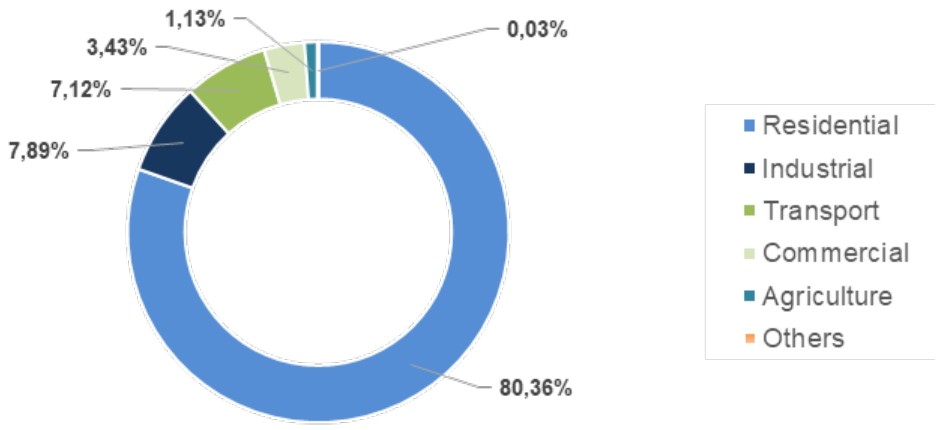

Figure 19: Share of energy consumption by economic sectors in Nepal

(NEEP, 2014)

Compared to other countries, Nepal has a high energy consumption in relation to its GDP. It does not yet have a strategy for sustainable, efficient energy use for either the electricity sector or its main primary energy source, biomass. Residential sector forms the major part of GHG emissions in the country.

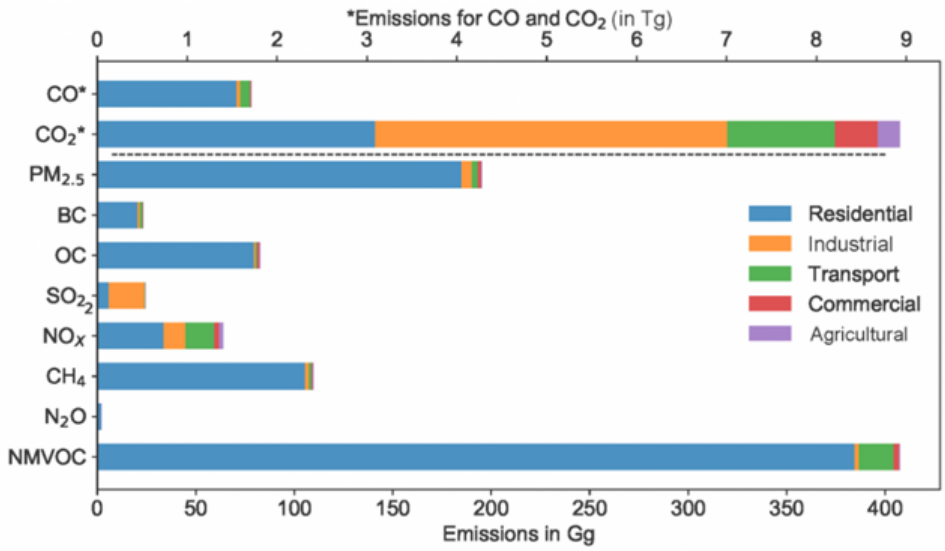

Figure 20: National emission estimates for aerosols and trace gases for all sectors in Nepal in 2011

(Sadavarte, 2019)

Buildings in Nepal traditionally are made of stone, adobe and burnt brick masonry, which are manually demolished and more than 50% of the material is being reused in construction applications. As the country lies on active tectonic plate, modern buildings have been built by using reinforced concrete frames with brick masonry fillers for the last 30 years. Most of the concrete and debris after demolition of a building is being disposed near construction sites or used as road infill. However, such activities re-suspend road dust from unpaved roads, a leading cause of air pollution, which can reach up to 500 µg/m^3. Furthermore, dumping debris into river banks aggravates flooding during heavy rain. Although being disposed, concrete waste still has value, and steel rods are separated for recycling and other such purposes (Ehler & Shrestha, 2015).

3.2.5 Country Perspective: Pakistan

Scenario of Building and Construction Industry

The construction industry is the second largest industry in Pakistan and is already mounting on the back of increasing infrastructure activities, rising demand of houses and construction recovery. It provides jobs to about 6.1% of total employed labour force or 2.43 million persons. The per capita consumption of cement in Pakistan is lowest among developing countries, i.e., 72 kg as compared to 603 kg in Japan, 600 kg in Thailand, 405 kg in China, 261 kg in the USA and 99 kg in India.

The outbreak of COVID-19 pandemic has further exacerbated the weaknesses in the Pakistani construction industry, which had already recorded contractions in 2019.The government had initially restricted activity in the construction industry amid the lockdown restrictions imposed to contain the pandemic; however, in mid-April 2020, it allowed the industry to resume operations. The GDP in Pakistan expanded 3.94% in the 2020/21 fiscal year.

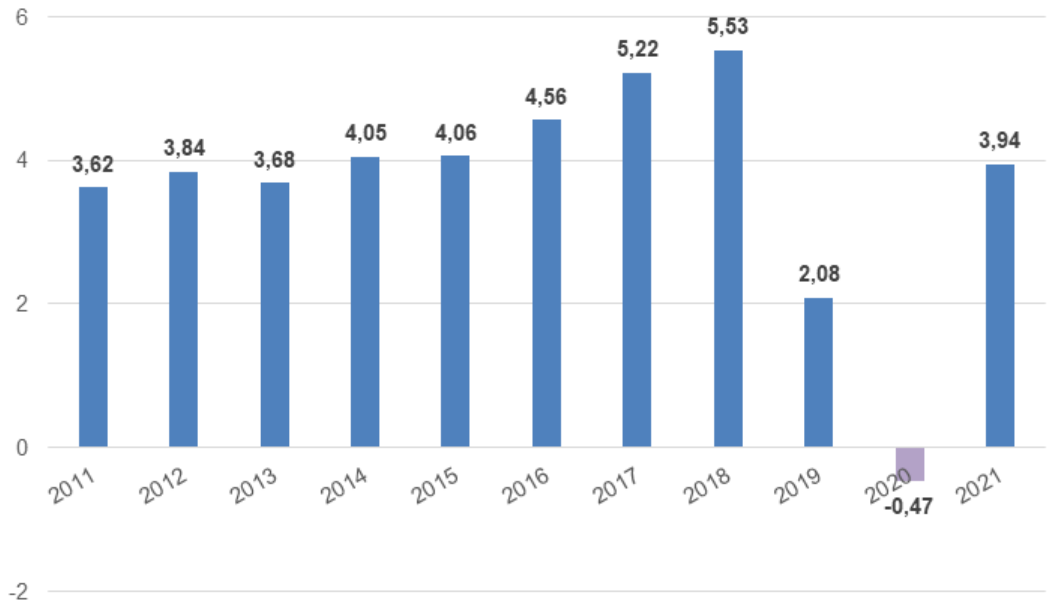

Figure 21: Pakistan GDP annual growth rate 2011 – 2021

(Trading Economics, 2021)

GDP from construction in Pakistan increased to 340,146 Pakistani Rupee (PKR) million in 2020 from 318,064 PKR million in 2019. To support the construction sector, and boost employment and economic output, Prime Minister Imran Khan announced a construction stimulus package in April 2020. The package includes a fixed tax rate for the construction industry, a subsidy worth PKR 30 billion (USD 91.5 million) for the Naya Pakistan Housing Scheme, a decrease in sales tax and incentives for builders to construct affordable housing.

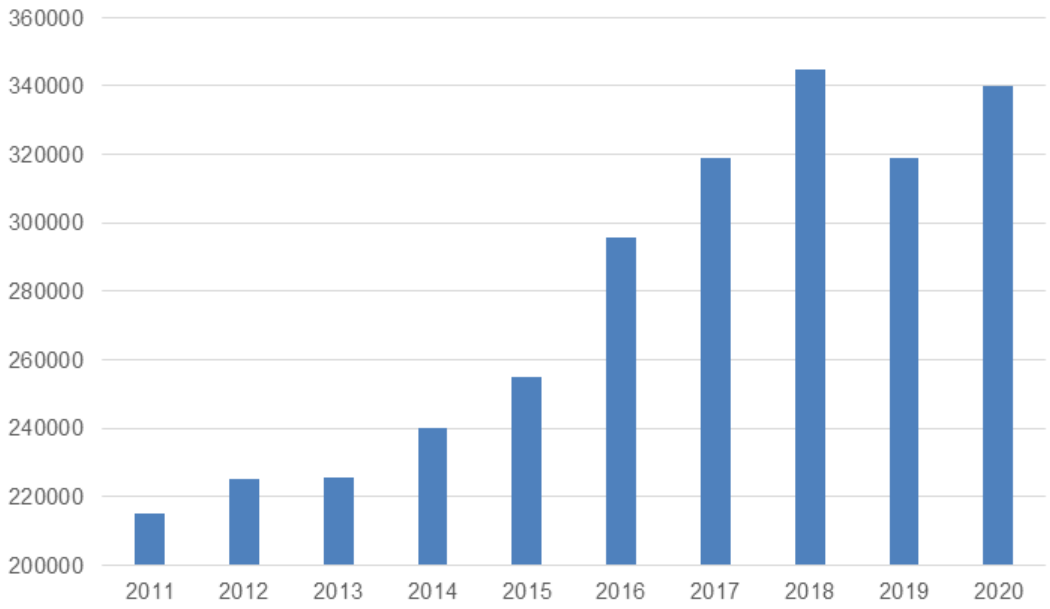

Figure 22: Pakistan GDP from construction 2011- 2020 (in PKR million)

(Trading Economics, 2021)

Policies and Initiatives

There is one federal authority that is responsible for energy conservation in all the sectors including buildings. The Building Energy Code of Pakistan (BECP) was developed in 1990 (Mahara, et al., 2018). Since then, there have been several technological developments in the last 20 years, which have changed the lifestyle of the people and increased the energy consumption at domestic level. It became essential to revise and update this energy code to cater to the recent developments. In 2011, Energy Provisions were developed to be included in the Building Code of Pakistan while in 2016 the federal government of Pakistan established National Energy Efficiency & Conservation Authority (NEECA), previously known as National Energy Conservation Centre (ENERCON) (Mahara, et al., 2018). NEECA aims to introduce and implement energy conservation policies and practices in Pakistan (Mahara, et al., 2018).
In the NDCs submitted by Pakistan in 2016, it pledged to use energy standards and labelling (ESL) to deploy high-efficiency technologies for lighting, space heating, refrigerators and air conditioners. The NDC also notes efforts to strengthen public sector capacity to promote, regulate and monitor ESL for manufacturers and importers.

Impact of Building and Construction Industry on the Environment

Pakistan is one of the countries with the highest energy consumption for domestic use. The annual energy consumption by the domestic sector is 45.9% of the total, while the industrial sector consumes about 27.5% (Sohail & Qureshi, 2011). About half of the total energy consumed is used in buildings and/or heating, ventilation and air conditioning (HVAC) and lighting appliances.

3.2.6 Country Perspective: Sri Lanka

Scenario of Building and Construction Industry

Real estate and construction is one of the top four fastest growing sectors in Sri Lanka. Sri Lanka has a strong focus on construction growth given its need for redevelopment after the end of the civil war. The construction industry grew by 20% in 2014, and there is currently about 185,806,080 m^2 of total space built. There is a significant backlog in meeting the growing demand for offices and residential spaces.

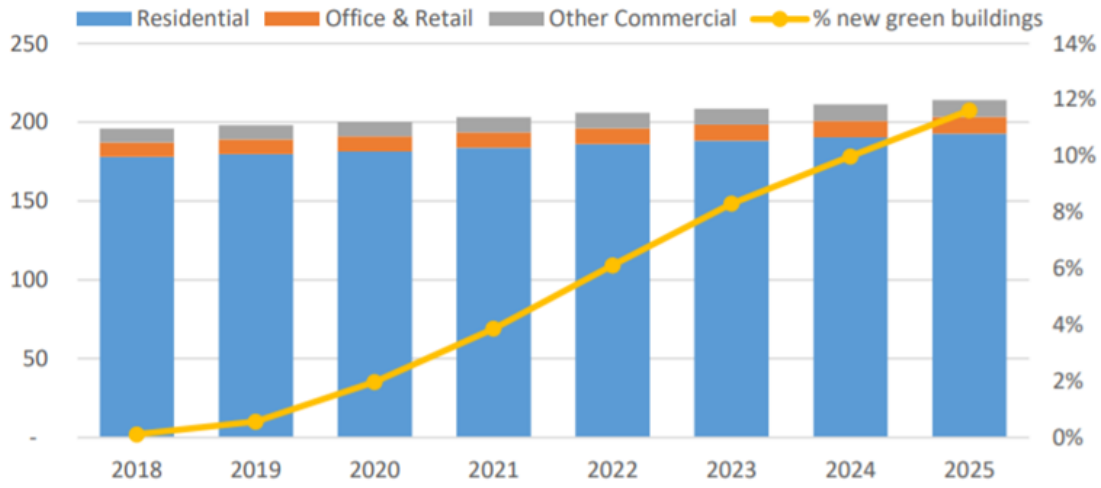

Figure 23: Projections for building stock in Sri Lanka (in million m^2)

(IFC, 2018)

Impact of COVID-19

The Sri Lankan economy advanced by 4.3% year-on-year in the first quarter of 2021, following a 1.3% rise in the previous period as shown in Figure 24. It was the fastest expansion since the last quarter of 2016, as the economy continued to carry out most of the business activities, even under the COVID-19 imposed restrictions amidst the second wave of the pandemic. The expansion was mainly driven by agriculture (6.1% versus 1.3% in quarter 4) and industry (5.5% versus 1.3% in quarter 4), due to the fact that despite occasional restrictions on the control of the virus, engagement in agricultural activities was allowed and the government supported keeping industrial establishments open and productive. The services sector also contributed positively to growth (3% versus 1.9%), despite continued weakness in tourism- and entertainment-related activities (–31.9% versus –49.1%).

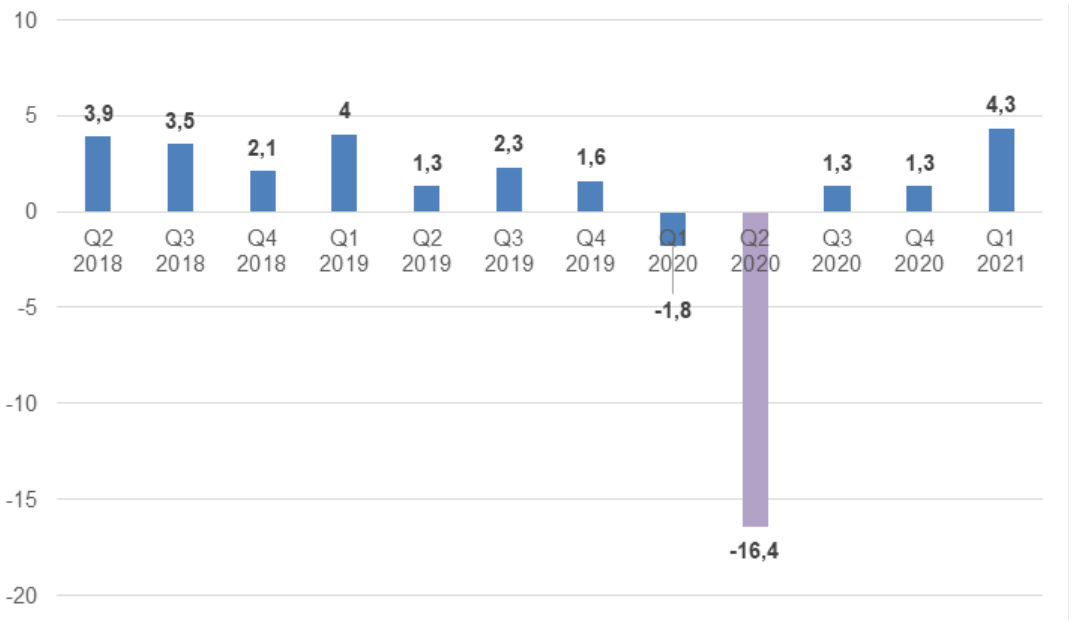

Figure 24: Sri Lanka GDP annual growth rate April 2018 – March 2021

(Trading Economics, 2021)

GDP from construction in Sri Lanka decreased to 137,391 Sri Lanka Rupee (LKR) million in the second quarter of 2021 from 154,286 LKR million in the first quarter of 2021.

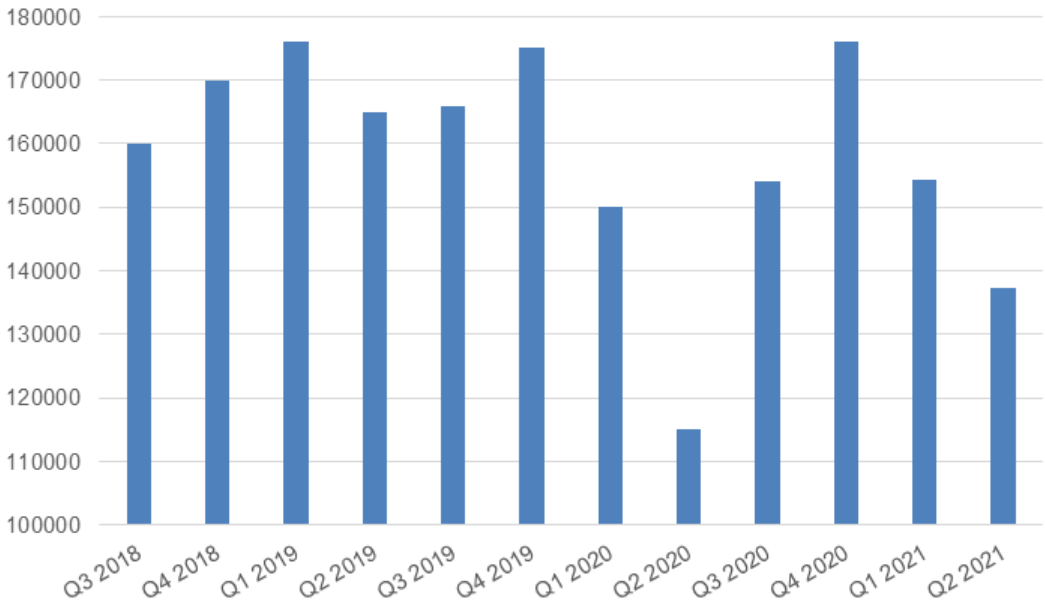

Figure 25: Sri Lanka GDP from construction July 2018– June 2021 (in LKR million)

(Trading Economics, 2021)

Policies and Initiatives

Law governing the built environment in Sri Lanka is largely based on legislation. Construction Law may be defined as the law that regulates built environment in relation to construction activities. This law also deals with physical planning techniques and protection of natural environment (Abeynayake, 2012).

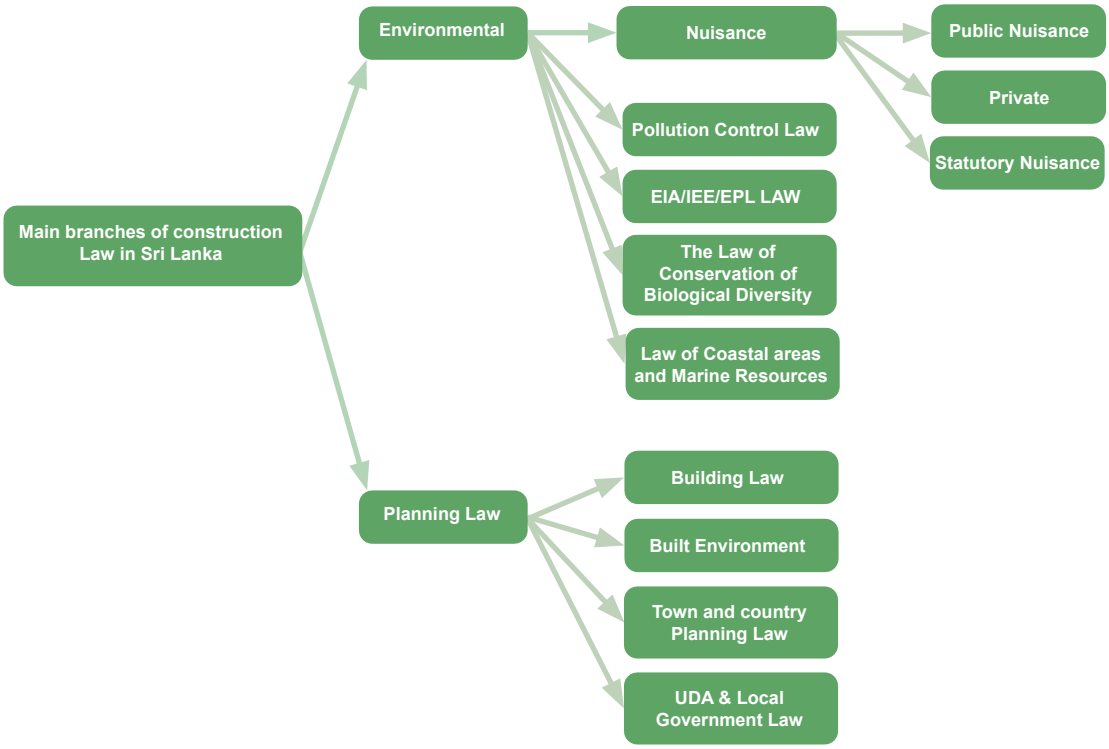

Figure 26: Main branches of environmental and physical planning law in Sri Lanka

Sri Lanka's NDCs were submitted in 2016 and could be referred to as the most detailed one. It consists of 14 sectors that include mitigation, adaptation, loss and damage, and means of implementation commitments. Among these, the adaptation sectors focus on health; food security (agriculture, livestock, and fisheries); water and irrigation; coastal and marine; biodiversity; urban, city planning, and human settlements; and tourism and recreation sectors. In addition to this, the NDC consists of loss- and damage-related commitments, and means of implementation for the NDC implementation (Wijenayake, 2020).

Impact of Building and Construction Industry on Environment

At present, there is a significant lack of country-specific research and related data inventories on building energy consumption, carbon emissions and C&D waste in Sri Lanka.

4. Policies and Stakeholders

4.1 Circular Economy Initiatives: Timescale and Status

In the last few years, several global platforms have started focusing on circular economy and resource efficiency. Multilateral and bilateral cooperation projects have been established with countries that are focusing on implementing specific policies in developing economies. The countries have taken conscious measures to adopt and enforce policies designed and managed sustainably and circularly and which avoid excessive degradation of natural assets. Developing economies have a low material footprint per capita. As a result, the impact of their economic activities often falls within the planet's regenerative capacity. However, on the downside, they struggle to meet all the basic needs concerning HDI indicators, such as education and healthcare. Natural capital, rather than human capital, is their dominant source of wealth, which means that the focus is on extracting and selling raw materials. At the same time, investment in education and skills is insufficient.

The positive argument is that these countries are building their basic infrastructure, and there lies an opportunity to apply circular strategies at various stages. Economies and business sectors that are early adopters of public policies and business strategies supporting a circular economy model can only earn more value from increased productivity and competitiveness (Mckinsey and Co., 2015). For example, the economic benefits associated with implementing a circular economy in the EU promises 'a net economic benefit of EUR1.8 trillion by 2030'. A similar study by FICCI and Accenture Strategy (FICCI, Accenture Strategy, 2018) indicates around USD 0.5 worth of India's GDP value that could be protected through Circular Economy business models by 2030 in India and USD4.5 trillion globally.

The policies, platforms, and initiatives in the context of circular economy in the built environment are listed, examined, and detailed below. The assessment is done based on the following criteria:

- Period of implementation – Year/Duration
- Status – Active/Inactive/Ended
- Focus areas, theme, or policy theme – Production/ Resource-Efficiency/ Energy-Efficiency/ Waste Management, etc.
- The phase of construction applicable to – Sourcing/Manufacturing/Construction/ Operation/Retrofit/End-of-first life

Year - Policy Name
Status | Theme: Production / resource-efficiency / energy-efficiency / waste management, etc.

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

4.1.1 International/Multilateral Initiatives

Table 1: International/Multilateral Initiatives

Source: Authors

Year	Initiatives/Policies	Country	Status/ Frequency
International-Multilateral			
2011	Indo-Swiss Building Energy Efficiency Project (BEEP)	India	Active
2016	EU Circular Economy Mission to China	People's Republic Of China	Ended
2017	World Circular Economy Forum – Global initiative of Finland and the Finnish Innovation Fund Sitra.	Global	Active
2017	G20* Resource Efficiency Dialogue	G20 members	Active
2017	Factor 10 – World Business Council for Sustainable Development (WBCSD)	Global	Active

* Argentina, Australia, Brazil, Canada, **China**, France, Germany, **India**, **Indonesia**, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the European Union.

2011 Indo-Swiss Building Energy-Efficiency Project
Active | Theme: Energy-efficiency

Sourcing | Manufacturing | **Design/ Construction** | **Operation** | Retrofit | End-of-first cycle

It is a bilateral cooperation project between Switzerland (Federal Department of Foreign Affairs of the Swiss Confederation and implemented by Swiss Agency for Development and Cooperation) and India (Ministry of Power and implemented by the Bureau of Energy Efficiency) focusing on enhancing energy efficiency in buildings. The project focuses on developing design charrettes, augmentation of building material testing infrastructure, and preparation of tools and guidelines to designing energy-efficient residential and public buildings.

2016 EU Circular Economy Mission to China
Ended | Theme: Circular economy, resource efficiency, and sustainable use of natural resources

Sourcing | **Manufacturing** | **Design/ Construction** | **Operation** | **Retrofit** | **End-of-first cycle**

Economy missions communicate and promote sustainable and resource-efficient policies, increase cooperation, better understand the challenges, and promote green solutions.

2017 World Circular Economy Forum
Active | Theme: Circular economy, resource efficiency, and sustainable use of natural resources

The platform brings together experts to present circular economy solutions. It is a global initiative of Finland and the Finnish Innovation Fund Sitra. These forums are likely to better address issues across the spectrum of circularity as it brings together a diverse set of stakeholders globally to enable knowledge sharing. Each annual WCEF has a different theme. WCEF online (2020) focused on rebooting the economy with circular solutions. WCEF2019 had a strong emphasis on scaling up the circular economy transition. WCEF2018 painted visions of a circular future the world should strive for and encouraged the world's leading economies to follow those visions. WCEF2017 identified vital elements of a circular economy and showcased solutions and lessons worldwide (The Finnish Innovation Fund Sitra, 2017).

2017 G20 Resource Efficiency Dialogue
Active | Theme: Resource efficiency

This dialogue aims to make efficient and sustainable use of natural resources a core element of the G20 talks. As an outcome, a road map developed led to the promotion of activities on resource efficiency more effectively. The comprehensive document included mutual sharing, knowledge transfer, policy strengthening, resource-efficiency reporting, and encouraging innovation and collaboration (Ministry of the Environment, Government of Japan, 2017).

2017 Factor 10 – WBCSD
Active | Theme: Resource efficiency

WBCSD is a global platform for businesses committed to circular economy. The membership of the companies in the construction and materials sector accounts for about 6%. Factor10 adapts in response to its members' evolving circular priorities over time and challenges.

The Indian cement sector companies and the WBCSD launched the Indian Cement Sector SDG Roadmap. This initiative represents the first country-level road map convened by nine leading cement companies, namely ACC, Ambuja Cement, CRH, Dalmia Cement (Bharat) Limited, Heidelberg Cement, Shree Cement, Orient Cement, UltraTech Cement, and Votorantim Cimentos. The Swiss Agency for Development and Cooperation (SDC) (World Business Council for Sustainable Development, 2019) funds this initiative partially.

Indonesia BCSD (IBCSD), part of WBCSD's Global Network of partner organisations, launched a working group in 2018, which focused on Sustainable Development Goals (SDGs).

2016 EU Circular Economy Mission to India
Ended | Theme: Circular economy, resource efficiency, and sustainable use of natural resources

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Similar to China, the EU organised a Circular Economy Mission to India on sustainable and resource-efficient policies.

4.1.2 National Initiatives

People's Republic Of China

Regarding sustainable consumption and production (SCP) targeted under Sustainable Development Goal 12, China has made notable progress towards the promotion of circular economy. Over 20 years ago, the China's Environmental Protection Administration implemented the four-in-one recycling programme and a stringent extended producer responsibility system to promote waste reduction and recycling by the public and increase resource efficiency and sustainability. The extended producer responsibility system regulates over 60 products in 13 categories, including PET and glass bottles, lightbulbs, motorised vehicles, and electronic waste such as TVs and refrigerators. It requires the mandatory recycling of these products (Lin & Bhardwaj, 2020).

The 12th Five-Year Plan (2011–15) implemented as a national development strategy plan outlines the country's policy towards recycling heavy industrial resources instead of previous models that practiced resource efficiency. Some objectives of the plan were to increase the reuse of industrial waste to 72% by 2015 while raising resource output efficiency by 15% (Mathews & Tan, 2016).

The 13th Five-Year Plan (2016–20) includes promoting circular production to establish a circular economy at all levels in society, creating a circular development system with new resource strategies, reducing waste and consumption, increasing resource efficiency, and supporting green initiatives. A new environmental protection tax and compensation framework, part of the plan, outlines promoting the country's green bond market (China Water Risk, 2016).

The National Climate Change Action Guidelines passed in 2017 and the Greenhouse Gas Reduction Action Plan, 2018 show commitment to reducing GHG emissions. These are the central government's first steps in addressing GHG and carbon reduction. The programme's first stage is to reduce 2% of GHG emissions by 2020, and ultimately by 50% by 2050, compared with the 2005 baseline level (Lin & Bhardwaj, 2020).

Currently, there is a 96% waste collection rate and a 60% recycling rate. Additionally, the daily waste generation rate decreased from 1.13 kg/day/person in 1998 to 0.41 kg/day/person in

2018, a 36% reduction from the historical peak in 1998. National regulations and advances in innovative recycling technologies developed in China help achieve recycling targets (Lin & Bhardwaj, 2020).

The 14th Five-Year Plan (2021–25) aims to cut energy intensity by 13.5% and carbon intensity by 18%. The National Development and Reform Commission released the Development Plan for the Circular Economy in the 14th Five-Year Plan period. It targets to develop the circular economy through various initiatives, such as promoting recycling, remanufacturing, green product design, and integration of renewable resources (Koty, 2021).

The policies introduced in the Five-Year Plans around circular built environment active in China are the following:

2002 China's Law on Cleaner Production
Mandatory | Theme: Resource efficiency and energy-efficiency

Before 1992, comprehensive utilisation of resources characterised China's policies leading to a 9% increase in the fly ash utilisation rate (Li & Lin, 2016).

The law defines cleaner production as applying measures for design improvement, utilisation of clean energy and raw materials, and implementation of advanced processes, technologies, and equipment. The intent is to reduce pollution at the source, enhance the rates of resource utilisation, and reduce or avoid pollution generation and discharge in the course of production. The Government has already made impressive efforts to transition towards a greener economy, having passed over 40 regulations on greening the cement industry, including strict regulations on efficiency requirements on new cement plants to ensure gradual phase-out of old technologies. In the cement industry, the amount of energy required to produce a metric tonne of cement fell by 41% through cleaner modes of cement production (Trucost & ICCS, 2015).

2008 China's Law on Circular Economy Promotion
Mandatory | Theme: Circular economy and resource efficiency

China is the first country to enforce a national law that considers circular economy to be the country's central developmental goal. This law aims to achieve sustainable development by increasing resource utilisation rates and resource recovery in production, circulation, and consumption. The law promotes the economic development model's transition and realises the economy's circularisation. On the surface, the circular economy legislation in China seems to have adopted a more high-end industry promotion and economic model transition route.

However, in essence, the legislation has deviated from the concrete issues that legislation could help to solve.

Developing a robust implementation framework can solve concerns around law enforcement that sets out detailed obligations and norms, and provides relevant liabilities to influence behaviour in the circular economy (Hu, et al., 2018).

Table 2: Policies focusing on up-gradation of industrial infrastructure, cleaner production, comprehensive resource utilisation

Source: Adapted from (Li & Lin, 2016)

Year	Policy	Description
1999, 2000, 2002	Lists of Backward Production Capabilities, Processes, and Products to Be Eliminated (the First, Second, and Third Batches in 1999, 2000, and 2002)	Backward production capabilities, processes, and products to be eliminated have the following features: violation of national regulations, backward production methods, poor product quality, severe environmental pollution, and high consumption of materials and energy.
2006	Notice on Accelerating the Structure Adjustment of the Steel Industry via Controlling Total Production Capability and Eliminating Backward Production Capability	Eliminate backward production capability, high resource consumption, severe environmental pollution, and unqualified production conditions. o Eliminate, before 2007, a series of backward devices including blast furnaces with capacity below 200 m^3 and converter furnaces with capacity below 20 tonnes. o Eliminate, before 2010, backward devices, including blast furnaces with a capacity below 300 m^3.
2010	Advices on Financial Services for Supporting Energy Saving and Emission Reduction and Eliminating Backward Production Capability	Projects under construction and inconsistent with the policies on energy-saving and emissions reductions or supposed to be phased-out should not be provided loans.
2008	Preferential Income Tax Lists of the Enterprises for Producing Special Safety Production Devices	If an enterprise purchases and utilises special equipment for environmental protection, energy- and water-saving, and safety production, related equipment purchase costs may be deducted from income tax.
2008	Notice on Preferential Income Tax for the Catalogue of Materials of Comprehensive Resource Utilisation	The revenue of enterprises that sell products generated with the materials in the catalogue and included in the catalogue should be deducted by 10% during income calculation. The list consists of building materials*, products, and technologies encouraged for development.
2011	Interim Management Method of the Central Financial Rewarding Fund for Energy-Saving Technologies (2011)	In East China, after the construction of energy-saving projects, the reward standard is CNY240 per tonne of standard coal, and in Middle and West China, it is CNY300 per tonne of standard coal.

Year	Policy	Description
2010	Notice on Opinions of Supporting Policies and Measures of Circular Economic Development Investment and Financing	Circular economy-related projects should receive credit support.
2012	Interim Management Method Circular Economy Development Funds	Special funds should support national urban minerals demonstration bases, kitchen waste recycling and safe disposal, circular transformation in parks, remanufacture, and demonstration and promotion of cleaner production technologies. Taking cleaner production as an example based on verification by experts, the government should freely promote mature and advanced cleaner production technologies by purchasing the technology.
2015	Taxation on Issuing the Catalogue of Value-Added Tax Preferences for Products and Labour Services Involving the Comprehensive Use of Resources (WBCSD, 2019)	Provides a comprehensive list of commodities and products that support reuse and recycle regimes for industries. The government introduced 50% to 100% value-added tax refunds for specialised products such as recycled tires, sand produced from construction waste, cardboard, and fiberboard.

* Building materials included are Dry style manufacturing of cement with daily output of chamotte at 4,000 tonnes or more; New types of wall-body materials, decoration materials, and water-proof and heat-insulation materials; 10,000-tonne-grade glass fibre direct melting process; Fine-quality plastic compound doors, windows, pipes, and wall- and floor-covering materials; Deep processing of plate glass; High-grade sanitary wares and hardware components; Ultra-thin modifying processing non-metal minerals and products.

2013 Circular Economy Development Strategies Plan
Mandatory | Theme: Circular economy and resource efficiency

The 12th five-year plan laid out a three-pronged ‘10–100–1,000’ strategy:

- Ten significant programmes focusing on recycling industrial wastes, conversion of industrial parks, remanufacturing, urban mining, and the development of waste-collection and recycling systems;
- One hundred demonstration cities such as Suzhou and Guangzhou; and
- One thousand demonstration enterprises or industrial parks nationwide. In 2012, the National Development and Reform Commission (NDRC) and the finance ministry called for 50% of national industrial parks and 30% of provincial ones to complete circular-economy transformation initiatives by 2015, to achieve close to zero discharge of pollutants.

The State Council released a national strategy for achieving a circular economy that targets increasing energy productivity (GDP per unit energy) by 18.5% relative to 2010, raising water productivity by 43%, and for the output of the recycling industry to reach 1.8 trillion yuan (USD 276 billion) compared to 1 trillion yuan in 2010, by 2015. Others include reusing at least 75% of coal gangue (Worthless rock present in deposits from coal mining) or 70% of pulverised fuel ash (Mathews & Tan, 2016).

2015 Guidelines for the Evaluation Label of Green Building Materials
Mandatory | Theme: Resource efficiency

The guidelines for evaluating green building materials are likely to accelerate the use of green materials and standardise the evaluation and labelling. Besides information on the product, it provides evaluation benchmark, green building materials grade, details about the evaluation agency, and validity.

Table 3: Current building material-related certification and labels in China

Source: Adapted from (Pacific Northwest National Laboratory, 2017)

Building material certification	Status	Description
China Compulsory Certificate (CCC)	Mandatory	Products listed in the compulsory certification category cannot be marketed, sold, imported, or used for any commercial purposes without acquiring a certificate issued by accredited certification authorities. The certification is for products in 22 categories and 159 subcategories. Building material products in the product catalogue for compulsory certification include, for example, architectural safety glass, solvent furniture paint, concrete anti-freezer, and porcelain tile.
Resource Conservation (e.g., energy and water conservation) Certification	Voluntary	Certification organisations have the autonomy to carry out their programmes. The Energy Conservation Certification covers, for example, electric appliances, office equipment, lighting products, electromechanical, electric transmission and transformation equipment, and building materials. The Water Conservation Certification applies to industrial water treatment, water usage in urban areas, irrigation and drainage, unconventional water resources utilisation, etc.
China Certification for Environmental Products	Voluntary	Building material products covered by this certification include, for example, paints, artificial boards, wallpaper, binders, ceramic tiles, carpet, concrete admixture, and wooden doors.

Building material certification	Status	Description
Low Carbon Products Certification	Voluntary	This certification aims to regulate low-carbon product certification, promote international trade, and protect the interest of relevant domestic industries. The first batch of certified products includes general-purpose Portland cement, sheet glass, aluminium alloy proximate matter for buildings, and three-phase asynchronous motors. The second batch of products includes ceramic tile or board for buildings. It is likely to add more products to the low-carbon product certification catalogue soon.
Green Building Material Assessment Label	Voluntary	It accredits building materials according to five dimensions: energy conservation, emission reduction, safety, convenience, and recycling throughout the whole life cycle. The label has a three-tier system based on performance (one-star, two-star, and three-star from low to high rank). Currently, seven products are assessed, including masonry materials, insulation materials, pre-mixed concrete, energy-saving glass for buildings, ceramic tiles, sanitary wares, and pre-mixed mortar. They may include more product categories in the future. Many green building and healthy housing projects have mandatory requirements to use Green Building Material Assessment Label products.
Type II Environmental Labelling and Type III Environmental Labelling (Environmental Product Declaration)	Voluntary	It indicates that the product conforms to relevant quality standards and adheres to specific environment protection requirements with low toxicity and energy-saving properties. It includes water-based paints, solvent-based coatings, wooden boards, adhesives, wallpaper, ceramic tiles, sanitary wares, doors and windows, cement, concrete, and wall planks.
China Fenestration Energy Efficiency Performance Labelling	Voluntary	It accurately describes the U-value, shading coefficient, air permeability, visible light transmittance, and other energy-saving performance metrics.

Currently, building-related certification, codes, and assessment standards in China include the following:

2010 Code for Green Building of Civil Building – Residential/Public Buildings
Mandatory | Theme: Resource efficiency

2010 Evaluation Standard for Green Construction of Building
Mandatory | Theme: Resource efficiency

2014 Code for Green Construction of Building
Mandatory | Theme: Resource efficiency

2016 Technical Code for Operation and Maintenance of Green Building
Mandatory | Theme: Resource efficiency

The codes have been through many revisions in China and address different buildings for various climatic zones.

1986 Design Standard for Energy Efficiency of Residential Buildings
1993 Design Standard for Energy Efficiency of Public Buildings
2013 Evaluation Standard for Green Industrial Building
2013 Evaluation Standard for Green Office Building
2015 Assessment Standard for Green Store Building
2016 Evaluation Standard for Green Hospital Building
2016 Assessment Standard for Green Hotel Building
2016 Assessment Standard for Green Museum and Exhibition Building
2019 Assessment standard for Green Building
Mandatory | Theme: Resource efficiency

2015 Assessment Standard for Green Retrofitting of Existing Building
Mandatory | Theme: Resource efficiency

Sourcing | Manufacturing | Design/ Construction | Operation | **Retrofit** | End-of-first cycle

India

As per the Indian Economic Survey 2018–19, the country will require USD4.5 trillion infrastructure investment by 2040, the majority of which will need to be focused on cities, as by 2030, about 600 million Indians will reside in urban areas (Ministry of Finance, Government of India, 2019). India's urban population has grown from 109 million in 1971 to 377 million in 2011 and 419 million in 2014. It is expected to grow to almost 600 million by 2030. The housing shortage, as per the demand survey by states for urban areas, is 10 million. The Housing for All Mission launched in June 2015 envisages the construction of these dwelling units by 2022.

To target fast-track delivery of these units, the Ministry of Housing and Urban Affairs (MoHUA) initiated several schemes under the PMAY (Ministry of Housing and Urban Affairs, 2021), including the following:

- Technology Sub Mission (TSM) identifies, evaluates, and certifies new emerging construction technologies. A total of 33 alternative technologies have been identified so far.
- Initiated the Global Housing Technology Challenge (GHTC), 2019, to transform the eco-system of the housing construction sector in the country by identifying and mainstreaming advanced proven technologies. Under the ASHA-India initiative, it provides acceleration and incubation support to potential future technologies.
- Light House projects under GHTC India serve as live laboratories implemented in Gujarat, Jharkhand, Madhya Pradesh, Tamil Nadu, Tripura, and Uttar Pradesh to demonstrate innovative construction technologies, which are cost-effective, green, and sustainable.
- Demonstration Housing Projects (DHPS) showcase the field application of new emerging technologies.

Swachh Bharat Abhiyan, besides other activities, envisages the processing of 100% solid waste in cities and towns by 2 October 2019, including effective management of C&D waste.

Owing to the projected demand, energy efficiency in buildings will play an essential role in the overall energy landscape as it is one of the most cost-effective ways of decarbonising India's economy. The design and construction of sustainable and energy-efficient buildings will play a prominent role in transitioning to low-carbon energy systems. As policy and markets drive uptake of more sustainable buildings to meet climate objectives, the linkages between material demand and GDP are likely to diverge from historical trends. Material demand in buildings may change owing to strategies, such as designing for energy efficiency, using longer-lasting and less carbon-intensive materials, reducing material losses at construction sites, and enhancing reusability and recyclability. These strategies will affect the quantity and composition of materials demand, consecutively involving CO_2 emissions from the industrial sectors that produce crucial materials such as steel, cement, and aluminium (Behal, 2019).

India's resource extraction per unit area is one of the highest globally (1579 tonnes/acre)

compared to the global average of 454 tonnes/acre (Lin & Bhardwaj, 2020).

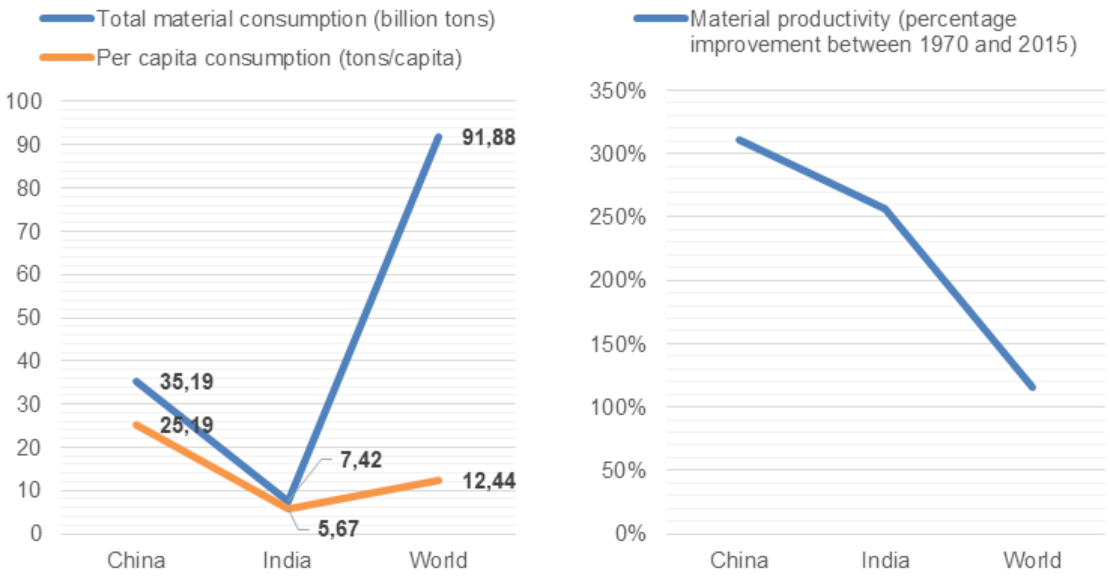

Figure 27: Material consumption and productivity

Source: Adapted from (Lin & Bhardwaj, 2020)

A detailed review of the circular economy policies in India is as follows:

2009 Mines and Minerals (Development and Regulation)
Mandatory | Theme: Resource extraction

Sourcing | Manufacturing | Design/ Construction | Operation | Retrofit | End-of-first cycle

It is an Act of the Parliament of India enacted to regulate the mining sector in India, amended in 2015 and 2016. It classifies sand as a minor mineral if used for construction purposes, and its management comes under the purview of state governments. Sand used to make concrete must adhere to the specifications for fine aggregates set out in Indian Standard 383:1970, while sand used for masonry mortar must adhere to Indian Standard 2116:1980. Both the standards suggest the use of 'natural sand deposited by streams' (river sand) (EU SWITCH-Asia Sustainable Consumption and Production Facility (SCPF), 2019).

Mining river sand for heavily consumed materials such as concrete and mortar has tremendously deleterious impacts on river ecology. It leads to downstream erosion, causing channel bed and habitat change, deepening rivers and estuaries, and enlarging rivers. The annual turnover from illegal mining in India is estimated to be INR 10 billion (Centre for Science and Environment, 2012). The extent of illegal mining has forced certain state governments to impose a ban on sand mining leading to a gap between demand and supply. The increase in demand will further

2007 Energy Conservation Building Code
Mandatory in notified states | Theme: Energy efficiency

Sourcing | Manufacturing | **Design/ Construction** | Operation | Retrofit | End-of-first cycle

aggravate this gap to 1430 million tonnes by 2020.

The Bureau of Energy Efficiency introduced the Energy Conservation Building Code (ECBC) in 2007 for commercial buildings (Bureau of Energy Efficiency, Ministry of Power, 2021). The ECBC was revised in 2017 to incorporate advanced technologies and set higher benchmarks for energy efficiency. The code prescribes energy performance standards for the buildings, including the envelope. It allows designers to choose a material or technology as long as they fulfil the minimum requirements.

2011 Perform, Achieve, Trade (PAT) Scheme
Mandatory | Theme: Energy efficiency

Sourcing | **Manufacturing** | Design/ Construction | Operation | Retrofit | End-of-first cycle

The PAT scheme aims at reducing the energy intake of the industries and enable the energy-intensive industries to introduce energy-saving technologies and re-organisation among firms.

Between 2011 and 2015, 85 cement plants in India participated in the first cycle of PAT, a market-based mechanism to improve energy efficiency (International Energy Agency, 2020). They achieved energy demand reductions equivalent to 9% of India's 2014 cement sector energy consumption. The second cycle, which ended in 2019, covered 111 cement plants and aimed for 4–5% lower energy use; official results of the cycle are pending (International Energy Agency, 2020).

2016 Ash Utilisation Policy Amendment (First Released in 2009)
Mandatory | Theme: Waste management

Sourcing | Manufacturing | **Design/ Construction** | Operation | Retrofit | **End-of-first cycle**

The Government of India has implemented several policies to promote the use of sustainable building materials. The Fly Ash Utilisation Policy amended by the Ministry of Environment, Forest and Climate Change (MoEFCC) in 2016 drove the markets of building products containing fly ash, such as AAC blocks, fly ash bricks, and Pozzolana Portland Cement.

Table 4: Policies focusing on up-gradation of resource re-utilisation and tax incentives

Year	Policy	Description
2016	Bureau of Indian Standards	Bureau of Indian Standards (BIS) has issued a third amendment to IS-383:2016 'Coarse and fine aggregate for concrete' to include fine and coarse aggregate produced by processing of C&D waste.
2017	Bureau of Indian Standards	India Road Congress (IRC) has issued IRC-121: 2017 Guidelines for using C&D waste in the road sector.
2017	Goods and Services Tax Council	The GST Council reduced tax rates to 12% on fly ash products. Presently, it is not at par with other building materials, such as red-clay bricks, earthen, or roofing tiles, with a 5% tax rate.

2016 Rules for the Management of Construction and Demolition Wastes
Voluntary | Theme: Waste management

Sourcing | Manufacturing | Design/ Construction | Operation | Retrofit | End-of-first cycle

The Central Pollution Control Board, MoEFCC, has drafted a Guide for Environmental Management of Construction and Demolition Wastes in March 2017. Subsequently, guidelines for Utilisation of Construction & Demolition Waste in Construction of Dwelling Units and Related Infrastructure in Housing Schemes of the Government were released by the Building Materials and Technology Promotion Council (BMTPC), Ministry of Housing and Urban Affairs (MoHUA) (Building Materials & Technology Promotion Council, 2018).

2018 Ready Reckoner for the Utilisation of Recycled Produce of Construction and Demolition Waste
Voluntary | Theme: Waste management

Sourcing | Manufacturing | Design/ Construction | Operation | Retrofit | End-of-first cycle

A ready reckoner for the Utilisation of Recycled Produce of Construction and Demolition Waste, 2018 by Building Materials and Technology Promotion Council (BMTPC), Ministry of Housing and Urban Affairs (MoHUA) was brought out to ease implementation of the Construction and Demolition Waste Management Rules, 2016 (Building Materials & Technology Promotion Council, 2018). The Rules clearly define the implementation process and the duties and responsibilities of various stakeholders, including the local authority. Although these rules are comprehensive and available in open-source, their adoption remains low. The Eco-Niwas

2018 Eco-Niwas Samhita (Residential Building Code)
Mandatory in notified states | Theme: Energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Samhita envisaged for release in parts is the energy conservation code for residential buildings launched in 2018 as Part I – Building Envelope of ECBC-R (Bureau of Energy Efficiency, Ministry of Power, 2021).

In the present form, the codes focus on performance parameters for energy efficiency, such as thermal transmittance or U-value, solar heat gain coefficient (SHGC), and visible light transmission (VLT). Under the current ambit of the codes, it does not consider other sustainability parameters, such as embodied energy and life cycle assessment (LCA), that are significant for the selection and application of building materials. However, ECBC-R may include building materials and structural systems' embodied energy in the future.

2021 Building Materials Directory of India
Voluntary | Theme: Resource efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The BMDI launched in July 2021 will likely establish standards and labels for building materials in the country.

Table 5: Building material-related certification and labels in India

Building material certification	Status	Description
BMDI – Building Material Directory of India	Voluntary	The Building Materials Directory for India (BMDI) is one of the major thrust areas of BEE for the successful adoption of ECBC and ECBC-R. The key objective of this programme is to provide the consumer an informed choice about the energy-saving and, thereby, cost-saving potential of the relevant marketed product. BMDI is one of the most cost-effective tools for improving energy efficiency and lowering the energy cost of building materials for consumers. The programme was developed in a collaborative and consensus-driven approach with active participation from all the stakeholders. The portal encompasses an online portal for the manufacturer's company and product registration, an administration data approval system, and a web-based interactive tool for the user. The directory would be an enabler for the successful adoption of the ECBC and provided a policy road map to guide formulation, enforcement, and monitoring of product labels, in the buildings sector, through market forces (Bureau of Energy Efficiency, Ministry of Power, Government of India, 2021).

Currently, the building-related certification, codes and assessment standards in India include the following:

2001 Indian Green Building Council (IGBC)-CII
2005 Green Building Rating for Integrated Habitat Assessment (GRIHA)
2014 Excellence in Design for Greater Efficiencies (EDGE)
2013 GEM ASSOCHAM
Voluntary | Theme: Resource efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Rating systems mainstreamed in the construction sector in India today, such as GRIHA, IGBC, and EDGE, view beyond just energy parameters in the case of building materials. They do not provide a comparative assessment of trade-offs between various building materials and technologies (Behal, 2019). GRIHA, for instance, awards points to projects demonstrating a reduction in embodied energy compared to the base case, utilising fly ash in the envelope, and using low-impact materials in the interiors. It also encourages the use of low-Volatile Organic Compounds (VOC) finishes and Chlorofluorocarbon (CFC)- and Hydro-chloro-fluoro Carbon-(HCFC)-free materials. Many states have incentivised the developer community with additional FSI for projects registered as green. However, in most cases, registration for certification with one of the primary schemes is sufficient to qualify for government support instead of the certification itself (Herda, 2017). As opposed to certification, the registration could lead to significant green-washing of projects if not monitored carefully. GRIHA, however, conducts a post-occupancy evaluation to ensure that the intended measures have been implemented on-site (Herda, 2017).

Indonesia

Adopting circular economy practices is likely to help the construction sector in Indonesia generate an economic impact worth USD12.1 billion by 2030 as per a study supported by the Ministry of National Development Planning, Indonesia, Embassy of Denmark and the United Nations Development Programme (UNDP). It also projects that the practices can reduce CO_2-e emissions and water use by 44.8 million tonnes and 0.3 billion m^3 respectively, by 2030 (Kementerian PPN/Bappenas, Embassy of Denmark, UNDP, 2021).

Currently, the consumption of building materials in the country is only 1.4 m^2/capita, far below that of other countries with an average of 3 m^2/capita. Meanwhile, Indonesia's domestic per capita consumption of 262 kg/capita in the cement sector is still significantly lower than other ASEAN countries such as Thailand, Vietnam, and Malaysia with 458 kg/capita, 617 kg/capita, and 763 kg/capita, respectively.

Similarly, Indonesia's domestic per capita steel consumption is only 50 kg and far lower than other ASEAN countries providing ample room for growth (Global Business Guide Indonesia, 2018).

Due to rapid urbanisation trends in Indonesia, the construction sector will witness a considerable demand. The government launched the 'One Million Houses' programme to meet the urban poor's housing shortage. It aims to reduce the backlog from 7.6 million houses in 2015 to 5.4 million housing units in 2019 (The Jakarta Post, 2018). The government also plans to spend over USD 412 billion between 2020 and 2024 to build airports, power plants, and other infrastructure to decentralise Indonesia's growth beyond Java (The Jakarta Post, 2019).

Going forward, the Vision Indonesia 2045 policy document has elaborated on the circular economy concepts. As an initial step in implementing the circular economy concept, the Government of Indonesia, in collaboration with the United Nations Development Programme (UNDP), with the support of the Danish Government, has published an analysis study of the environmental, economic, and social potential for the implementation of a circular economy in Indonesia in five industrial sectors, namely food and beverages, construction, electronics, textiles, and plastics. This circular economy development study will be followed by developing the National Action Plan and the circular economy in the next National Medium Term Development Plan (RPJMN) 2025–2029 (Kementerian PPN/Bappenas, Embassy of Denmark, UNDP, 2021). A detailed review of the policies/codes/regulations around the circular economy in Indonesia is as follows:

2000 Energy standards for Buildings (SNI) in Indonesia
SNI 03- 6389-2000- Energy conservation for building envelope of building
SNI 03- 6390-2000- Energy conservation for air conditioning systems in building
SNI 03- 6197-2000- Energy conservation for lighting systems in building structures
SNI 03- 6196-2000- Energy auditing procedure for building
Mandatory | Theme: Energy-efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The standards/codes provide recommendations that take into account productivity, comfort, and cost-effectiveness. As part of the building envelope, it outlines the design criteria, design procedures, and energy-efficiency standards.

2010 Ministry of Environmental Decree No. 8: Criteria and Certification of Eco-friendly Building
Mandatory | Theme: Resource efficiency and energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

This decree regulates the criteria, certification, and registration process of green buildings. This ministerial regulation aims to encourage building operators to construct and/or manage buildings by applying environmental principles and significant aspects in handling the impact of climate change (Regulation of the State Minister for the Environment, 2010).

Green Building Council Indonesia (GBCI), currently one of the leading certification bodies in Indonesia, has established six different GREENSHIP rating tools: New Building, Existing Building, Interior Space, Net Zero Healthy, Homes, Neighbourhood (Green Building Council Indonesia, 2021). Besides GBCI, the other certifications include LEED, EDGE, and Green Mark.

2012 Ministry of Environmental Decree No. 27: Analisis Manajemen Dampak Lingkungan (AMDAL)
Mandatory | Theme: Resource efficiency

Sourcing | Manufacturing | **Design/ Construction** | Operation | Retrofit | End-of-first cycle

The government regulation provides a legal basis for environmental impact assessment for buildings, known as AMDAL. Buildings with a land area of at least 5 ha and a building area of at least 10,000 m^2 are required to apply (Waste4change, 2020).

Several countries in Europe and Asia also apply a form of licensing similar to AMDAL, such as Environmental Impact Assessment (EIA).

2012 Jakarta Provincial Government Regulation No 38: Green Buildings
Mandatory | Theme: Resource efficiency and energy-efficiency

Sourcing | Manufacturing | **Design/ Construction** | Operation | Retrofit | End-of-first cycle

The Law and Government Regulation No. 36/2005 made it mandatory for eligible new buildings to consider energy conservation measures (Global Buildings Performance Network, 2021). However, requirements for new buildings less than 500 m^2 are voluntary. The government developed its green building regulation, Governor Decree No. 38/2012, mandatory for new complex commercial buildings. For existing buildings/retrofits, the draft National Green Building Guidelines only requires building audits and implementation of green requirements where feasible.

The Law regulates the planning, construction, utilisation, maintenance, and deconstruction of buildings in Jakarta. The Regulation mandates 45 watts of electricity per m^2, optimised natural lighting, a minimum temperature of 25°C in residential buildings, and treatment and use of wastewater. It applies to the following building types:

- Apartment buildings, office buildings, trade buildings, and buildings which have more than one function within one building, with floor space larger than 50,000 m^2
- Buildings for business, hotel, social and cultural functions, and health care buildings with floor size greater than 20,000 m^2
- Buildings for social and cultural functions, educational service buildings, with floor size greater than 10,000 m^2 (IEA, 2017)

The Jakarta Government also signed the 30:30 commitment to reduce energy consumption, carbon emissions, and water consumption from buildings by 30% by 2030 (Kementerian PPN/ Bappenas, Embassy of Denmark, UNDP, 2021). As of May 2016, the implementation of the Jakarta Green Building reached 260 buildings with a total floor area exceeding 15 million m^2 (Jakarta Green Building, 2016).

The Jakarta Government also mandated reductions in the electricity consumption in its government buildings under Jakarta Governor Regulation No. 156 of 2012 on Electricity and Water Savings. After implementing this Regulation in 2013, the city achieved a 4% reduction in its energy bills (Kementerian PPN/Bappenas, Embassy of Denmark, UNDP, 2021).

2015 Regulation of the Minister of Public Works and Public Housing No 2: Green Building
Mandatory | Theme: Resource efficiency and waste management

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The Regulation lists the requirements that need to be fulfilled in each construction process step – initial planning, technical planning, construction process, utilisation and demolition – for buildings to receive a green building certification.

2015 Regulation of the Minister of Public Works and Public Housing No 5: General Guidelines for Sustainable Construction Implementation
Mandatory | Theme: Resource efficiency and energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

This is a basic regulation relating to general guidelines for implementing sustainable construction in infrastructure project execution to provide a direction for sustainable construction implementation that creates sustainable infrastructure, eventually contributing to sustainable development. However, there are still gaps between the regulations and their implementation in infrastructure construction projects.

2017 Presidential Regulation No. 22: Rencana Umum Energi Nasional (RUEN)
Mandatory | Theme: Energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The RUEN aims to achieve energy efficiency of 17.4% by 2025 and 38.9% by 2050 relative to the BAU in 2005 in Barrel Oil Equivalent in the buildings sector (Kementerian PPN/Bappenas, Embassy of Denmark, UNDP, 2021).

2018 Regulation of the Minister of Public Works and Public Housing No 22: BIM
Mandatory | Theme: Resource efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The Ministry recognised the importance of Building Information Management (BIM) and developed a BIM road map for Indonesia 2017–24. It formulated a BIM Team to accelerate the BIM adoption in the Indonesian Government, especially the Ministry of Public Works and Housing (Sopaheluwakan & Adi, 2020). Consequently, in 2018, the ministry issued a regulation mandating BIM in the construction of government buildings. The adoption could aid urban mining and material recovery by developing and maintaining material inventories that encourage the reuse and recycling of materials (Kementerian PPN/Bappenas, Embassy of Denmark & UNDP, 2021).

2020 Government Regulation No. 27: Management of Specific Garbage
Mandatory | Theme: Waste Management

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The Regulation recognises six types of waste, including building demolition debris. The Regulation assigns responsibility to both producers and non-producers to manage the garbage. For example, the Regulation requires the producer to prepare plans and/or programmes to limit the produced waste.

The Ministry of Public Works and Housing Circular Letter No. 17 of 2020 also helps regulate the use of OPC cement to minimise greenhouse gas emissions in Indonesia.

Nepal

A ‘National Policy Framework’ has been developed specifically for the brick sector to make the industry more energy-efficient, environment friendly, and socially responsive. It is likely to achieve reductions in black carbon (Black carbon, or soot, is part of fine particulate air pollution ($PM_{2.5}$) and contributes to climate change) and CO_2 emissions and promote related co-benefits on development and health. The brick kiln initiative aims to achieve substantial reduction in black carbon and other emissions from brick kilns by employing various technologies and policy approaches (EU SWITCH-Asia Sustainable Consumption and Production Facility (SCPF), 2019).

The strategic policy actions will provide the basis for decision-makers, national governments, and subnational entities to make informed and evidence-based policy decisions to improve the operation of the brick sector.

A review of the policies around the circular economy in Nepal is as follows:

1999 Mines and Minerals Rules, 2056
Mandatory | Theme: Resource extraction

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

'Specified Minerals' implies that any mineral for which the department has issued a license to carry out mining operations contracted or specified by the Government of Nepal.

2011 Solid Waste Management Act
Mandatory | Theme: Waste management

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The Government of Nepal enacted the Solid Waste Management Act of 2011, effective from 15 June 2011. The Act's objectives include maintaining a clean and healthy environment by minimising the adverse effects of solid waste on public health and the environment.

The local bodies, such as municipalities, have been responsible for constructing, operating, and managing infrastructure for MSW collection, treatment, and final disposal. The Act mandates local bodies to take the necessary steps to reduce, reuse, and recycle (3Rs), including segregation of MSW at the source. It also provides for the involvement of the private sector, community-based organisations (CBOs), and non-government organisations (NGOs) in SWM through competitive bidding.

2015 Nepal National Building Code 2072
Mandatory | Theme: Resource efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Under the Ministry of Physical Planning and Works (MPPW), the Department of Urban Development and Building Construction (DUDBC) developed the Nepal National Building Code (NBC) in 1993. The United Nations Development Programme (UNDP), the United Nations Centre for Human Settlement (UNCHS), and a few domestic and foreign subcontractors' teams provided their technical assistance in developing the Nepal-NBC (Parajuli, et al., 2000).

The NBC implementation went into effect after the Building Construction System Improvement Committee (established by the Building Act 1998). The NBC implementation became mandatory in all the municipalities in Nepal following the Notification released in the Nepal Gazette in 2006. The Government has formulated and implemented new fundamental regulations for planning and construction of houses, part of the Urban Planning & Development Act, Building Code for Nepal, 2072.

2015 Building Bye-laws Nepal 2072
Mandatory | Theme: Resource efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The laws have paid particular attention to reconstruction after the earthquake and required open space. For proposals concerned with residential construction planning, the area in such planning shouldn't be less than specified in Land Rules, 2021 (EU SWITCH- Asia Sustainable Consumption and Production Facility (SCPF), 2019). Similarly, adjacent houses can only be constructed if at least three houses are of the same height. For constructing adjacent buildings, the owner is responsible for applying for the construction permit and repairing adjacent houses. Building Code Development Project was launched in 1992 Parajuli, et al., 2000). Its objective included the development of regulations and design documents for use by the planners and engineers to improve the seismic safety aspects of the existing buildings and suggest safer building design and construction practices to be introduced/enforced gradually in Nepal.

Green Building Rating System In Nepal - *A green building rating system in Nepal has not been formulated yet, is still in action.*

Green Building Guidelines

The Green Building Guidelines aim to introduce simple, practical green building design and construction philosophy that Nepal can simply and efficiently apply. There is an urgent need for more specific policies and detailed guidelines related to sustainable housing as a whole. It requires a provision for eco-friendly housing in National Building Codes. To promote sustainable housing, the style of municipality plans and implementation processes need to adapt the measures of green building principles at the municipality level. The Guidelines are based on six guiding principles (components), and this study has considered these components for further developing the Green Labelling system and Green Building Rating system (EU SWITCH-Asia Sustainable Consumption and Production Facility (SCPF), 2019).

Pakistan

To support the construction sector and boost employment and economic output, the Prime Minister of Pakistan announced a construction stimulus package in April 2020. The package includes a fixed tax rate for the construction industry, a subsidy worth USD 191.5 million for the Naya (New) Pakistan Housing Scheme, a decrease in sales tax, and incentives for builders to construct affordable housing.

The Environmental Protection Department of Punjab, the most populated province of Pakistan, and the National Energy Efficiency Conversation Authority (NEECA) are working together with the All-Brick Kiln Owners Association of Pakistan and the International Centre for Integrated Mountain Development (ICIMOD) to develop environmentally friendly brick kiln technologies in the sector (CCAC 2018).

2005 National Energy Conservation Policy
Mandatory | Theme: Resource extraction

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

In 2005, the National Energy Conservation Centre (ENERCON) and the Ministry of Environment, Islamabad published a report titled 'National Energy Conservation Policy 2005'. This report has broad guidelines for energy conservation in all the sectors, including buildings.

2005 Solid Waste Management (SWM) Policy
Mandatory | Theme: Waste management

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Although Solid Waste Management policies exist, implementation and enforcement are lacking due to the inadequacies in governmental institutions. For C&D waste, the policy specifies using construction waste and sand as the top layer at urban disposal sites.

2011 Building Code of Pakistan
Mandatory | Theme: Energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Pakistan Engineering Council (PEC) is responsible for the development and implementation of the building codes. ENERCON is a national coordinator for energy conservation measures and policies. The PEC and ECRON jointly worked to finalise the Energy Provisions-2011 for inclusion in the Building Code of Pakistan.

The BCP stresses the compliance and enforcement of the code. It states that the review and approval of the plans and specifications shall be following the EP-2011 by respective development authorities or municipalities.

2013 National Mineral Policy
Mandatory | Theme: Resource extraction

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Mining in Pakistan is governed by a legal instrument of National Mineral Policy 2013. Out of the many broad goals of the policy, a few of them are listed here:

- Mitigation of adverse environmental effects of mineral development,
- Generation of mass-scale employment and socio-economic uplift through enhanced skills, sustainable mineral development, technology transfer, and regional infrastructure development,
- Generation of geological data, development of a national and provincial cadastre, and provision of online access to such data and ensuring safe mining operations and safety and security of investors.

Measures under National Mineral Policy to ensure less environmental impact are as follows:

- Companies need to ensure that their mining operations occur in an environmentally acceptable and safe manner under regular monitoring.

Green Building Certification in Pakistan

Pakistan Green Building Council plays a vital part in creating awareness to understand the importance of green buildings and sustainability. It provides access to the Green Building Guidelines manual to improve their chances of getting Green Certification.

SEED (Sustainability in Energy and Environmental Development) - *Green Building certification system by Pakistan Green Building Council*

Pakistan Green Building Council has launched a green building certification system in partnership with around 70 organisations, including academia, government agencies, private organisations, local rollout partners, professional associations, and institutes of Pakistan (EU SWITCH-Asia Sustainable Consumption and Production Facility (SCPF), 2019).

SEED stands for “Sustainability in Energy and Environmental Development” and seeks market transformation in Pakistan’s building and construction sector to minimise its carbon footprint. It reduces energy and water consumption. SEED certification can potentially achieve up to 40% energy savings.

There are about 18 to 20 LEED-certified buildings in Pakistan registered with the US Green Building Council.

Sri Lanka

In the updated Nationally Determined Contributions (NDCs) prepared by the Ministry of Environment, Sri Lanka (2021), the government expects to achieve carbon neutrality by 2060 (Ministry of Environment, Sri Lanka, 2021). As part of the NDCs, Sri Lanka has already launched initiatives around promoting circular economy. To achieve the NDCs, it defines implementation of Demand-Side Management (DSM) measures by promoting energy-efficient equipment, technologies, and system improvements in a national Energy Efficiency Improvement and Conservation (EEI&C) programme. It includes mandating Energy Efficiency Building Code by 2022.

The NDCs in the water sector defines the use of wastewater for gardening, sanitary, construction, and other purposes to reduce demand for treated water. It also aims to introduce bye-laws and building codes to include the reuse of wastewater in new industrial constructions, including areas under industrial estates, by 2026.

The Government also commits to introducing a circular economy concept to selected industrial sub-sectors and designated industrial zones, and adopting a life cycle approach for selected subsectors to green the supply chain. It will establish a pilot project on the zero-waste concept in selected industrial parks or industrial subsectors. Additional considerations include adopting ISO standards for the circular economy concept (ISO/TC 323) and building industry capacity to adopt the circular economy concept.

The government targets to make necessary amendments to Sri Lanka Standard Institute (SLSI) standards for cement production, enabling the increase of fly-ash and other similar materials as substitutes for clinker in line with industry standards and trends worldwide (Ministry of Environment, Sri Lanka, 2021).

1999 Mines and Mineral (Amendment) Act, No. 66
Mandatory | Theme: Resource extraction

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

This Act amends the Mines and Minerals Act, No. 33 of 1992 (Colombo Telegraph, 2021), dealing with administrative and legal proceedings by repealing and amending several sections. Section 28 of the Act mandates a license to mine, transport, process, store, trade, or export minerals (Sand, Soil, Clay, Gravel, etc.) in Sri Lanka. It ensures that a permit is issued according to the provisions of the Act. Section 61 of the Act defines the requirement of a license holder to comply with the standards and procedures of the National Environmental Act No. 47 of 1980 to ensure the protection of the environment as a necessity to grant a license for mining-related activities (Colombo Telegraph, 2021).

2003 National Environmental Policies and Strategies
Mandatory | Theme: Resource extraction

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The policy aims to promote the sound management of Sri Lanka's environment, balancing social and economic development needs, and environment integrity. It also seeks to manage the environment by linking stakeholders' activities, interests, and perspectives to assure environmental accountability (EU SWITCH-Asia Sustainable Consumption and Production Facility (SCPF), 2019).

2006 National Policy on Sand as a Resource for the Construction Industry
Mandatory | Theme: Resource extraction

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

Sand is a mineral defined in the Mines and Minerals Act No. 33 of (1992) and is the state's property. The current demand (the demand excludes 'Colombo Port City Development Project' and any other special projects) for fine aggregates (sand) is 40 million m^3/annum. However, the supply is not over 15 million m^3 (Daily News, 2020).

The policy sought to manage the sector sustainably. It encourages significant construction projects to optimise the use of sand and alternate aggregates such as quarry dust wherever possible, bearing in mind the need to mitigate the environmental impacts of quarrying (EU SWITCH-Asia Sustainable Consumption and Production Facility (SCPF), 2019).

Sri Lanka also passed the National Environmental (Amendment) Act. No. 56 of 1988, which prohibits mechanised sand mining in rivers.

2008 Energy Efficiency Building Code – GreenSL Rating System
Mandatory | Theme: Energy-Efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The energy-efficiency building code was first introduced in 2002 as a standard, and was revised and published as a code in 2008. The second revision of this code has been completed, and a mandatory requirement for new commercial buildings to comply with the code is expected soon. Various agencies have supported improving energy efficiency in buildings. The two latest pilot projects planned to be implemented under the Sri Lanka Green Power Development and Energy Efficiency Improvement Investment Programme are: (i) to retrofit an existing commercial building to be an energy-smart building, and (ii) thermal energy storage retrofit to support additional air conditioning requirements of an existing building (Asian Development Bank, 2021).

2009 Green Building Council of Sri Lanka – Green SL Labelling System (GLS)
Mandatory | Theme: Resource efficiency and energy-efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The Green Building Council of Sri Lanka, established in 2009, runs the GreenSL Rating System and the GreenSL Labelling System (GLS) certifications. The GBCS has certified 61 buildings and labelled 30 products (Green Building Council of Sri Lanka, 2021). The rating system certifies both existing and new buildings.

Apart from the GreenSL rating system, buildings in Sri Lanka are also certified by LEED.

2009 Green Building Council of Sri Lanka
Mandatory | Theme: Resource efficiency and circular economy

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle

The GLS is an ISO-type I system and involves third-party certification. It encompasses multiple environmentally acceptable criteria across the life cycle (from the raw material extraction to the end of useful life) of sustainable materials/ products for certification (Green Building Council of Sri Lanka, 2021).

2014 National Policy on Construction
Mandatory | Theme: Energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle
		■			

The policy initiative includes:

- Supporting human resource development
- Targeting of the construction sector for employment generation, poverty alleviation, and social uplifting
- Ensuring the availability of materials, plant, and equipment through the local materials and related industries and liberalised trade
- Creating an enabling regulatory framework
- Enabling fair competition for government contracts through the establishment of clear procurement guidelines and regulations
- Establishing National Registers for Stakeholders by Construction Industry Development Authority (CIDA)
- Creating an attractive investment climate for infrastructure development, including private capital and foreign direct investment.

2019 National Energy Policy and Strategies of Sri Lanka
Mandatory | Theme: Energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle
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As per the Energy Balance of Sri Lanka Sustainable Energy Authority, 2018 (Asian Development Bank, 2019), the key industries contributing to GHG emissions are cement manufacture, lime production for the construction industry, and industries using limestone and soda ash.

The policy declares ‘Enhanced energy efficiency at end-use’ as one of the nine elements. It targets establishing specific benchmarks for the energy consumption of commercial, transport, and domestic sectors by 2008 (since the revised policy is relatively new, it is prudent to examine the status of implementation of previous policy published in 2008). However, the limited scope of industrial benchmarks is complete, and other industries and sectors largely remain uncovered (Asian Development Bank, 2019).

2018 National Policy on Sustainable Consumption and Production
Mandatory | Theme: Energy efficiency

Sourcing	Manufacturing	Design/ Construction	Operation	Retrofit	End-of-first cycle
			■		

The national policy aims to minimise the use of natural resources and toxic materials and generation of waste and pollutants throughout the entire production and consumption process in all economic sectors (Asian Development Bank, 2019). In building and construction specifically, the policy focuses on:

- Review, strengthen and empower existing legal instruments, such as Environmental Impact Assessment (EIA)
- Promote disaster and climate-resilient buildings and constructions
- Local authority regulations amended to ensure that all the state sector buildings, constructed in the future, comply with Green Building Certification
- Western province to have a model SMART CITY by 2025
- Habitable built environment for all established by 2030.

4.2 Stakeholder's Map

A greater collaboration involving a range of stakeholders is needed to accelerate circularity in the built environment. It includes multiple stakeholders at international, national, and sub-national levels from diverse social and economic sectors concerning the built environment. Multilateral/bilateral organisations, financial institutions, public and private housing developers, research and development organisations, academia, certifications and labelling, supply chain of materials and technology providers are the key stakeholders to raise awareness and facilitate the state of play for the circular built environment. A broader overview of these collaborators is collated that contributes and accentuates the importance of a sustainable, resilient, and circular built environment.

4.2.1 Multilateral and Bilateral Organisations

United Nations Environment Programme (UNEP)

The United Nations Environment Programme (UNEP) is one of the global authorities that sets the environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment. UNEP is actively working in Asia and the Pacific to pursue growth that catalyses the efficient use of the region's natural assets, reduces degradation of the environment, and brings social and economic benefits to the people, bringing together all the three dimensions of sustainable development. UNEP works at the sub-regional level to forge strong partnerships for collaborative and effective environmental management. In 2012, United Nations adopted a global 10-Year Framework of Programme to enhance international cooperation and accelerate the shift towards sustainable consumption and production (SCP) patterns in both developed and developing countries.

World Health Organisation (WHO) South-East Asia

World Health Organisation is dedicated to the well-being of the people leading towards global efforts to expand universal health coverage that direct and coordinate the world's response to health emergencies. The WHO South-East Asia region covers a quarter of the world population. It is committed to building a better, healthier future for the nearly 2 billion people of this region. South-East Asia being prone to natural disasters, disease outbreaks and health risks of climate change, one of WHO's key priorities is to strengthen emergency risk management for

sustainable development. The eight regional flagship programmes of WHO South-East Asia are in sync with the UN Sustainable Development Goals (SDGs) and global targets for health and well-being.

South Asia Co-operative Environment Programme (SACEP)

South Asia Co-operative Environment Programme (SACEP) is an inter-governmental organisation, established in 1982 by the governments of South Asia to promote and support protection, management and enhancement of the environment in the region. Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka are the member countries of SACEP. Over the years, SACEP has implemented numerous projects and programmes in the areas of environment education, environment legislation, biodiversity, air pollution, and the protection and management of the coastal environment.

Organisation for Economic Cooperation and Development (OECD)

The Organisation for Economic Co-operation and Development (OECD) is an international organisation that works to build policies that foster prosperity, equality, opportunity, and well-being for all. The OECD has strengthened its engagement with South-East Asia in recent years as a strategic priority. It focuses on new approaches needed to share the benefits of growth, improve well-being and achieve sustainable development goals. They support these efforts by fostering international and regional dialogue with comparative data and analysis, structural policy performance indicators, and medium-term economic projections. The Economic Outlook for South-East Asia, China, and India is a regular publication by OCED on regional economic growth, development, and regional integration in emerging Asia.

4.2.2 Financial Institutions

World Bank Group (WBG)

The World Bank Group works in every prime area of development that provides a wide array of financial products and technical assistance to help countries share and apply innovative knowledge and solutions to the various challenges. It is one of the largest funding and knowledge repositories for developing countries. Its five institutions share a commitment to reducing poverty, increasing shared prosperity, and promoting sustainable development. The International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA) from the World Bank provide financing, policy advice, and technical assistance to governments of developing countries. IDA focuses on the world's poorest countries, while IBRD assists middle-income and creditworthy poorer countries. Furthermore, World Bank is working on a Climate Action Plan with the Asian governments, private sector, and other development partners establishing a range of innovative solutions to support greener and cleaner energy policies that promote circular economy.

Asian Development Bank (ADB)

The Asian Development Bank (ADB) is a special member of ADFIAP committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific while sustaining its efforts to eradicate extreme poverty. ADB has developed an Asia and the Pacific Climate Bank that works with governments and civil society to deploy new and innovative investment, knowledge, and strategies to meet the critical battle against climate change. It is the first multilateral

development bank (MDB) to set clear climate investment targets for 2030 by implementing a long-term climate change operational framework and establishing a climate risk screening and management framework for its operations. ADB has also established platforms such as NDC advance and the Article 6 support facility of the Paris Agreement for strengthening the capacities of developing countries of Asia to achieve their Nationally Determined Contributions (NDCs) and to address climate change.

Asian Infrastructure Investment Bank (AIIB)

The Asian Infrastructure Investment Bank (AIIB) is a multilateral development bank whose mission is financing the Infrastructure for Tomorrow – infrastructure with sustainability at its core. Like WBG and ADB, AIIB has also developed an Energy Sector Strategy: Sustainable Energy for Asia that sets out a clearer framework to invest in energy projects that increase access to clean, safe and reliable electricity for millions of people in Asia. Sustainable cities, transport, finance, and water are other areas that this bank promotes.

International Finance Corporation (IFC)

IFC is the largest global development institution focused on the private sector in developing countries. IFC is a member of the World Bank Group, which advances economic development and improves lives by encouraging the growth of the private sector in developing countries. IFC is helping the private sector in South Asia by supporting jobs, raising incomes, and expanding access to infrastructure and financial services. The use of renewable energy, cleaner production, improving water and energy efficiency, and facilitating public-private partnerships are some factors IFC is expanding on. For example, IFC has launched two large offshore and onshore programmes in India, mobilising international capital markets to support infrastructure development.

National Developments and Private Banks

Over the years, national development banks (NDBs) have played an important role in South Asia's development. Infrastructure requirements and staggering resources required the involvement of private investments to lower the burden on governments. To facilitate infrastructure development, NDBs were established that include sustainable infrastructure through public–private partnerships (PPPs). These institutions play a crucial role in providing technical and financial resources to promote sustainable and circular initiatives.

One such initiative is the South Asian Development Fund (SADF) that supports industrial development, poverty alleviation, protection of the environment, institutional/human resource development, and promotion of social and infrastructure development projects in the South Asian Association for Regional Cooperation (SAARC) region. The 'Infrastructure Window' of the SADF is primarily utilised to fund projects in areas such as energy, power, transportation, telecommunications, environment, tourism, and other infrastructure areas.

Similarly, at the country level, India has the National Housing Bank (NHB) owned by the Reserve Bank of India (RBI) that provides housing financial support. Other PPP banks like IDFC Ltd and India Infrastructure Finance Company Ltd (IIFCL) for financing Indian infrastructure projects, Indian Renewable Energy Development Agency Ltd. (IREDA) for non-renewable energy in India, Nepal Industrial Development corporation for industrial financing, Housing Building Finance Company Ltd. of Pakistan, DFCC Bank and Lankaputhara Development Bank in Sri Lanka, China Development Bank (CDB) owned by the government of China are some institutions to name a few.

Furthermore, an Association of Development Financing Institutions in Asia and the Pacific (ADFIAP) was founded in 1976 that acts as the focal point of all development banks and other financial institutions engaged in the financing of development in the Asia-Pacific region.

4.2.3 Public and Private Sector: Housing and Urban Development

Policies for national activities including housing, construction and urban development fall under the role of housing ministries and other public–private authorities responsible for the infrastructure development in Asia. The housing developers and the real estate industry in the private sector are other actors that contribute to the built environment. Several business models of private companies are present in the literature that focuses on global sustainability targets. The private and public sectors need to create a level playing field in order for circular materials, technology, and sustainable infrastructure to become the new normal in the built environment. This requires bold leadership from both companies and policymakers and governments to transform the market.

Table 6: Public Sector Stakeholder: Housing and Urban Developments

Public Sector	Country
Ministry of Housing and Urban-Rural Development (MoHURD)	People's Republic of China
National Development and Reform Commission (NDRC)	People's Republic of China
National Energy Commission (NEC)	People's Republic of China
China Centre for Urban Development (CCUD)	People's Republic of China
Ministry of Housing and Urban Affairs (MoHUA)	India
Building Materials and Technology Promotion Council (BMTPC)	India
Bureau of Energy Efficiency (BEE)	India
Housing and Urban Development Corporation (HUDCO)	India
National Buildings Construction Corporation (NBCC)	India
Central Public works department (CPWD)	India
Ministry of Public Works and Public Housing (Kemen PUPR)	Indonesia
Ministry of National Development Planning (BAPPENAS)	Indonesia
Ministry of Urban Development (MoUD)	Nepal
Ministry of Physical Infrastructure and Transport (MoPIT)	Nepal
Department of Urban Development and Building Construction	Nepal
Kathmandu Valley Development Authority (KVDA)	Nepal
Ministry of Housing and Works (MoHW)	Pakistan
Naya Pakistan Housing and Development Authority (NAPDHA)	Pakistan
Alternative Energy Development Board (AEDB)	Pakistan
Pakistan Housing Authority Foundation (PHA)	Pakistan
Pakistan Public Works Department (PWD)	Pakistan
Ministry of Housing and Construction	Sri Lanka
National Housing Development Authority (NHDA)	Sri Lanka
Sustainable Township Development Programme (STP)	Sri Lanka
Urban Development Authority (UDA)	Sri Lanka

4.2.4 Academia

Research and Development Organisations, NGO's, think tanks and various other educational institutions corresponding to the circularity in the built environment sector acts as brokers for policy knowledge, centres for research and incubators for new ideas.

International Energy Agency (IEA)

The International Energy Agency (IEA) is the global authority for energy-efficiency data, analysis and policy advice that helps government in policy-making, implementation and advisory. The IEA together with the Global Alliance for Building and Construction (GlobalABC), has developed a global Roadmap 2020–2050 to enable the transition towards low-emission, efficient and resilient buildings and construction. Further, IEA is tracking emerging trends by using digital technology to enable greater energy-efficiency gains, including active energy management systems (EMS).

4.2.5 Supply Chain of Materials and Technology Providers

Manufacturing companies and technology providers are perceiving a change in their operational environment in the direction of sustainability expectations of production. Material chains can be seen at different scales in different countries. The reduction in the consumption of raw materials, use of non-toxic, high-grade materials that can be reused and recycled, and procurement of renewable materials (bio-based or biodegradable) are some key areas to facilitate circularity in these supply chain of materials. One such initiative is the Asia Pacific Green Public Procurement (GPP) Network project, funded by and co-led with Korea Environmental Industry & Technology Institute that aims at enhancing GPP knowledge-sharing and networking in the Asia Pacific region, with a view to stimulate markets for eco-friendly products and services.

China and India are some of the largest cement-producing countries globally. The use of recycled cement and sand, therefore, becomes essential in bringing circular economy (CE) into sustainable infrastructure development. Another important factor to highlight here is the transparent communication about the sustainability performance of the manufactured products that include environmental product declarations (EPDs), Life-cycle Assessment (LCA), and material passports. Currently, there is a lack of availability of LCA data of building materials in many developing countries of Asia. Recently, one initiative, the energy-efficient Building Materials Directory of India (BMDI) was launched in 2020 in India to provide the consumer an informed choice about the energy-saving and thereby cost-saving potential of the relevant market product.

The use of low-embodied vernacular materials and recycled products are presented in the collected good practices, as will be seen in the section corresponding to case studies.

4.2.6 Certifications and Labelling

Green Building Council (GBC)

The Green Building Councils are independent, non-profit organisations covering businesses and governments to collectively drive a built environment that supports the regeneration of resources and natural systems, providing socio-economic benefit through a thriving circular economy. There are established green building councils in China, India, Indonesia, Pakistan, and Sri Lanka amongst the selected six countries of the study.

Global Ecolabelling Network (GEN)

The Global Ecolabelling Network (GEN) is a non-profit association of leading ecolabelling organisations worldwide. The Ecolabel standards address multiple environmental and health issues, which include toxicity, air quality, energy and water use, recyclability, use of natural resources, and other areas of concern.

Table 7: Global Ecolabelling Network Members from Selected Countries

Member	Programme Name	Country
China Environmental Labelling	China Environmental United Certification Center	People's Republic of China
China Environmentally Friendly Certification	China Quality Certification Centre (CQC)	People's Republic of China
GreenPro	Confederation of Indian Industry	India
Indonesian Ecolabel	Ministry of Environment	Indonesia
Green Label Indonesia		Indonesia
Eco Label Sri Lanka		Sri Lanka

4.2.7 Primary Stakeholders

The study focuses on the deep-dive of the selected six Asian countries; China, India, Indonesia, Nepal, Pakistan, and Sri Lanka. The primary data was gathered using an interview-based questionnaire to the key built environment stakeholders (Annexure 1 Stakeholder list) to understand the state of play for circularity in the built environment and enumerate the current building and construction trends in the respective countries. The global survey data and good practice case studies were collected from these personal interviews. The validation of the viewpoints and findings was done through a subsequent stakeholder consultation meeting.

4.3 CASE STUDIES

Introduction

Circular Built Environment case studies showcase good practices of various project types in different life cycle phases across various countries. Environmental, social and economic impacts in selected projects are explained, and related Sustainable Development Goals identified. Compact illustrated overviews of the case studies summarise their main challenges and success factors. In providing these examples, it is expected that they can be successfully replicated, adapted to different environments and scaled up. The SBC programme thanks the authors, experts and other stakeholders contributing to the collection and dissemination of the case study data.

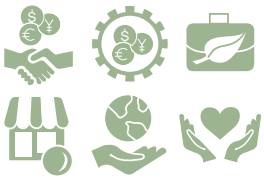
Webpage

https://www.oneplanetnetwork.org/sites/default/files/2021-11/SBC_cases_web_ASIA_211102.pdf

Life Cycle Phase(s)

Project type

Impacts



Related SDGs

Zero Construction & Demolition Waste Management Practice, Shenzhen, China 2012

Project type

Material, Deconstruction

Impacts

Capital cost, Operational cost, Environmental impacts

Related SDGs

SDG8, SDG9, SDG12, SDG17

Life Cycle Phase(s)

Keywords

Policies promoting circularity, Construction and demolition waste management, Use of reused or recycled content in new products and buildings, Zero waste, Sustainable development

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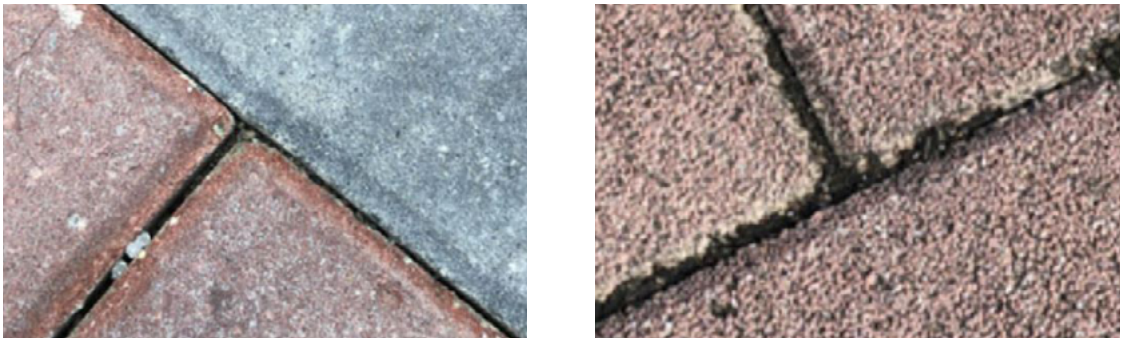

Figure 28: Comparison of new bricks and recycled bricks.

Credit: Mengjie Shi and Zhikun Ding.

Overview

The government has set up the Nanshan Demolition office, located in Nanshan District, Shenzhen, for dismantling three villages – Changyuan Village, Fuguang Village, and Tianyu Village – and carry out the expansion of a new campus of Southern University of Science and Technology and Shenzhen University. It showcases an example of planned construction and demolition (C&D) waste management practice. About 3.72 km^2 of the area was demolished that generated 666 000 m^3 of C&D waste, which comprised concrete (30%), crushed brick (40%), unproductive soil (25%), and non-inert waste (5%). The waste deposited on-site goes up to 4–5 m high. It will include high transportation costs and high traffic safety risks to transport the waste.

This project would require 50 million RMB to transport the waste out of the construction site. By cooperating with Shenzen Yuezhang Green Building Technology Development Company and reusing and recycling C&D waste in this project on the site itself, the cost came down to 20 million RMB. As a result, the project realised zero waste.

Furthermore, unproductive soil separated from C&D waste was piled up as 20-m high Cangxiu Mountain. It not only reduced transportation cost, but also become a landscape of the campus thus resulting in 'zero transportation'. Due to the profit chain in the procurement of materials for construction units, the government enforced that purchased bricks will not be used on-site in this project, thus guaranteeing the utilisation of recycled bricks.

Impacts

About 66,667 m^2 of land resources was saved, and consumption of raw materials, e.g., sand and stone of 600,000 m^3, was reduced. Every 10,000 m^3 of soil consumes 16 million litres of petroleum by the distance of 20 km. By reusing the soil to make a mountain landscape, the project saved 78,000 tonnes of carbon emissions (Shi, 2021).

Table 8: Recycled Materials
(Shi, 2021)

No.	Product Use	Use	Quantity	Unit
1	Non-burning solid brick	Brick membrane and masonry	795,925	Piece
2	Hollow concrete brick	Masonry engineering	142,518	Piece
3	Square brick	Square	3,649,285	Piece
4	Permeable brick	Sidewalks, gardens, squares	34,839	m^2
5	Coloured Dutch brick	Sidewalk ground	1514	m^2
6	Planting brick	Parking lot green belt	1624	m^2
7	Roadside brick	Roadside	4476	m
8	Recycled coarse aggregate	Temporary construction roads on campus; Replacement of building foundation soil	16,282	m^3
9	Recycled fine aggregate	Campus supporting road base	24,235	m^3

Replicability

A planned C&D waste management practice can significantly reduce capital investment. Similar approach can be replicated to other sites by producing on-site recycled materials, thereby, resulting in zero transportation and environmentally friendly solutions.

Main challenges

Lack of knowledge and standards for recycled C&D waste, poor management system and under-developed market for recycled C&D waste products

Main success factors

- Overall planning: forming a comprehensive utilisation equaliser.
- The project produced recycled building materials on demand. With low-economic value and high transportation cost of the recycled products, the 'on-site utilisation' can significantly reduce the transportation cost.

C&D Recycling Waste Plant, Surat, India 2020

Project type

Material, deconstruction

Impacts

Environmental impacts, New businesses & Green jobs and skills

Related SDGs

SDG8, SDG9, SDG12, SDG17

Life Cycle Phase(s)

Keywords

Policies promoting circularity, Construction and demolition waste management, Use of reused or recycled content in new products and buildings

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Figure 29: ReUrban Compact Technology by CDE Asia

Overview

India generates an estimated 150 million tonnes of C&D waste every year. But the official recycling capacity is less, i.e., 6500 tonnes per day (TPD) – just about 1%. (Roychowdhury, 2020). In accordance with the C&D Waste Management Rule, 2016 by the Ministry of Environment, Forest and Climate Change, India, a state-of-the-art mobile wet processing C&D waste recycling facility has been established to process 300 TPD waste at Surat, India in 2020, under a public–private partnership (PPP) model awarded to Surat Green Precast Private Limited (SGPPL) as management facility and CDE Asia as technology provider. Based on the circular model (refer to Figure 30), the waste is collected from 10 collection centres or transfer stations (TS). The collected waste is further processed using ReUrban Compact technology, latest in India, that allows 96% recovery of high-quality sand (50%), aggregates (28%), and soil (18%). The recycled sand and aggregates are reused in construction and to manufacture certified products such as tiles, blocks, pavers, etc. A similar approach is now being replicated in various other cities of India.

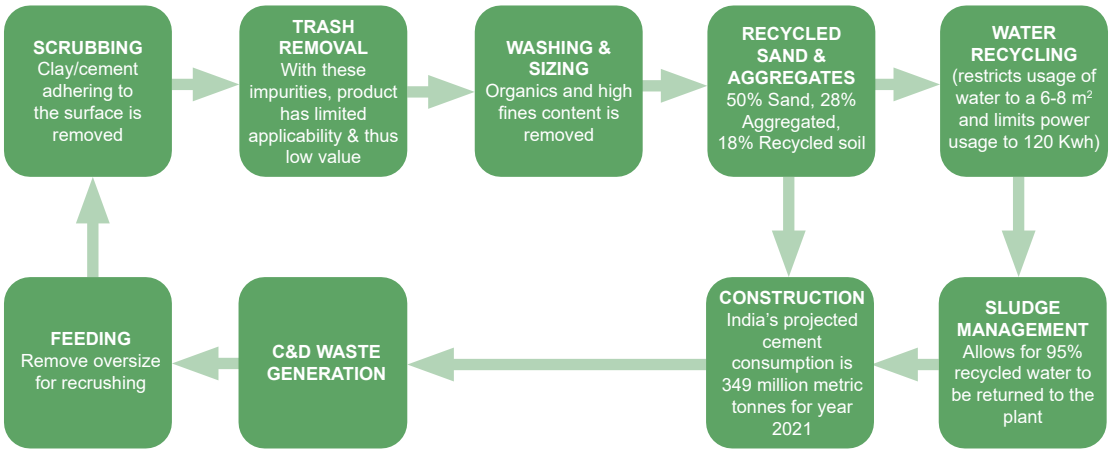

Figure 30: Circular model adapted for C&D waste recycling at Surat, India

Impacts

This circular model of recycling of C&D waste has showcased considerable environmental impact savings (refer to Table 9) as opposed to landfilling for the city of Surat. Though the capital cost (USD 1,481,730) and operational costs are high, it will reduce 508 tonne of CO_2 emissions, which is the same as burning 250,000 kg of coal every year. This will save 9100 Giga Joules of energy, enough to power 3,000 Indian homes for an entire year, free 30,000 yd^2 of land from landfills, thus unlock 100 crore worth of real estate every year.

New businesses, green jobs and skills: The manufactured recycled products are sold at 30% cheaper rates in the market with a buyback of recycled products by the Surat Municipal Corporation.

Table 9: Projection of environmental impact savings in one year for Surat Plant

(Environmental Benefits of C&D Waste Recycling- LCA analysis of Surat, 2019)

Impact Strategy	Unit	Based on current recycling data (26,424 tonnes/ year)	Dacility operation at full recycling potential (109,500 tonnes/year)	Entire portion of C&D waste in Surat in sent for recycling (182,500 tonnes/year)
Global warming	tonnes CO2 eq	73,5	73,5	508
Non-renewable energy	GJ primary	1317,4	1317,4	9099,3
Land occupation	Acres of garbage	0,88	0,88	6,1

Replicability and scalability

The ReUrban plant is a mobile technology in which the same set-up can be used in a different location thus making it highly replicable and scalable.

Main challenges

Initial resistance of the settlers to leave their environment and livelihood
Continuity of the project throughout the different periods of government

Main success factors

Improvement of the quality of life of poor communities, environmental and landscape recovery of a degraded urban area

Community Seed Bank, India, 2020

Project type

Material, Building, Research, Neighbourhoods

Impacts

Capital cost, Environmental impacts, Social Impacts

Related SDGs

SDG1, SDG3, SDG6, SDG7, SDG11, SDG12, SDG13, SDG15

Life Cycle Phase(s)

Keywords

Design for disassembly, reuse and easy to recycle, Adaptability, Flexibility and refurbishment of buildings and neighbourhoods, Conservation of native seeds, Sharing and multi-use of spaces, Use of reused or recycled content in new products and buildings, Circular energy, Creating awareness about traditional methods of construction

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Figure 31: Off grid structure, running on solar power

Figure 32: Loft area, a resting space and extended storage area

Overview

‘Community Seed Bank’ is a project that aims to use local methods and materials for creating community space for seed preservation in traditional construction methods. Mr. Pradeep Kumar, an IT professional with a vision to reverse-migrate to his native in Karur, Tamil Nadu founded Rangamalai Organic Farms, which requires a ‘Seed Bank’ to conserve the native seeds of various vegetables, trees, and food crops. This project aims to inspire the villagers to do farming in methods non-harmful to nature. By choosing natural building methods for seed bank, the intention is to create awareness about sustainable buildings constructed in

indigenous ways and the use of minimal energy and local materials. Thannal Natural Homes, an organisation in India, guided Mr. Pradeep to build the seed bank with the help of Thannal natural building workshops, an initiative by Ar. Biju Bhaskar.

The main walls are in lime stabilised cob with natural plasters. It uses local palm trees for structural members, old terracotta tiles for roofing, and runs on off-grid solar energy. The bank showcases multipurpose: office space and display area of seeds, verandah space for various value addition work post-harvest and interaction between farmers from the community, dark room for storage of grains, and loft as living quarters. The money is invested in the village economy and serves as an example for traditional knowledge transfer for low-cost rural projects to be sustainable through community building.

Impacts

Project cost: USD 27,000

Environmental impact: Low impact since all the materials are low embodied materials that are procured from in and around the site.

Social impact: Increased awareness for building natural homes, sustainable methods of farming with enhanced community engagements. It creates an opportunity for upskilling of masons to adapt the ancient methods to present-day needs – like stabilising mud with lime, admixtures from plants and animals etc.

Replicability

The features of natural buildings vary from place to place, adapting efficiently to the available materials and local methods. Replicating the same method using the same set of artisans is an easy process. Still, it may not be economical due to several site conditions changing in a particular site. Adapting ourselves and learning from the vernacular knowledge of shelter making is the key to natural building.

Scalability

The project is scalable, but one must take care of a few factors: If the span is huge, the use of bamboo will be economical than wood. The specific technical knowledge to scale up the spans using bamboo needs to be attained by making mock-up samples and load testing. Civil engineers and artisans experienced in bamboo or mud must work together to achieve this. Another way to scale up is to tackle the problem with thoughtful design; by limiting the spans and heights, but increasing the number of building units to reduce the complexity.

Main challenges

- The preparation of estimates of costs at the initial stage of the project was complex due to unique challenges, such as available materials, per-unit cost and labour charges.
- Contractors were unwilling to take such a work as a result of lack of prior experience. The project was executed on daily wage labour without any contract. However, in the end, the mason got trained and were open to work on a contract basis in the future.

Table 10: Detailed material summary

S.No	Material	Quantity (1 unit=100 ft^3)	Source/ Remarks	Usage
1.	Pebble stone	6 Units	Sourced from Nearby Quarry	Foundation
2.	Mud type 1	14 Units	From the site itself	Wall/Plaster
3.	Mud type 2	7 Units	From the site itself	Wall/Plaster
4.	Lime	144 Bags	Local Lime Kiln	Foundation/Wall/ Plaster
5.	Bricks	1,000 Bricks	Local Brick Kiln	Plinth beam
6.	Waste Bricks	1 Units	Reused as surkhi	Plinth Beam, Mortar
7.	Bamboo	80	Market	Secondary Roof
8.	Bamboo Padal (panels of bamboo branches)	8	Market	Wattle wall
9.	Stone Pillars	5	Traditional Sculptors Living	Roof
10.	Straw	6 Bundles	Market	Wall
11.	Kadukkai / Haritaki seeds (Terminalia Chebula, termite repellent)	48 Kg	Ayurvedic Medicine shop	Wall, Plaster, Plinth beam
12.	Jaggery (binding agent)	48 kg	Market	Wall, Plaster, Plinth beam
13.	Starch (as natural polymer)	25 kg	Market	Wall, Plaster
14.	Cornice Bricks	400 Bricks		Wall
15.	Wooden frame for opening for opening	4 Number	Vengai tree used	Door and Window
16.	Doors	2 Number	Teak	
17.	Windows	4 Number		Hall and loft
18.	Wooden Beam	6 Beams	Palm	
19.	Wooden Rafters	80 Trees	wood/Native tree/ Sourced from place< 100km	Roof and Loft
20.	Wooden planks	430 sg. ft	Silver oak and coconut planks	Loft floor
21.	Wooden patterns/ Reapers	2,500 Run.ft	Silver oak	Roof
22.	Mangalore Tiles	2,200 Tiles	Reclaimed Tiles	Roof
23.	Terracotta floor tiles	2,000 Tiles		Floor, Roof
24.	Cashew Nut shell Oil	240 Litres	Factory made products	Treatment for Wood
25.	Linseed Oil	50 Litres		
26.	Boric Acids	125 kg		
27.	Borax Salt	65 kg		
28.	Copper Sulphate	4 kg		
29.	Small Bamboo	250 Bamboo poles	Market	Living roof
30.	Pondliner	1 Sheet	Factory made product	Living roof
31.	Country wood pillars	10	Harvested in farm	Side roof
32.	Admixtures	-	Plant & Animal Derivatives from farm - Cow Dung & Cow Urine	Foundation, Wall, Plaster
33.	Solar panel	1000 watts	Fixed on Rooftop	

Figure 33 (up, left): Virali *(Dodonaea viscosa)* in cob used as termite resistive admixtures

Figure 34 (up,right): Verandah with living roof on top

Figure 35 (down, left): Cob walls with mud pot storage

Figure 36 (down, right): Seed storage method - Dombai, traditional in Tamil Nadu, India

Strawclay: Insulation Bricks for Passive Solar Heated Buildings, Ladakh, India, 2021–

Project type

Material, Building, Research

Impacts

Improved air quality, new jobs and businesses

Related SDGs

SDG8, SDG9, SDG12, SDG17

Life Cycle Phase(s)

Keywords

Construction and demolition waste management, Design for disassembly, Reuse and easy to recycle, Use of reused or recycled content in new products and buildings

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Figure 37: Strawclay bricks

Figure 38: Phyang Building

Overview

According to some estimates, farmers in northern India burn about 23 million tonnes of paddy stubble every year. Due to urban heat island effect, the National Capital Region (NCR) in India experience harsh pollution often reaching the severe levels of the air quality index (AQI). The straw, which is a huge burden in the Punjab region of India, is rescued and transported to Ladakh where it is used to manufacture straw-clay bricks, a local intervention. These straw-clay bricks are low-density bricks with higher insulation properties. Thus, a straw-clay brick saves pollution twice, once in Punjab (or Delhi NCR) and then in Ladakh, a climate-sensitive zone. To mainstream the concept of passive solar heating and use of high insulation in buildings, it is critical that the local and national government make policy modifications and promote

the usage of such low-carbon building materials that go beyond sustainability, and have a regenerative impact on the environment. Mr. Sonam Wangchuk along with the architectural team of Himalayan Institute of Alternative and several volunteers at SECMOL contributed to the development of the building. Sustainable chain of transport of straw from Punjab to Leh, incentivisation of PSH buildings in Ladakh, and to mechanise the production of bricks are a few ongoing objectives.

Impacts

Improved air quality in the cities due to stoppage of burning of straw by using it as an alternative building material.

New jobs and business: Increase local jobs in manufacturing of straw-clay bricks by providing jobs to the locals in Leh.

Environmental impacts: See Table 11.

Table 11: Environmental impacts

Implementation	Percentage achieved
Recycle of water and waste	100%
Reduction in material used using arch foundation	30%
Reduction in plastering material and cement for mortar by use of interlocking stabilised mud blocks	100%
Reduction in cost by use of reclaimed door/windows	50%
Reduction in use of steel and concrete by brick vault construction	60%
Overall steel reduction	50%
Overall cement reduction	30%
Reduction in volume of other materials	25%

Replicability

The cold arid regions of the world can benefit from the passive solar heated buildings.

Main challenges

- Hesitation of government in adopting the technology, as it is not in the government schedule list, yet.
- Lack of financing opportunities to incentivise the locals to the technology.
- Transportation of straw for the construction of the bricks.

Main success factors

- The new design of PSH buildings at Phyang achieved indoor temperatures of around 22 °C average without any back-up heating when outside temperatures were around –10 to –15 °C. At the same time, the non-heated rooms in non-PSH buildings were at around -3 °C.
- The PSH buildings are capable of achieving full autonomy through passive solar heating in Ladakh.
- The cost of heating of conventional buildings exceeds the construction cost of the PSH buildings itself in roughly 11 years.

Pulluvila Thota: Net Zero campus, Mysore, India, 2021

Project type

Material, Building, Research

Impacts

Capital cost, Environmental impacts

Related SDGs

SDG1, SDG3, SDG6, SDG7, SDG11, SDG12, SDG13, SDG15

Life Cycle Phase(s)

Keywords

Construction and demolition waste management, Design for disassembly, Reuse and easy to recycle, Adaptability, flexibility and refurbishment of buildings and neighbourhoods, Sharing and multi-use of spaces, Use of reused or recycled content in new products and buildings, Circular water, Circular energy, Financing circular processes

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Figure 39: Kitchen garden in the backyard for farming, use of reclaimed doors and windows

Overview

As defined by WorldGBC, net-zero carbon buildings are highly energy-efficient buildings with all remaining operational energy use from renewable energy, preferably on-site but also off-site production, to achieve net-zero carbon emissions annually in operation (Laski & Burrows, 2017). Only a few examples in India are available that showcase this concept in standalone homes. An attempt has been made to achieve 100% net-zero energy and net-zero waste campus (Site area: 7 acres, Built-Up area: 4,000 ft²) by Mr. Rajesh Kumar Jain from RLEEF architects and consultants, India. In this project he focused on utilising the strength of material and technologies by reducing the volume of material required, reducing burnt products, reusing reclaimed material, reducing high energy consumption material, recovering and recycling C&D waste.

The project Pulluvila Thota, a remote sustainable house, portrays an effective example of capital investment and trade-off in utilising the skills of workers by training them on-site for alternative technology methods for using site resources to the maximum. An integrated climate-based approach for design including sustainable solutions such as rainwater harvesting, DEWATS, use of off-grid solar renewable energy, kitchen waste, biogas, chemical-free air bubble concept bioswimming pool, permaculture system of organic plantation and vegetation are used. Furthermore, reuse of old doors and windows, tandoor hand-cut flooring, using discarded ceramic tiles, filler slabs, cuddapah for shelves short spans roof, stabilised compressed interlocking mud bricks and bricks for vaults, vault filling with fly ash, lime wash for painting, load-bearing structures with arch foundation facilitates the holistic concept.

Impacts

Project cost: USD 170,000

Thermally comfortable surrounding: With improved indoor air quality, mechanical ventilation is not required.

Environmental impacts: see Table 12.

Table 12: Environmental impacts

Implementation	Percentage achieved
Recycle of water and waste	100%
Reduction in material used using arch foundation	30%
Reduction in plastering material and cement for mortar by use of interlocking stabilised mud blocks	100%
Reduction in cost by use of reclaimed door/windows	50%
Reduction in use of steel and concrete by brick vault construction	60%
Overall steel reduction	50%
Overall cement reduction	30%
Reduction in volume of other materials	25%

Replicability

It can be replicated to other locations with design modifications as per the climatic zone requirements. A similar 'holistic' approach can be used to establish a base frame to develop a net-zero solution.

Main challenges

- Monitor daily on-site activities because of its remote location, extra effort to motivate and train labours and gain confidence
- Work out an appropriate energy system by understanding the need and usage of the gadgets, to economise the system with suitable return on investment
- Lack of on-site power supply.

Main success factors

- Involvement of network of individuals and organisation, educate client, labours, students and professionals by sharing the results
- Thermal security, food security, water management and security, energy security, 5Rs, capacity building and dissemination of more practical on-site experiences
- Use of recycled C&D waste and reclaimed material for the building envelope.

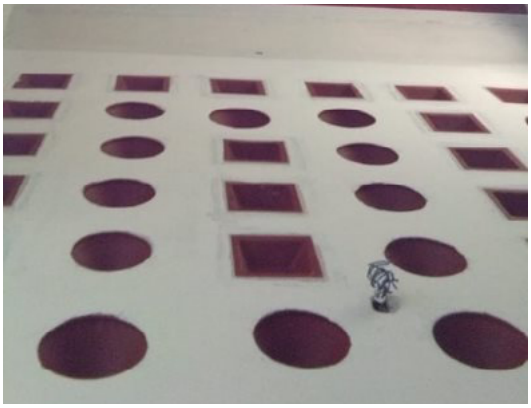

Figure 40 (up, left): Solar energy use, off-grid

Figure 41 (up, right): Roofing system: Brick Vaults and filler slab hollow bricks, china mosaic

Figure 42 (middle, left): Bio Pool; chemical free- use of air bubble concept storage

Figure 43 (middle, right): Arch Foundation

Figure 44 (down, left): Filler slabs

Image credits: RLEEF

Government Policy to Reduce Energy Use
Jakarta, Indonesia, 2013

Project type

Policy

Impacts

Environmental impacts

Related SDGs

SDG3, SDG6, SDG7, SDG11, SDG12, SDG13

Life Cycle Phase(s)

Keywords

Policies promoting circularity, Circular water, Circular energy, Financing circular processes

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Figure 45: Ecoloft Jababeka Golf case for EDGE advanced certification.

Credits: Ecoloft

Overview

The Governor Regulation No. 38 of 2012 on Green Buildings modulates the construction, planning, utilisation, maintenance, and deconstruction of buildings in Jakarta. The regulation mandates efficiency of the building veil systems, ventilation systems, air conditioning, lighting systems, building transportation systems, and electrical systems along with the planning of water use, land, and waste management for the new buildings. For existing buildings conservation, water and energy efficiency, indoor air quality, thermal comfort, operational management, and maintenance are essential.

This regulation became mandatory in April 2013 for all new and existing buildings of a certain type and sizes including office and residential buildings over 50,000 m², hotels and health facilities over 20,000 m², and educational facilities over 10,000 m². Compliance with the code is now integrated into the building permit application process (The Government of the Province of Jakarta Special Territory, 2012).

To support this regulation, the Jakarta Government, in collaboration with the IFC and GBCI, implemented an international standard called 'Excellence in Design for Greater Efficiencies' (EDGE) in 2015 (UNDP, 2021). One such certified case is the Ecoloft, Jababeka Golf Homes having 19 units totalling 2,432 m². It demonstrates three aspects: comfort, efficiency, and health by reducing window-to-wall area ratio, using horizontal bamboo shading devices, solar hot water collectors, solar photovoltaics, enabling safe and clear water resources, high comfort through efficient cooling, cellular lightweight concrete blocks for internal and external walls with parquet and woodblock finishes and UPVC window frames. Its predicted savings for EDGE certification, which demonstrated 82% energy savings, 31% water savings, and 47% less embodied energy in materials.

Impacts

1.37 million tonnes of CO_2e can be reduced by year 2030 by implementation of the Jakarta Green Building Code, which is equivalent to 300,000 cars off the road or planning about 1 million trees.

Replicability

Since, IFC has helped to develop regulations in Colombia, Costa Rica, Indonesia, Panama, Peru, the Philippines and Vietnam as an internationally recognized green building certification system, EDGE can be deployed to fulfil the requirements of the Global ESG benchmarks for real estates (GRESB), International Capital Market Association and Climate Bonds initiative.

Building With Nature, Indonesia, 2021

Project type

Neighbourhood, Policy, Regeneration

Impacts

Project cost, Environmental impacts, Social impacts

Related SDGs

SDG11, SDG13, SDG14, SDG15

Life Cycle Phase(s)

Keywords

Adaptability, flexibility and refurbishment of buildings and neighbourhoods, creating coastal resilience through nature-based solutions, ecosystem-based disaster risk reduction, ecosystem base adaptation

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Figure 46: Community groups constructing permeable structures.

Credit: Nanang Sujana

Figure 47: Drone picture permeable structures in front of Demak

Credit: Witteveen+Bos

Overview

Since 2012, Indonesia has been implementing the Building with Nature approach in Central Java in collaboration with Wetlands International, EcoShape, national and international partners and local communities. Communities suffered from extensive flooding, lost income and were even evacuated. A large-scale initiative enhanced coastal resilience along a 20 km eroding coastline through mangrove restoration combined with development of sustainable aquaculture and other livelihoods using sustainable permeable structures. Each structure is 100 m long with an opening of about 5–10 m in the middle. It used local materials such as wood, bamboo, twigs or other brushwood. Communities were empowered to join policy dialogues to express their needs, successfully securing additional government support for these measures. Through capacity building, knowledge exchange and embedding Building with Nature into policy and planning, the project supports the replication and scaling up of the approach.

Impacts

Project cost: USD 9,253,600

The Building with Nature approach is *economically viable*: no coastal protection investments or traditional investments would have caused the loss of productive aquaculture land (avoided costs).

Direct benefits: Creation of *sustainable and productive land* (aquaculture) along with several additional income-generating benefits (increase of wild catch, recreation, timber and non-timber products and biodiversity conservation).

Social impacts: Helping build the skills of traditional farmers through 'Coastal Field Schools'" that teach sustainable aquaculture practices. Shrimp yields have tripled and margins have doubled as a result.

Replicability

Demak is typical for many low-lying muddy coasts in Indonesia and across Asia that have replaced their mangroves with aquaculture ponds. Such coasts often face severe erosion and catastrophic floods that leave millions of people at risk of losing their houses, land, roads and income. For many such places, Building with Nature is a feasible, replicable and scalable solution. But it requires the right conditions, including the presence of involved and committed stakeholders from different sectors and disciplines, and favourable and well-understood bio-physical environment. Following the collaboration in Demak, the Indonesian Ministry of Marine Affairs and Fisheries (MMAF) altogether installed 23.5 km of structures in 13 districts between 2015 and 2019. The Indonesian Ministry of Public Works and Housing has developed and tested new semi-permeable structure designs, and is producing technical guidelines on their use to be accepted nationally.

Main challenges

- Land subsidence has been a challenge and needs to be halted and prevented urgently in order to fully restore the eroding coastline. In 2017, it was noticed that new mangroves were disappearing, and monitoring poles in the water submerged. Subsidence of the land and foreshore was wiping out the gains from mud accumulation. Near the city of Semarang, it reached between 8–15 cm/year in places, but it spread right along the Demak coast, caused by the abstraction extraction of groundwater, mainly by industry in the city and along the highway.
- The perception of Building with Nature in Indonesia is the application of the approach in Demak, while the approach can be applied in many forms, requires further awareness raising to support upscaling.

- Overall investments in nature-based solutions is still low due to traditional preference for grey infrastructure, which is connected to lack of knowledge, uncertainty and challenges in collaboration between sectors amongst others.

Main success factors

- Design and construction of permeable structures along the at-risk coastline to trap sediment to expand the intertidal area and enable mangrove recovery: 9 km in Demak which has halted the erosion threatening coastal villages. Local communities now own the permeable structures in Demak. The Indonesian government has replicated this with up to 23.5 km elsewhere in Indonesia.
- The improvement of aquaculture productivity through sustainable best practices and integration with mangrove restoration motivated community groups to contribute to the range of coastal defence measures. The Bio-rights finance mechanism incentivised this by engaging communities in coastal restoration work and in return supporting sustainable livelihood development including through coastal field schools.
- A successful outcome depended on a blend of technical and social processes in the landscape, supported by science and policy developments. Therefore, Building with Nature is only possible through multi-disciplinary collaboration. Engagement of community members has been essential in establishing the landscape vision, the design process, implementation of measures and adaptive management.

Figure 48 (up, left): Flooding and land subsidence in Demak. Credit: Cynthia Boll

Figure 49 (up, right): Water hyacinth shredded to make compost for the ponds. Credit: Cynthia Boll

Figure 50 (down, left): Mud accumulation behind permeable structures. Credit: Wetlands International

Figure 51 (down, right): Riverine mangrove restoration integrated with aquaculture ponds. Credit: Wetlands International

Eco-Building Method: Earthquake-Resistant Glass Bottle Buildings, Nepal, 2011–

Project type

Neighbourhood, Policy, Regeneration

Impacts

Environmental impacts

Related SDGs

SDG4, SDG11, SDG12, SDG17

Life Cycle Phase(s)

Keywords

Design for disassembly, reuse and easy to recycle, Adaptability, flexibility and refurbishment of buildings and neighbourhoods, Use of reused or recycled content in new products and buildings

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Figure 52: Kindergarten glass bottle and bamboo building

Figure 53: Glass bottle building from inside

Overview

An eco-building method was developed by the Kevin Rohan Memorial Eco Foundation (KRMEF) in Nepal where natural materials like bamboo for structure, discarded waste; car tyres filled with sand as a foundation, and non-recyclable glass liquor bottles used as a walling material and as a replacement of bricks. With a successful accomplishment of their first disaster-safe low-cost bamboo and bottle structure, it is now being replicated in various parts of Nepal. The foundation has a tie-up with the American embassy that supplies waste bottles once a week. They also collect the waste bottles from the restaurants in Kathmandu at zero cost. So far, a G+2 structure has been achieved with a bamboo frame and glass bottles wall that is designed keeping in mind the disaster risk. Recycled paper, clay, sand, straw, and cow manure are some other materials that are being used in walls as an infill and plaster.

The KRMEF foundation works on a unique sustainable financial model that promotes three pillars; ecology, economy, and social inclusion. They have constructed a café and a guest house with the same material that helps in generating funds for the foundation. Volunteers from various other countries come here to learn sustainable agricultural and natural building practices. With these volunteers, KMREF constructs shelters for those who have lost their homes during the earthquake. Thereby, reducing the funds otherwise required for professionals working on site. Thus, it generates jobs for local people in the agriculture and building field in collaboration with the volunteers and funding received from the different international organisations as donations or a fee for the workshops. Some public-use buildings such as a library, a school for farmers, a guest house, and a kindergarten have been built using this sustainable technology and financial system enhancing the circular economy.

Impacts

Low capital and operational cost since most of the building materials are procured locally and the bottles are collected at a zero cost.

Social impact: A huge impact in uplifting the people by providing free shelters to the one in need through donations and other fundings. The model also promotes the natural building methods through workshops and volunteering.

Social impacts: Helping build the skills of traditional farmers through ‘Coastal Field Schools’” that teach sustainable aquaculture practices. Shrimp yields have tripled and margins have doubled as a result.

Replicability

It is being replicated in various parts of Nepal and has a potential to be expanded in other countries with sensible collaborations between locals and various non-governmental organisation.

Main challenges

No support from the government for the adaptation and promotion of sustainable strategies or procurement of waste material.

Main success factors

- Reuse of waste materials that would otherwise have gone to the landfill.
- An integrated model showcasing a successful collaboration between locals, NGOs and funding agencies.

Figure 54 (up, left): Volunteers

Figure 55 (up, right): Recycled glass bottle house under construction

Figure 56 (down, left): Leela's Eco-Cafe

Figure 57 (down, right): Tyres used for earthquake shock resistance foundation

Bamboo & Earth: Owner Driven Reconstruction (ODR)

Nepal 2015–

Project type

Material, Building, Research, Neighbourhood

Impacts

Capital cost, Operational cost, Environmental impacts

Related SDGs

SDG8, SDG9, SDG12, SDG17

Life Cycle Phase(s)

Keywords

Construction and demolition waste management, Adaptability, flexibility and refurbishment of buildings and neighbourhoods, Use of reused or recycled content in new products and buildings, Reconstruction.

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Figures 58: Owner Sanu Maya Tamang building her own house with ABARI.

Credit: Sagar Chitrakar

Overview

The 2015 devastating earthquakes left thousands of people homeless in rural areas and in the most densely populated areas of Kathmandu, Nepal with little to no options for affordable, sustainable home reconstruction. Given the high number of homes that needed to be rebuilt, ABARI, an organisation in Nepal, established a decentralised 'Owner driven reconstruction' (ODR) approach. It was identified as a noble approach uplifting individual homeowners to implement safe building design and construction in natural disaster-affected areas. To implement this strategy, ABARI distributed free Open-Source handbooks of design of school and permanent homes for public use (available on website); this used the same technology of houses built at the epicentre that survived the 2015 earthquake. For mass rural construction, post-disaster rammed earth is used as a primary material with wattle and daub as secondary (refer to Figure 59). The provision of vertical reinforcement at every corner and openings of the rammed earth provides tensile strength to the structure as opposed to previous traditional practices. To maintain the ethnicity of the community and tradition, ceramic tiles are used as roofing materials. For the framing of the roof, bamboo is used as a rafter and wooden studs as purlins.

Impacts

Use of low embodied materials, material foot print, low capital and operational cost

Replicability

Due to available knowledge base repository for ODR construction and use of locally available materials, it becomes a highly replicable case. It can be affirmed that the planned implementation of the right knowledge and construction methods can drive resilience and post-disaster recovery at a much faster pace.

Main challenges

- Government acceptance, approval and support for bamboo and earth in earthquake reconstruction
- Community perception of understanding of new technology mostly due to trauma from an earthquake and lack of government support for the technology
- Rigid existing supply chains in support for concrete structures due to centuries of building evidence in more developed locations.

Main success factors

Using this strategy, they were able to build more than 8 schools and 30 homes in less than two years achieving the aim to inspire and build confidence among locals to use locally available resources as a post-disaster recover method.

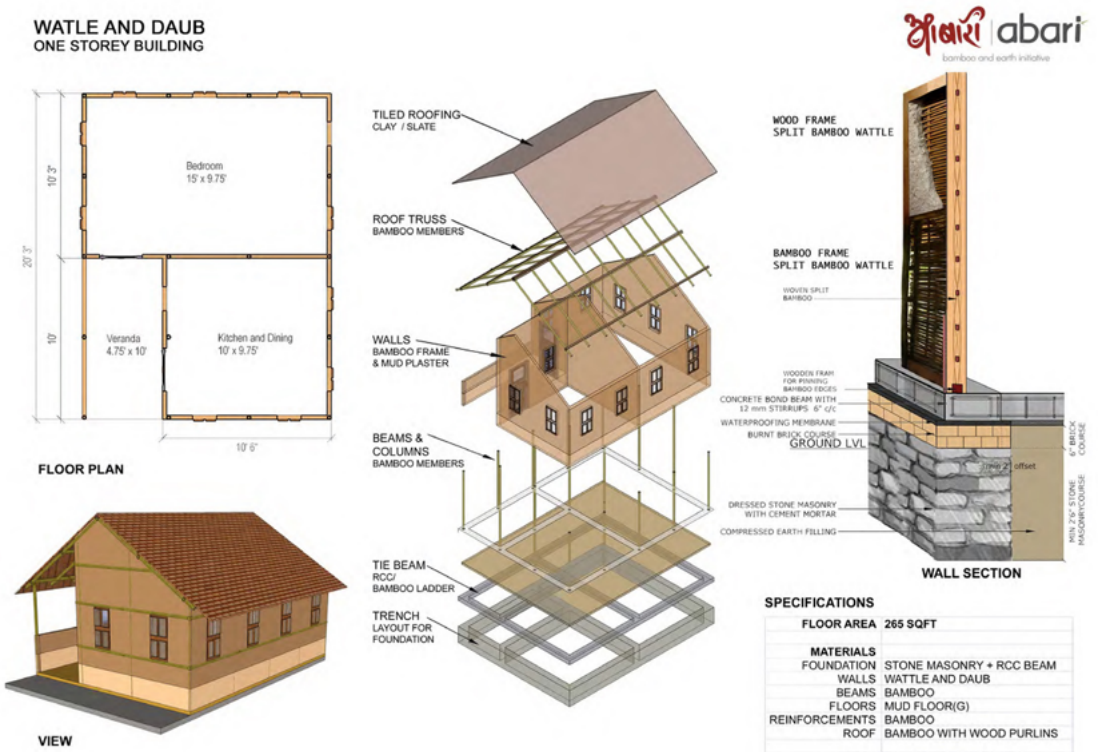

Figure 59: Open source handbook for ODR construction.

Credit: ABARI

Denzo Hall Rahguzar Walking Street for Regeneration of Karachi's Historic Core, Pakistan 2021

Project type

Neighbourhood, Urban Renovation, Regeneration

Impacts

Capital cost, Operational cost, Environmental impacts, Social Impacts, New businesses & Green jobs and skills

Related SDGs

SDG6, SDG11, SDG12, SDG13, SDG16

Life Cycle Phase(s)

Keywords

Adaptability, flexibility and refurbishment of buildings and neighbourhoods, Sharing and multi-use of spaces, use of reused or recycled content in new products and buildings, Circular water, financing circular processes, Sustained-urbanism, Eco-urbanism

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Figures 60 & 61: Before (left) and after (right).

Credit: Heritage Foundation, Pakistan

Overview

In view of poor governance and lack of funding for urban services in many developing countries such as Pakistan, increasing urban disarray is evident in major urban centres. The 122 m x 12 m, Denzo Hall Rahguzar Street is the first low-carbon climate-smart eco-urban enclave for urban regeneration of Karachi's historic core suffering from urban blight. The aim of the project is to foster use of low carbon bio-degradable materials, promote refurbishment and adaptive reuse, minimise use of water and energy, prevent wastage, reuse and recycle materials, adoption of facilities and spaces for multiple usage, leading to adoption of circular rather than linear economy. It demonstrates a unique partnership of civil society organisation and local administration, along with efforts of local community. The project was conceived and designed by Architect Yasmeen Lari and financed and implemented by Heritage Foundation of Pakistan through its social, environmental and cultural impact funding, in partnership with Karachi administration represented by Deputy Commissioner.

Impacts

Capital costs/Project Cost: USD 183,000

Operational cost: Approx. USD 300 /month for cleaning, rest is maintained itself by the community.

Environmental impact: Low environmental impact due to usage of low embodied energy material such as terracotta, mud and bamboo. Plantation of 600 trees across the street has enhanced the biodiversity. A new municipal solid waste management system has been implemented to maintain the waste from the shops and street vendors. The water gets replenished through permeable pavements and rainwater harvesting system.

Social impact: The regeneration of the street has changed the ideology of the people by encouraging women and children to use this safe space.

New businesses: Increase in public activities have led to the establishment of new shops, street activities, culture gatherings and awareness programmes.

Green jobs and skills: It is highly encouraging for women to step out and learn sustainable construction techniques through workshops conducted at the street and participate in various cultural activities.

Replicability and scalability

The project is eminently replicable and scalable as it provides the means to deal with urban blight and economic stagnation exacerbated due to climate change. In the face of the exponential rise of urban population by 2050, urban centres have become responsible for 70% of global carbon emissions (UN-Habitat, 2020). The urgency of adopting the eco-centric/ circular economy methodology cannot be emphasised enough. To prevent the urban centres from becoming global warming battlegrounds, the case of Rahaguzar street put forward in Karachi's eco-enclave can be adapted to become applicable to diverse economies.

Main challenges

- People in position of power are oblivious to climate change impact and are keen to carrying out business as usual, using the same materials and practices conforming to the needs of linear economy and carbon-intensive materials and methods
- Planning and building bye-laws that are no longer relevant, pose a hurdle in bringing about practices to promote circular economy as a driver of economic development
- Environment professionals continue to be unaware regarding the urgency of adoption of key ingredients of eco-focused climate smart design for urban elements, innovation in the use of sustainable locally sourced materials, ensuring reduced waste and practicing water conservation, as well as benefits of recycling and refurbishment.

Main success factors

- Economy in cost of production and implementation, and sustainability due to locally sourced green materials, controlling waste and reducing use of water and energy wastage
- Value preservation and resource optimisation by extending existing resources through use of recycled wood and cast iron, efficient use of primary resources earth and bamboo and by controlling waste
- System effectiveness by optimising the use of walking street for multiple activities comprising commerce, recreational and cultural events, controlling noise and air water pollution by rerouting motorised traffic, rainwater harvesting and conserving water through aquifer wells and reuse of grey water for plantation; refurbishment of heritage buildings and preventing their demolition to prevent new high carbon construction.

Figures 62 & 63 (up, left and right): Women at Rahguzar Chowk receiving training for bamboo structure (22–24 September 2021)

Figures 64 & 65 (down, left and right): Community level consultations and awareness programmes at the Walking Street

Credit: Heritage Foundation, Pakistan

COWAM Project: Post-Disaster C&D Waste Management

Sri Lanka, 2010–

Project type

Material, Research, Policy, Deconstruction

Impacts

Environmental impacts, Green jobs & skills

Related SDGs

SDG8, SDG9, SDG12, SDG17

Life Cycle Phase(s)

Keywords

Construction and demolition waste management, Adaptability, Flexibility and refurbishment of buildings and neighbourhoods, Use of reused or recycled content in new products and buildings, Reconstruction.

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Figure 66: Recycled blocks

Figure 67: Construction waste crushing machine at COWAM Centre

Overview

Following the catastrophic Tsunami of 2004, which caused 4,000 deaths and destroyed 15,000 houses, discarding the construction and demolition (C&D) waste became a crucial issue in the hard-hit coastal belt of Sri Lanka. Approximately, USD 5 million was spent in managing tsunami debris in Sri Lanka. A large part of the debris from the destroyed buildings, infrastructure and

roads was dumped in environmentally sensitive areas. Further C&D waste got generated when ruins were demolished and buildings reconstructed. In this situation, The COWAM (Construction Waste Management) project within the framework of the EU-ASIA PRO ECO II B Post-Tsunami programme was initiated to manage C&D waste in Sri Lanka. The Galle Municipal Council (GMC) was selected as the beneficiary. Galle being a high-density area, the aim was to provide the Galle area with practical situations for implementing a sustainable C&D waste management programme and for it to become a model for all the other local authorities in the country. The recycled waste generated was utilised to redevelop the coastline of the affected area. In 2009, the project fundings were completed and now COWAM centre is operated under the direct supervision of Galle Municipal Council.

Impacts

The centre offers jobs for local people and produces materials for the construction of local roads, pavements at lower rates.

Sustainable municipal roads construction with a reduction of the use of virgin construction materials, a reduction of C&D waste being sent to landfills, a reduction of illegal dumping and the promotion of local economic development can be identified as the other benefit of COWAM Project.

Main challenges

- Lack of a framework or statutory guidelines that could be enforced during a disaster
- Lack of funds, resources, and equipment, and coordination issues at the time of disaster
- Lack of heavy vehicles, lack of manpower, inability to forecast the amount and composition of waste, and inability to identify suitable temporary dumping sites.

Main success factors

- Management of disaster waste management is much harder than ordinary C&D waste management. It acts as a successful model that showcases the potential to overcome a natural disaster with circular approaches and resilience
- It facilitated the implementation of various small-scale C&D waste management recycling plant in Sri Lanka by creating an awareness of effective use of recycled waste.

Figure 68: COWAM Centre

Figure 69: Recycled sand and aggregate

Community-based Solid Waste Management System

Galle, Sri Lanka, 2017–

Project type

Policy, Neighbourhood

Impacts

Capital cost, Operational cost, Environmental impacts

Related SDGs

SDG3, SDG6, SDG11, SDG12, SDG13, SDG16

Life Cycle Phase(s)

Keywords

Solid waste management, Adaptability, Circular water, Financing circular processes, Community upliftment, Environmental sanitation

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Figures 70: Waste collection carts

Figures 71: Informal discussions between the selected community green leaders and HELP-O

Overview

China Garden is a densely populated small town in Galle, Sri Lanka, in which 270 low-income group families working as labourers reside. A sample survey carried out by HELP-O, a local NGO in Sri Lanka, found that no regular waste collection service exists in this area (Dickella, 2017). Poor route planning and narrow road networks in many such informal neighbourhood or low-income housing areas are the primary reason for the lack of access to Municipal Solid

Waste Management System (MSWM). CITYNET Yokohama Project Office and the Institute for Global Environmental Strategies (IGES), in Japan partnered with HELP-O under a public–private partnership (PPP) model for improving the MSWM in Galle City. A new MSWM system for China Garden as a pilot project was established that will be replicated in other similar communities unveiling as a one-of-a-kind solution in Sri Lanka that focuses on micro-level solid waste management problems of such communities.

In line with SDG3, SDG6, SDG11, and SDG12, a community-based green city conceptual framework was developed that focuses on waste segregation, collection, transport, treatment, monitoring, implementation, and awareness between civil societies and stakeholders. The new system required the use of a bicycle or hand-cart for the door-to-door collection of waste due to lack of accessibility for motorised vehicles. Green leaders and sub-committees were formed for effective implementation of the strategy, which included awareness programmes and community interactions regarding waste segregation, personal hygiene, clean and green environment, among others. The collected bio-degradable waste (77%) is recycled through composting (aerobic) or/and bio-gas (anaerobic) methods that produce manure as an end product, which is utilised for farming purposes. The non-biodegradable waste, on the other hand, is purchased by recycling companies, thus targeting a circular model of the system. For example, Random Global Private Company purchases glass waste (13 tonnes/month) for recycling, which use to be originally dumped into landfills. Further, for monitoring and effective implementation, HELP-O is working with the Galle Municipal Council (GMC) to draw up a new future plan along with a phone app ‘E-Sabha’, which will be launched in 2022 as an easy complaint portal that will improve communications between the community and the authorities.

Furthermore, another solution has been devised for new constructions in the town to establish an inhouse solid waste management system, referred to as ‘energy pits’ that work on the principle of a close loop biogas system. It will enable the user to recycle solid waste and greywater at home with biogas as an end product. This biogas can be further utilised in the kitchen for combustion. HELP-O is now in negotiation with GMC to add it into the housing plan approval process.

Impacts

Low capital cost and operational cost as low-energy consumption methods are being used. Reduction of 20–30% in the family monthly costs.

Health and wellbeing: Improved personal and communal health, hygiene and sanitation as opposed to previous environment that acted as a breeding ground for various diseases.

Numerous community-level plantation and cleaning drives further improvised the biodiversity of the place.

Replicability

The project is replicable in other small-scale communities and a similar framework can be established between the stakeholders, often neglected by the government and the MSWM system.

Main challenges

- Changing the negative mindset and attitude of the citizens, businesses, city officials and waste collection staff

- Building capacity to create sustainable operation and maintenance is difficult to achieve in a short-term pilot project
- Organisation of local communities into legally recognised entities so that they can participate in collaborative management with powerful forces such as government and private sector.

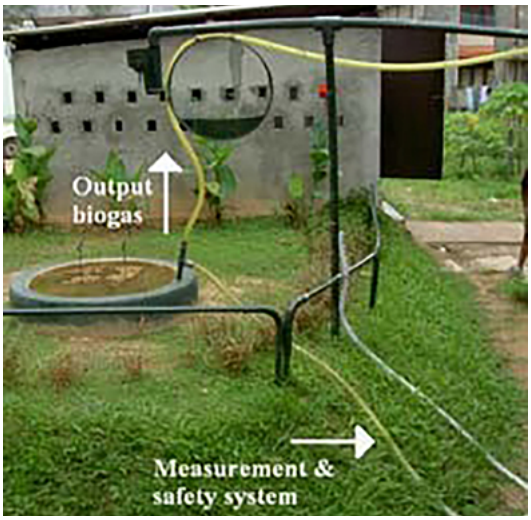
Main success factors

- Addressed the basic needs of the residents and got them involved from the beginning in identifying and planning the options
- Support from the mayor and strong partnership among key stakeholders, including GMC, HELP-O, private sector and citizens
- A facilitation role of HELP-O between GMC and citizens and technical support from CITYNET and IGES

Figure 72 & 73 (up, left & right): Collected plastic and glass bottles sold to companies for recycling

Figure 74 (down, left): Biogas plant

Figure 75 (down, right): Composting



Figures 76 & 77 (left, up & down): Biogas unit

Figures 78 & 79 (right, up & down): Community involvement

6. The Built Environment and the SDGs

Circularity in the built environment is not explicitly mentioned in the 2030 Agenda, even though many of its targets are related closely with circularity. SBC has conducted a survey to seek feedback from built environment experts on the core indicators for circular built environments (CBE) globally by ranking the importance of the Sustainable Development Goals (SDGs) and prioritising indicators corresponding to their respective targets. In an ongoing effort by SBC, the data is collected through an online survey of global experts familiar with circularity. In 2020, SBC conducted a workshop where the outcome of the indicator survey SDGs was discussed with a group of experts.

This state of play report studies the expanded responses on the global scale as well as attempts to select, customise and develop further relevant circularity recommendations and indicators for the built environment to be implemented in countries to build back better (post-COVID-19 recovery) and improve quality of life by decreasing emissions, increasing resilience and providing local jobs, especially in the field of affordable housing by 2022 and beyond.
SBC has a mandate to implement SDG12 to accelerate the shift towards sustainable consumption and production (SCP) patterns. The group identified other most important sustainable development goals for circularity: SDG9 Industry, SDG11 Cities, and SDG13 Climate. Also, SDG6 Water, SDG7 Energy, SDG8 Employment and SDG3 Health were recognised.

This correlates well with the SBC survey outcomes based on 176 responses by global experts as shown in dark blue line in Figure 80. Out of the total 176, 30 responses are for Asia represented in the light blue line in the figure. Responses provided by the experts in Asia region corresponds to the priorities conferred by the global responses. Only relevant difference occurs in SDG6 Water and Sanitation and SDG17 Global Partnerships, where regional respondents confer higher importance than the global response.

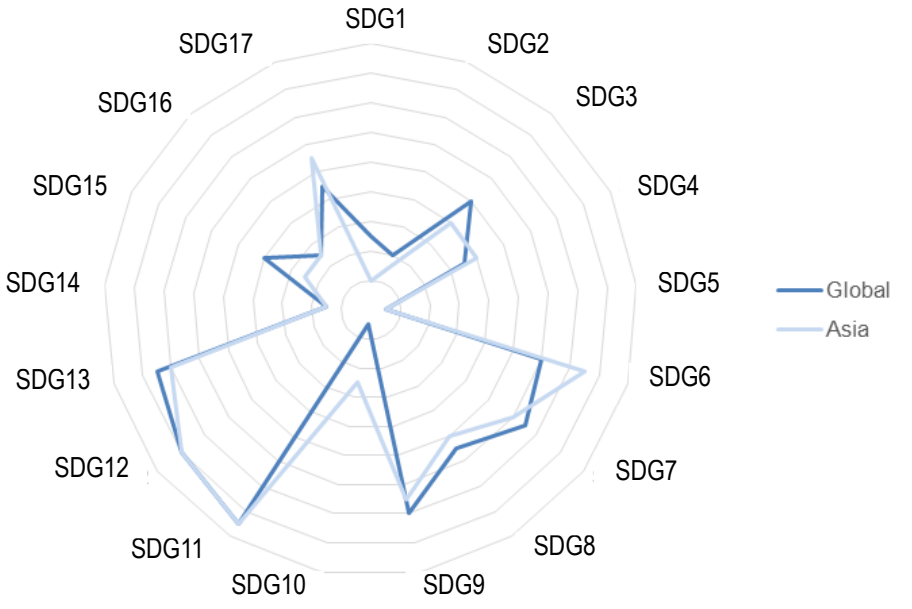


Figure 80: Comparison of global and regional responses to SDG priorities concerning the circular built environment

Source: One Planet SBC Circular Built Environment (CBE) survey on circularity in the UN2030 Agenda.

Table 13 lists the 14 SDG indicators prioritised by global respondents:

- Highest relevance is given to material footprint (12.2, 80%; 8.4, 79%), waste management and recycling (11.6, 61%; 12.5, 80%), use of local material (11.C, 75%) and use of clean technologies (9.4, 67%).
- Other priority indicators are water efficiency (6.4, 58%) and waste water treatment (6.3, 60%), integration of climate change policies (13.2, 59%), access to clean energy (7.1, 54%), access to affordable housing (11.1, 57%), implementation of sustainable public procurement (12.7, 54%), and scientific and technological development (12.A, 54%).

Table 13: SDG indicators prioritised from the global survey. Priority indicators are those considered as crucial by 50% or more survey respondents.

S. No.	Target: Indicator	Respondents finding the indicator crucial
1	**12.2** Efficient use of natural resources: material footprint	80%
2	**12.5** Waste reduction, recycling and reuse: national recycling rate	80%
3	**8.4** Resource efficiency in construction: material footprint	79%
4	**11.C** Sustainable and resilient buildings utilising local materials: financial support	75%
5	**9.4** Clean and environmentally sound technologies: CO_2 emission per unit of value added	67%
6	**11.6** Air quality and waste management: proportion of urban solid waste regularly collected	61%
7	**6.3** Water quality: proportion of wastewater safely treated	60%
8	**13.2** Climate change measures: countries with an integrated policy/strategy/plan	59%
9	**6.4** Water use: change in water-use efficiency	58%
10	**7.2** Renewable energy: share in the total final energy consumption	58%
11	**11.1** Affordable housing: proportion of urban population living in inadequate housing	57%
12	**12.7** Public procurement practices: countries implementing policies	54%
13	**7.1** Access to affordable and modern energy: reliance on clean fuels and technology	54%
14	**12.A** Scientific and technological capacity: support to developing countries	54%

The analysis of the data collected from respondents of Asian region is also carried out in similar way. The responses were received from Japan, South Korea, Sri Lanka, China, Indonesia, India, Nepal and Pakistan. With the number of responses not being high in some of the countries, in order to derive useful inference the countries were divided into two groups based on Humar Development Index (HDI).

High HDI countries are Japan, South Korea, Sri Lanka and China and lower HDI countries are Indonesia, India, Nepal and Pakistan (United Nations Development Programme, 2020).

6.1 Ranking of SGDs in High HDI Countries

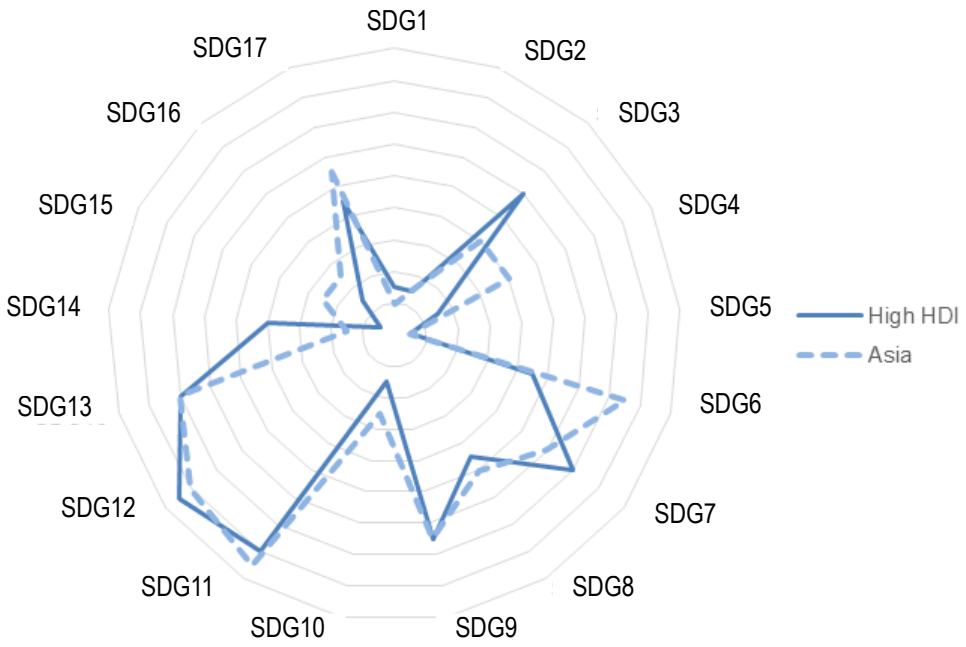


Figure 81: SDG priorities of Asian and high HDI countries responses

Source: One Planet SBC Circular Built Environment (CBE) survey on circularity in the UN2030 Agenda.

Figure 81 shows SDG priorities of Asian and high HDI countries. Compared to the data collected for Asia, high HDI countries show high importance to SDG12 Sustainable Consumption and Production, SDG13 Climate, and SDG7 Energy.

Table 14 lists the cross-linkages of 14 SDG indicators prioritised by respondents of global responses with responses of high HDI countries in Asia.

Table 14: SDG indicators prioritised from survey data of high HDI countries of Asia and ranking of 14 Global SDG indicators. Core indicators in the global survey are marked green and secondary indicators blue. Indicators prioritised in Asia but not at global responses are shown with black.

S. No.	Target: Indicator	Respondents finding the indicator crucial	Global ranking (Table 13)
1	**8.4** Resource efficiency in construction: material footprint	70%	3
2	**11.C** Sustainable and resilient buildings utilising local materials: financial support	70%	4
3	**12.2** Efficient use of natural resources: material footprint	60%	1
4	**11.1** Affordable housing: proportion of urban population living in inadequate housing	50%	11
5	**12.5** Waste reduction, recycling and reuse: national recycling rate	50%	2

S. No.	Target: Indicator	Respondents finding the indicator crucial	Global ranking (Table 13)
6	**9.4** Clean and environmentally sound technologies: CO2 emission per unit of value added	50%	**5**
7	**11.B.1** Resource-efficiency policies: local governments implementing risk reduction strategies	40%	-
8	**11.B.2** Resource-efficiency policies: countries with national and local risk reduction strategies	40%	-
9	**12.1** 10YFP on SCP: countries with national action plan	40%	-
10	**12.7** Public procurement practices: countries implementing policies	40%	12
11	**7.1** Access to affordable and modern energy: reliance on clean fuels and technology	40%	13
12	**7.2** Renewable energy: share in the total final energy consumption	40%	10
13	**6.4** Water use: change in water-use efficiency	40%	9
14	**13.2** Climate change measures: countries with an integrated policy/strategy/plan	40%	8
15	**8.1** Economic growth: growth rate of real GDP per capita	30%	-
16	**11.3** Inclusive urbanisation: proportion of cities with a direct participation structure	30%	-
17	**11.6** Air quality and waste management: proportion of urban solid waste regularly collected	30%	6
18	**12.A** Scientific and technological capacity: support to developing countries	30%	14
19	**7.3** Energy efficiency: energy intensity in terms of primary energy and GDP	30%	-
20	**7.A** Clean energy research and technology: mobilised amount of USD	30%	-
21	**7.B** Infrastructure and technology: investments in energy efficiency as a % of GDP	30%	-
22	**4.7** Sustainable development skills: extent to education mainstreamed	30%	-
23	**6.3** Water quality: proportion of wastewater safely treated	30%	7

Respondents from high HDI countries of Asia confer the highest importance to indicators concerning material footprint (12.2, 60%; 8.4, 70%), use of local materials (11.C, 70%), waste management (12.5, 50%), use of clean technologies (9.4, 50%). Proportion of urban population living in inadequate housing (11.1, 50%) figured at a higher importance then the global response. Public procurement policies (12.7, 40%), clean fuel and energy (7.1, 40%;

7.2, 40%), water use (6.4, 40%) coincided with the global prioritisation although it can be noticed that the percentage of high ranking of these indicators is less than 50%, which can be attributed to the less number of responses received from the high HDI countries of Asia. There are some peculiarities described here:

- The data from high HDI countries of Asia indicate additional indicators other than global indicators in the priority list. Resource-efficiency policies at national and local levels (11.b.1,40%; 11.b.2, 40%), which are not considered by global responses in top 14 , figured in the top 14 regional response for HDI countries
- Air quality (11.6, 30%) and wastewater treatment (6.3, 30%), considered in top 14 indicators by global respondents, figured lower in the priority given by regional responses.

6.2 Ranking of SGDs in lower HDI countries

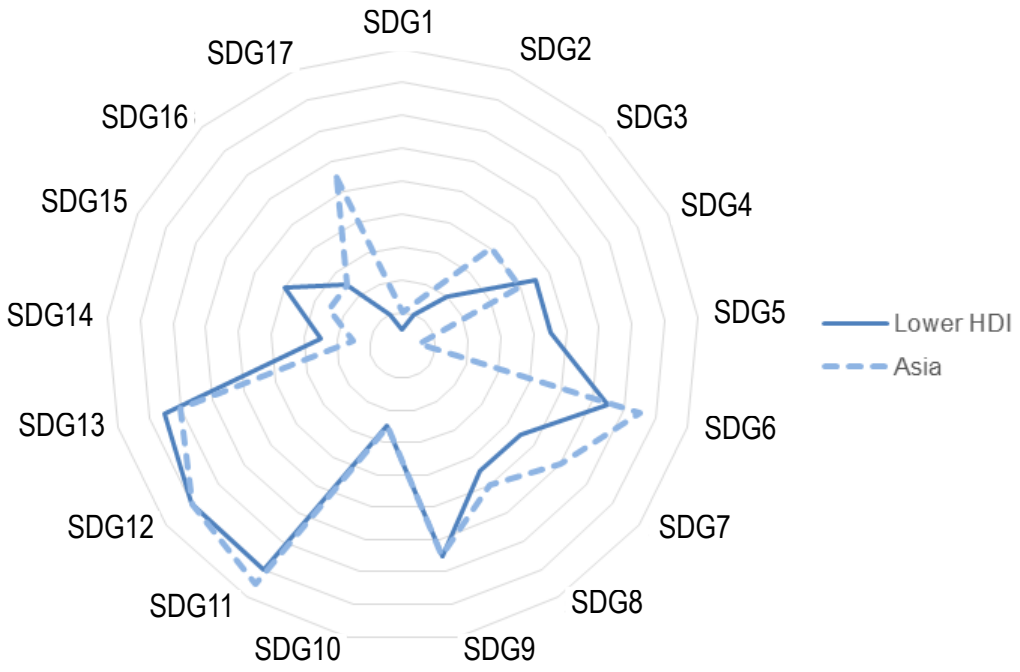


Figure 82: SDG priorities of Asian and lower HDI countries responses.

Source: One Planet SBC Circular Built Environment (CBE) Survey on circularity in the UN2030 Agenda

Figure 82 shows SDG priorities of Asian and lower HDI countries. Compared to the data collected for Asia, lower HDI countries show high importance to SDG12 Sustainable Consumption and Production and SDG13 Climate and SDG11 Resilient and Sustainable Cities. SDG9 Sustainable Industrialisation gets same importance as compared to overall data from Asia.

SDG6 Water and Sanitation, SDG7 Access to Energy, SDG8 Economic Growth and Productive Employment get slightly less importance in lower HDI countries than overall scenario in Asia. Table 15 shows the cross linkages of 14 SDG indicators prioritised by respondents of global responses with responses of lower HDI countries in Asia.

Table 15: SDG indicators prioritised from survey data of lower HDI countries of Asia and ranking of 14 Global SDG indicators. Core indicators in the global survey are marked green and secondary indicators blue. Indicators prioritised in Asia but not at global responses are shown with black.

S.No	Target: Indicator	Respondents finding the indicator crucial	Global ranking (Table 13)
1	**11.C** Sustainable and resilient buildings utilising local materials: financial support	76%	4
2	**12.2** Efficient use of natural resources: material footprint	76%	1
3	**8.4** Resource efficiency in construction: material footprint	72%	3
4	**12.5** Waste reduction, recycling and reuse: national recycling rate	72%	2
5	**12.7** Public procurement practices: countries implementing policies	64%	12
6	**17.18** Reliable data: sustainable development indicators produced at the national level	64%	-
7	**12.1** 10YFP on SCP: countries with national action plan	60%	-
8	**6.4** Water use: change in water-use efficiency	60%	9
9	**13.2** Climate change measures: countries with an integrated policy/strategy/plan	60%	8
10	**11.6** Air quality and waste management: proportion of urban solid waste regularly collected	56%	6
11	**11.7** Green and public spaces: share of the built-up area	56%	-
12	**11.B.1** Resource-efficiency policies: local governments implementing risk reduction strategies	56%	-
13	**12.A** Scientific and technological capacity: support to developing countries	56%	14
14	**7.1** Access to affordable and modern energy: reliance on clean fuels and technology	56%	13
15	**6.3** Water quality: proportion of wastewater safely treated	56%	7
16	**11.1** Affordable housing: proportion of urban population living in inadequate housing	52%	11
17	**12.8** Sustainable development awareness: extent to education mainstreamed	52%	-
18	**9.4** Clean and environmentally sound technologies: CO_2 emission per unit of value added	52%	5
19	**11.B.2** Resource-efficiency policies: countries with national and local risk reduction strategies	48%	-
20	**9.3** Access to financial services: proportion of small-scale industries	48%	-
21	**7.2** Renewable energy: share in the total final energy consumption	48%	10

Respondents from lower HDI countries of Asia confers the highest importance to indicators concerning use of local materials (11.C, 76%), material footprint (12.2, 76%; 8.4, 72%) waste management (12.5, 72%). Public procurement practices (12.7, 64%) figured at a higher importance than the global response. Indicators for water use (6.4, 60%), integrated policy for climate change (13.2, 60%), waste management (11.6, 56%) have same priority as global data. Similarly, support to developing countries (12.A, 56%) and clean energy (7.1, 56%) also has same priority as global data.

- Reliable data at national level (17.18, 64%) and countries with national action plan on SCPs (12.1, 60%), green and public spaces (11.7, 56%) which are not considered by global responses in top 14 figured in the top 14 regional response.
- Indicators such as clean technologies (9.4, 52%) and renewable energy (7.2, 48%) which is considered in top 14 indicators by global respondents figured lower in the priority given by regional responses.

6.3 Comparison of Ranking in Higher HDI and Lower HDI Countries

Figure 83 shows the comparison of data from two group of countries. Both high HDI countries and lower HDI countries data show similar importance for, SDG12 Sustainable Consumption and Production, SDG13 Climate Change, SDG11 Resilient and Sustainable Cities, SDG8 Employment Sustainable, and SDG9 Industrialisation.

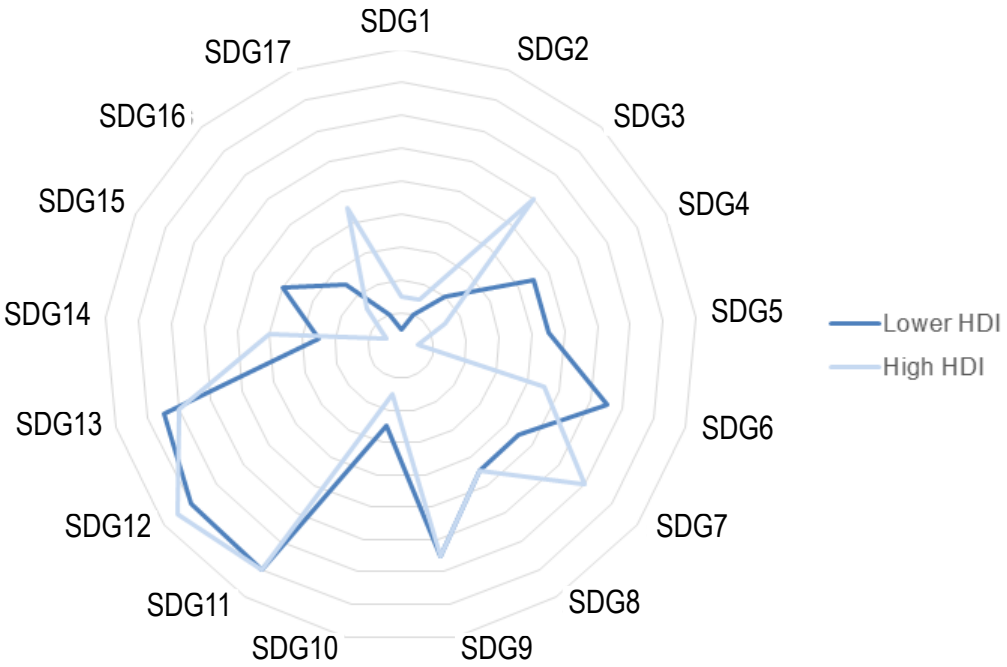


Figure 83: Circularity ranking of SDGs for high HDI and lower HDI countries.

Source: One Planet SBC Circular Built Environment (CBE) Survey on circularity in the UN2030 Agenda

The main difference in the responses for importance of SDGs in the high and lower HDI countries is as follows:

- High HDI countries show higher importance for SDG7 Energy, SDG3 Health and SDG17 Global Partnerships compared to lower HDI countries.
- Lower HDI countries show higher importance for SDG6 Water and Sanitation, SDG4 Education, SDG5 Gender Equality, and SDG15 Halt Biodiversity Loss.

At indicators level, material footprint uses of local materials; waste management have high importance in both high and lower HDI countries. In higher HDI countries, urbanisation is considered as an important factor for considering the circularity in the built environment.

In the case of lower HDI countries, the core indicators remain the same as in high HDI countries. Indicators that are linked to reliance on government policies, availability of reliable data, technological support and global partnership have higher importance. It can be noted that indicators linked to clean technologies and renewable energy are given lower priority in the responses.

The outcome of the survey was consistent for the core SDGs and indicators for both high HDI and lower HDI countries. Correlation of secondary SDGs and indicators variation in the two groups should be more focused and need to be studied at the country level.

7. Conclusions

The current scenario of life cycle assessment, building life cycle, and circularity in the built environment is examined in this study from the detailed policy mapping, UN2030 Agenda indicator global survey, and the collected good practice case studies validated through stakeholder consultation and numerous interviews. It facilitated the compilation of robust, credible, and critiqued circularity barriers and recommendations against relevant SDGs and life-cycle considerations across the various phases of the built environment in Asia to forge a sustainable future.

7.1 Current Scenario of Life-cycle Assessment

The buildings sector accounts for the largest, i.e., 30% of the final energy consumed around the world, or around 3,100 Mtoe, including almost 55% of global electricity consumption directly and indirectly in 2019.

Table 16: Global Building sector's emissions

Source: (International Energy Agency, 2020)

Sources	Description	Global Emissions (2019)
Direct sources	Fossil fuel combustion in buildings for space conditioning and water heating as well as cooking and other service applications	3 $GtCO_2$
Indirect sources	Consumption of electricity and heat by electrical and electronic devices/equipment used in buildings	6.8 $GtCO_2$
Material production & construction	Energy- and process- related, mostly from Cement and Steel	3.5 $GtCO_2$

The residential sector is by far the largest component in the buildings sector in terms of floor area (80%), final energy use (70%) and CO_2 emissions (60%) (International Energy Agency, 2020). Therefore, building stock growth becomes a key element of the energy demand and related emissions. For India, it is estimated that majority of the building stock required by 2030 is yet to be built. Notably, the construction industry is already the second largest sector,

providing significant employment. China is forecast to more than double its existing stock of buildings and infrastructure by 2050. China continues to use almost half the world's concrete (International Energy Agency, 2020).

7.2 Building Life-cycle and Circularity

The whole-life carbon includes both embodied carbon and operational carbon. Over its lifetime, a building's carbon footprint consists of the embodied carbon from the extraction, manufacture and processing of building materials and construction, as well as the operational carbon from the energy use of its operations.

As policy and markets drive uptake of more sustainable buildings to meet climate objectives, the linkages between material demand and GDP are likely to diverge from historical trends. Therefore, the programmes of the developing economies need to be designed around circularity and sustainability to avoid and offset emissions.

Finally, to reach the ultimate goal of whole-life net-zero carbon in buildings, the embodied carbon of building materials should be reduced and offset through low-carbon materials, more efficient manufacturing techniques and the optimisation of materials usage. Indeed, material efficiency strategies can reduce the whole life-cycle emissions of residential buildings by up to 35-40% in Group of Seven (G7) countries (IRP (International Resource Panel), 2020). Increased data collection, labelling, the development of new construction techniques and disclosure of building performance will be essential tools for enabling this transformation at scale, in all regions.

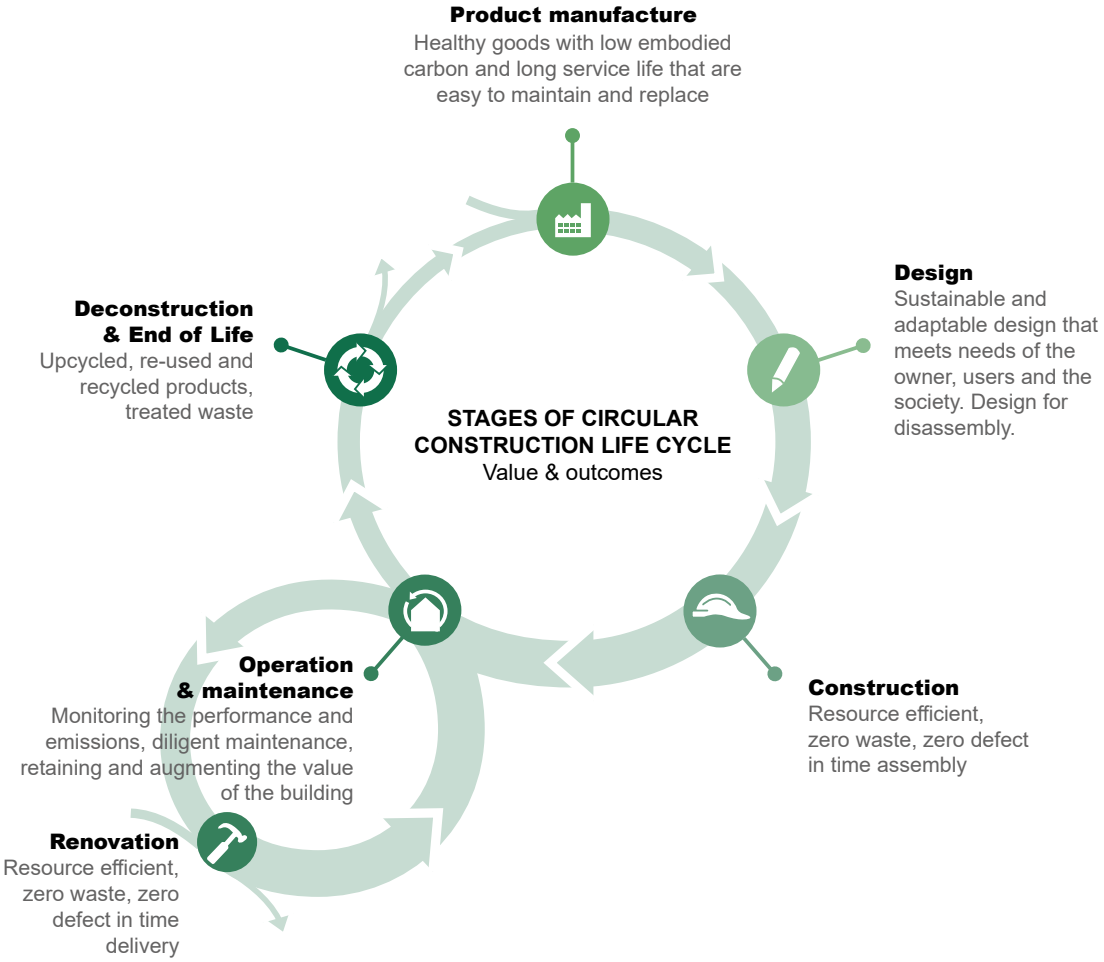


Figure 84: Stages of circular construction life cycle - value & outcomes

Credit: Ninni Westerholm. Developed from UNEP (2021).

Ellen MacArthur Foundation defines circular economy as an “industrial system that is regenerative and restorative by design, rethinks products and services to design out waste and negative impacts, and builds economic, social, and natural capital.” (Ellen Macarthur Foundation, n.d.). Circularity is an integral element of the international policies on climate and is part of both adaptation and mitigation efforts. The mitigation actions include achieving resource efficiency, through appropriate selection and design optimisation allowing reductions in embodied carbon. Resource efficiency directly contributes to climate change targets and in most cases without having medium- or long-term effects. Besides the global and national benefits, it also delivers strong consumer benefits: monetary as well as cultural.

There is a need to address existing and new policy instruments orchestrated within a comprehensive policy framework in order to infuse signals and incentives that promote circular economy and resource efficiency. The framework should also have a built-in system for monitoring and review and where necessary, revision.

7.3 Barriers, Facilitators and Transition Perspectives

To understand and suggest areas of intervention country-wise, a policy mapping was undertaken. The assessment of the policies described in Section 4 ‘Policies and stakeholders’ of the report has been done across six stages namely, Sourcing, Manufacturing, Design/ Construction, Retrofit, and End-of-cycle/Deconstruction.

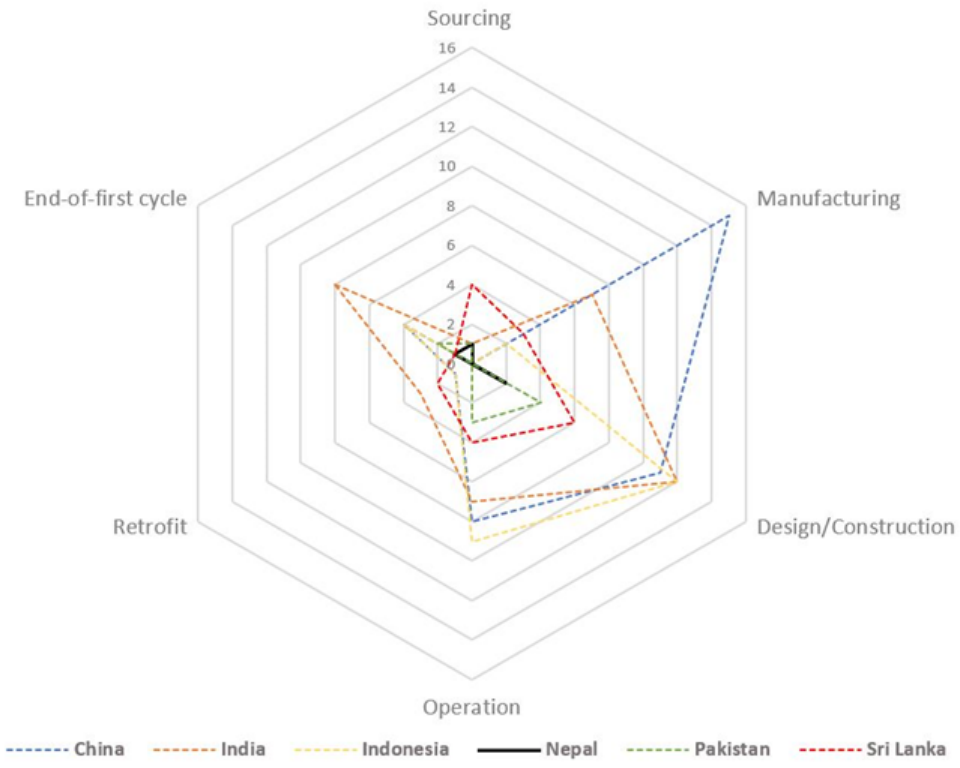


Figure 85: Country-wise policy mapping

Source: Authors

Table 17: The total number of policies around circular economy in the built environment reviewed for each country

Country	No. of policies
China	39
India	38
Indonesia	28
Nepal	4
Pakistan	10
Sri Lanka	20

The country-level assessment points towards specific gaps in achieving circular economy goals in the true sense. For instance, there are not many policies addressing the 'retrofit' market in the Asian countries. This can be attributed to the fact that majority of the construction and development is under process or the building stock is not old enough. Raw-material sourcing is another area that needs to be addressed. China's initiatives on the processing and manufacturing are commendable as they are pushing the adoption of circularity in their industries. Countries such as Nepal and Pakistan, which are in the process of formulating policies around circularity could learn and adopt. India's efforts from the policy standpoint to address challenges of waste generation, management, and re-use are leading by example. However, the overall challenge of implementation of the policies persists.

The transition towards a circular built environment requires stakeholders to adapt or change their role in the value chain (Thelen, 2021). Identifying the key drivers, constraints, and opportunities to transform the linear built environment to the circular built environment requires a review of existing and upcoming policies, interviews with industry leaders, and consultation with stakeholders and professionals. The components of the circular built environment are already emerging. Nevertheless, there are barriers that must be addressed to mainstream circularity in the built environment. Through the study, the barriers are identified at the three changing roles of the stakeholders.

The following illustration exhibits the current flow of materials and the role of key stakeholders in the built environment. It also highlights the areas requiring major interventions to ensure a shift towards circularity.

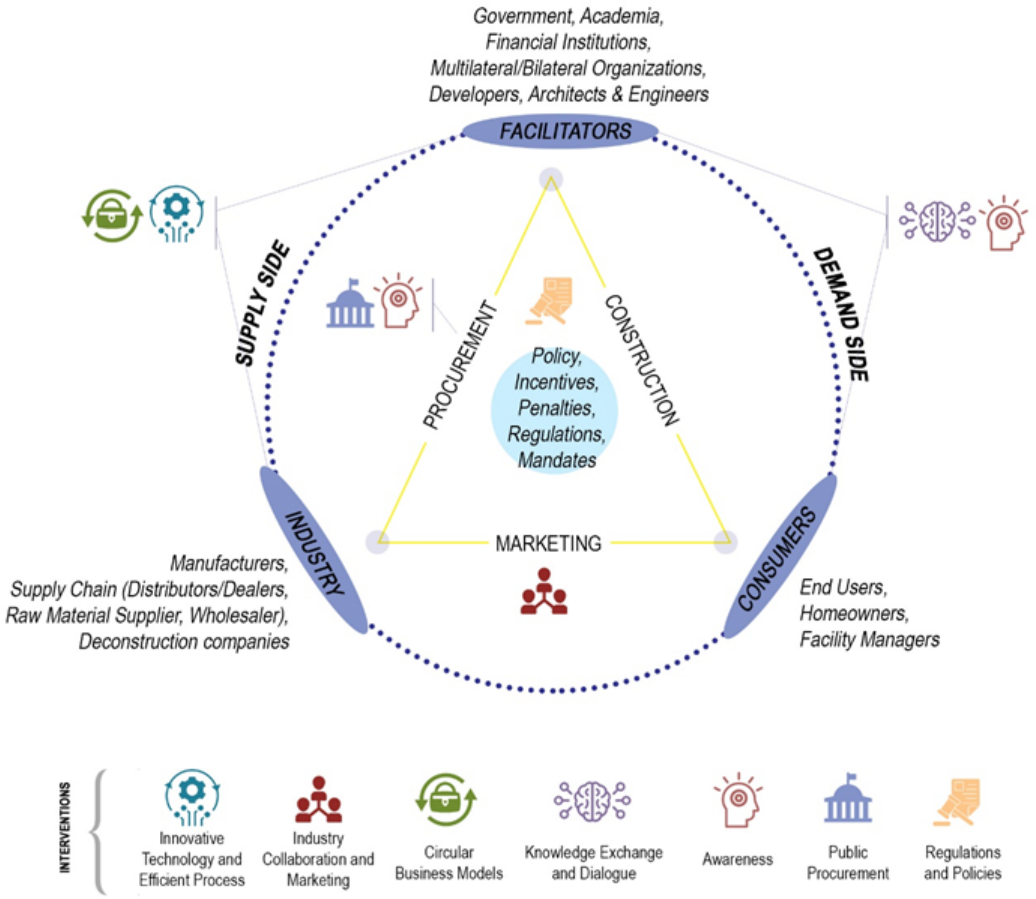


Figure 86: Flow of materials, interventions and the role of key stakeholders in the built environment.

Source: Authors

Table 18: Barriers and recommendations

Source: Authors

BARRIERS and RECOMMENDATIONS
SUPPLY SIDE-Barriers
• The current market structure does not provide the necessary framework that enables a circular infrastructure development process. It seems dependent on market demand, rather than environmental necessity. • There are limited mechanisms to incentivise the supply-side stakeholders. China for instances does incentivise in the form of tax-benefits and penalise the defaulters by limiting their access to finance. • Several studies highlight that developing a feasible business model for circular construction processes is challenging and high costs of circular materials hamper the circular economy implementation.

Manufactures	Supply Chain	Deconstruction Companies
• **Data disclosure:** There is unavailability of environmental product declarations (EPDs), life-cycle assessment (LCA), and material passports for new and second-hand material. Second-hand materials also face challenges regarding how the lifecycle of such materials in guaranteed. Manufacturers are unwilling to disclose production related data fearing the likely loss in businesses. • **Product standardisation & quality control:** Comparison of recycled sand and aggregates is a challenge in the market as there are no set standards to compare the recycled products. • **Lack of awareness** on benefits of transition to cleaner fuels for production • **Technology accreditation and validation** are major constraints especially in the case of new- and upcoming-technologies.	• **Market for second-hand products:** Suppliers experience problems to differ second-hand materials from standardised products. Therefore, adaptation is regarded difficult and expensive. • There is a lack of implementation between strict regulations for new materials, and the carbon saved by the implementation of second-hand materials in new and existing buildings.	• **Material banks:** The idea of material banks proves valuable in decreasing carbon emissions and pollution by reusing materials. • Though, demolition companies still regard deconstruction of a building more expensive than demolishing it due to the time it takes to carefully take a building apart compared to the demolishing process. Contractors are unwilling to take such work due to lack of prior experience.

SUPPLY SIDE-Recommendations:

- There is need for developing strategies around enhanced outreach, digitisation and formalisation manufacturing sector. This could be done by the creation of associations of manufacturers through online B-to-B global networking and transaction platform. Solutions like these would help aggregate demand and bring scale and efficiencies to technologies.
- The lack of certainty regarding the availability of second-hand materials can be tacked by implementing design strategies which are mainly focused on enabling the application of used materials. Another strategy raising the convenience of acquiring second hand materials is digitalisation of processes.
- Taking up nature-based solutions (NbS) can increase the construction sector's sustainability and circularity while improving the liveability of the built environment. Cities supporting the uptake of NbS for buildings through policies and incentives are driving change on the ground. (Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme, 2020)

- Industrial symbiosis opportunities may be found between demolition yards, construction sites and local industry. For example, plaster board may be produced using gypsum created by the chemical industry.
- Developing self-sustaining business models as the market is largely driven by informal players.
- There is a need to identify markets for waste/ waste-products before setting up facilities or initiating waste segregation of a specific type. Countries could also explore setting up centralised processing facilities for smaller projects and centralised facility for larger projects
- It is essential to introduce cost slabs for segregated and non-segregated wastes brought to landfills. Following the ban to import waste by China in 2018, led to the development of waste policies in countries such as Australia.

FACILITATORS-Barriers

Government	Academia	Developers, Architects & Engineers
• Developing countries in Asia are highly populated. Aspects related to adequate water supply, health and sanitation becomes crucial. There is a lack of focus on water footprint in most of the developing countries like India, Pakistan, and Nepal. • There are limited large-scale projects and experience with new technologies that demonstrates and promotes circularity in the built environment.		
• **Incentivisation:** There is a lack of government intervention, incentivising circularity in Asia Region. It is regarded as if regulators still have to elucidate what circularity means in order to take measures specially in developing countries. • There are no effective incentives to drive reduction in waste. Since waste avoidance is harder to measure, most government policies at the National level direct funds to promoting recycling, rather than reducing production of waste, which is much lower in the waste management policy hierarchy. • **Reporting & Accountability:** There is a lack of robust measurement, verification and reporting framework around policies with defined responsibilities for	• Limited attention to circular economy in architecture studies and design. • Lack of education programmes in circular thinking for primary and secondary school, vocational and higher technical education • No capacity or time for market actors to follow informative courses about the benefits and the approach of circular economy For e.g. In more recent times with involvement of new construction technologies, countries have started to forget the traditional and vernacular methods of construction that may be more sustainable.	• **Awareness:** Environment professionals continue to be unaware regarding the urgency of adoption of key ingredients of eco-focused climate smart design for urban elements, innovation in the use of sustainable locally sourced materials, ensuring reduced waste and practicing water conservation, as well as benefits of recycling and refurbishment. • The inability to interpret the building codes efficiently and include design measures complementing the code often becomes a deterrent in nation-wise adoption. • Overall investments in nature-based solutions are still low due to traditional preference for grey infrastructure, which is connected to lack of knowledge, uncertainty and challenges in collaboration between sectors amongst

ease of implementation. • **Bureaucracy** is often observed as a deterrent to the implementation of circular economy policies in developing countries. • The manufacturers especially of intensive products and technologies need to commit to **science-based targets** in line with Paris goals.		others. Countries like India have initiated 'global housing technology Challenge' to encourage adoption of new and innovative technology solutions. • The benefits of reducing and recycling are not conveyed to the builders.
Recommendations - Government	**Recommendations - Academia**	**Recommendations - Developers, Architects & Engineers**
• There is a need to develop robust incentivisation mechanisms including dis-incentivisation by levying taxes to push the front runners adopting circular economy production principles. Recognising the manufacturers through an R&R mechanism is essential to motivate the market going forward. • Illegal sand mining and extraction of resources is a concern that needs to be addressed through stringent laws and policing especially in countries like Sri Lanka and India. • Government acceptance, approval and support for utilising local labour and materials such as bamboo & earth for reconstruction in the wake of natural disasters. • The circular economy should also be integrated in quality certification and labelling. This will also improve competition with primary raw materials. • Boost policy co-ordination across different levels of government to achieve the NDC. For instance- buildings in India are a subject of the state. The states are responsible to	• Create awareness on global resource scarcity. Architects need to be enabled to design with focus on resource optimisation. • Prepare a repository of commercially viable circular economy models for manufacturers, supply chain, and building professionals for adoption and promote indigenous solutions. • There is a need to develop course curriculum where students get exposure to problems of the community to develop technological solutions to address the issues around circularity in the built environment. • Work towards a more strategic approach to energy RD&D; systematically embed RD&D components in broader energy policies; lay out a long-term energy RD&D strategy and technology roadmaps; use impact-oriented results measurement at a broader scale than project level; systematically collect, monitor and make available detailed data on energy RD&D, including but not limited to funding.	• Digital tools such as software for Building Energy Modelling (BEM) and Life-Cycle-Assessment (LCA) provide detailed methods for evaluating energy performance. Digital tools can help to optimise energy performance, cost, and comfort, and visualise the results. • Since money still is an important enabler to get things to be done in the built environment, investors can demand circularity by exercising financial leverage. This entails that investor only grant finance to developments that prove circular. • For new buildings, emphasis should be given to designing the structure, site and skin such that a building can optimally serve one or more purposes, facilitate circularity in the inner layers and can be readily disassembled for a new lifecycle. • Circular Business Models: The materials that are owned by the client or Real Estate developer can be sold to other parties. This can be enabled by a material passport that is attached to a secondary

implement the policies brought out at the centre. Establishing and defining state-wise targets would aid the promotion of circular economy objectives, faster. • Countries such as Nepal, Pakistan, and Sri Lanka need to focus on the development of building codes, certifications, and material labels. • Fast-track Environment Clearance to projects implementing Circular economy principles.	(International Energy Agency, 2020) • Continue to engage in international collaboration through bilateral and multi-lateral platforms • Disaster Risk Reduction: Development of strategies that focus more on circular principles of 'building back better' and is not limited to 'building back faster' because of political pressures or social pressures, etc. • More research required into the technology required for converting different waste streams into new products and materials in keeping with circular economy principles.	material market place. Whereas, when the end-of-life phase starts, the initiative phase of another development process aspiring to use a building as donor building might have already started, and that is where the loop repeats itself.
DEMAND SIDE		
End users	**Homeowners**	**Facility Managers**
• The reluctance of consumers to buy 'used' products and materials or pay a reasonable price. • Consumer behaviour and response to government schemes	• Community perception of understanding of new technology mostly due to trauma from a disaster and lack of government support for the technology.	• Data repository and logging are key to evaluate the operational performance of the intended design measures. Often the records unkempt and unutilised to assess building performance year-on-year.
DEMAND SIDE – Recommendations		
• Involving the consumers in the design, construction, and maintenance process would not only lead to the creation of markets for green buildings but also empower buyers to demand green buildings. • The inclusion of local workforce at a distance is essential to the labour market to upscale materials. This process is both beneficial to the environment and the economy due to the creation of jobs and the reduction of raw resource use.		

Annexure 1

Table 19: Interviews - Stakeholder's list

Name	Organisation	Country	Group
Mr. Wang Xin	Tongji University	China	Academia
Mr. Rohit Ranjan	Himalayan Institute of Alternatives, Ladakh	India	Academia
Mr. Sonam Wangchuk	Himalayan Institute of Alternatives, Ladakh	India	Academia
Ar. Biju Bhaskar	Thannal	India	Professional
Ms. Sonia Rani	GBCI	India	Professional
Mr. Sanjay Prakash	SHiFt (Studio for Habitat Futures)	India	Professional
Dr. Hina Zia	Jamia Millia Islamia	India	Academia
Mr. Sanjay Singh	CDE Asia	India	Supply Chain
Mr. Rajesh Kumar Jain	RLEEF	India	Professional
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