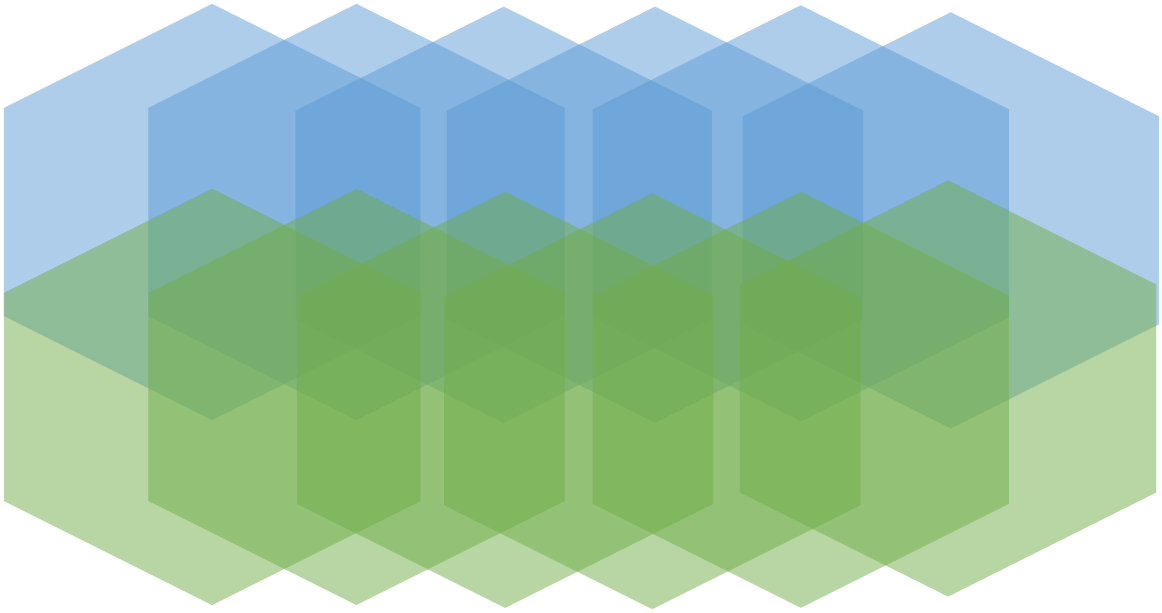
Stocktaking and Analytical Options for Green Buildings in Cambodia



The report is prepared to strengthen our understanding of green building concepts and practices in the construction and building sector, and provide recommendations for the development of Guidelines and Certification for Green Buildings in Cambodia

"Guidelines and Certification for Green Buildings in Cambodia" Project

Supported by Mekong-RoK Cooperation Fund (MKCF)

2021

The Kingdom of Cambodia

The National Council for Sustainable Development

December 2021

Published by:

The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia.

Contact Information:

The General Secretariat of the National Council for Sustainable Development/Ministry of Environment.

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Foreword

I am pleased to congratulate the Department of Green Economy (DGE) of the General Directorate of Policy and Strategy (GDPS) for producing this important document, titled 'Stocktaking Report and Analytical Options for Green Buildings in Cambodia'. The report is an essential introduction to the analysis of green building experience globally and the contextualization of the potential application of green building certification standards in Cambodia to support a sustainable transition of the building and construction sectors.

I would like to highlight that the building and construction sectors contribute to almost 40% of global CO2 emissions. Understanding this matter, it is critical to emphasise that the building and construction sectors are the priorities for low-emission development, and the sustainable transition of the built environment will contribute to combating climate change. Achieving environmentally sustainable building and construction sectors in Cambodia has become a challenge to date due to the limited regulations and policies focusing on green buildings and confined sustainable construction knowledge among property developers and architect firms.

The integration of green building concepts into Cambodia's building and construction sectors through initiatives canvassed in this report will support Cambodia in achieving its goal of low-emission development and promote resource efficiency through minimising water and energy consumption in buildings.

This document is well-aligned with and supported by the Royal Government of Cambodia's (RGC) commitments to promote sustainable development. The RGC has established key strategies and policies to encourage sustainable urban development in Cambodian cities, where high-rise residential, commercial and office buildings are highly concentrated. The strategies include the Green City Strategic Plan Methodology (2016), Phnom Penh Sustainable City Plan (2018-2030), and Sustainable City Strategic Plan for Seven Secondary Cities (2020-2030). This green building initiative will accelerate the achievement of a sustainable built environment in Cambodia. Moreover, Cambodia's updated Nationally Determined Contribution (2020) to the Paris Agreement on climate change highlights the potential role of green buildings and its priority in Cambodia's building and construction sectors to reduce carbon emissions through building energy consumption reduction and efficiency measures.

I would like to re-emphasise that the green building concepts will significantly transform Cambodia's building and construction sectors toward a more sustainable built environment. Also, this promotes vibrancy, public health, environmental sustainability, inclusiveness, affordability, and sustainable lifestyles for Cambodian people. I would like to take this opportunity to once again express a sincere appreciation to the leadership of GDPS, the DGE technical team, and the reviewers for the arrangement and contribution to this document, and to the Mekong-ROK Cooperation Fund (MKCF) for sponsoring this work. I strongly believe that this Stocktaking Report and Analytical Options for Green Buildings in Cambodia will be useful to all stakeholders and unlock opportunities to further research and develop support for green buildings in Cambodia.

Phnom Penh, 24 December 2021

Say Samal
Chair of the National Council for Sustainable Development
Minister of Environment

Acknowledgements

The stocktaking report of green buildings in Cambodia was prepared by the Department of Green Economy (DGE) of the General Secretariat of the National Council for Sustainable Development (GSSD)[1] as part of the project on 'Guidelines and Certification for Green Buildings in Cambodia', sponsored by the Mekong-ROK Cooperation Fund (MKCF) under the coordination of Mekong Institute (MI). This stocktaking report was produced by the collaboration of a broad range of stakeholders, such as the management teams of the Ministry of Environment, DGE technical staff, and international reviewers who are knowledgeable in academia and green building professions. Their diligent contributions have made this report possible, and they are appreciated.

The following management team supported and reviewed this report with valuable comments:

- H.E Tin Ponlok — Second Vice-Chair of the National Council for Sustainable Development and Secretary of State, Ministry of Environment
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The following leading authors and project team members diligently conducted the desktop review, report writing, and reviewed and addressed the comments from the internal and external reviewers:

- Mr. Nop Sokhai — Deputy-Director, Department of Green Economy (NCSD) and Project Coordinator
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The following contributors provided key information and technical advice regarding green buildings and related legislation and policies in Cambodia:

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- Mr. Sok Sam On — Local Architect.

We would like to express sincere thanks to the following external reviewers who provided technical and academic feedback for improving the quality of the report:

- Dr. Martin Schoch — Green Building Expert and International Consultant (King Mongkut's University of Technology Thonburi)
- Dr. Ing. Susanne Bodach — Green Building Expert
- Mr. Ravi Jayaweera — Researcher at University of Hamburg and Build4People Project
- Mr. Chea Bunseang — Chairman, Cambodia Green Building Council
- Mr. Sim Bovisal — Architect, Cambodia Green Building Council.

[1] In 2022 GSSD will be renamed as the General Directorate of Policy and Strategy of the Ministry of Environment and it still serves as the secretariat of NCSD.

We also thank to the Korea Institute of Civil Engineering and Building Technology (KICT) team led by Dr. Chang-U CHAE, Head of the National Green Building Centre, Senior Research Fellow, who provided ideas and recommendations for the development of Cambodia's guidelines and certification for green buildings.

Our special thanks and appreciation go to the external reviewer who contributed technical feedback and editing of the report:

- Ms. Fiona Lord — PhD Candidate, Institute for Sustainable Futures, University of Technology Sydney, Australia.

The views expressed in this report are those of the authors and are not necessarily reflective of the GSSD or supporting partners.

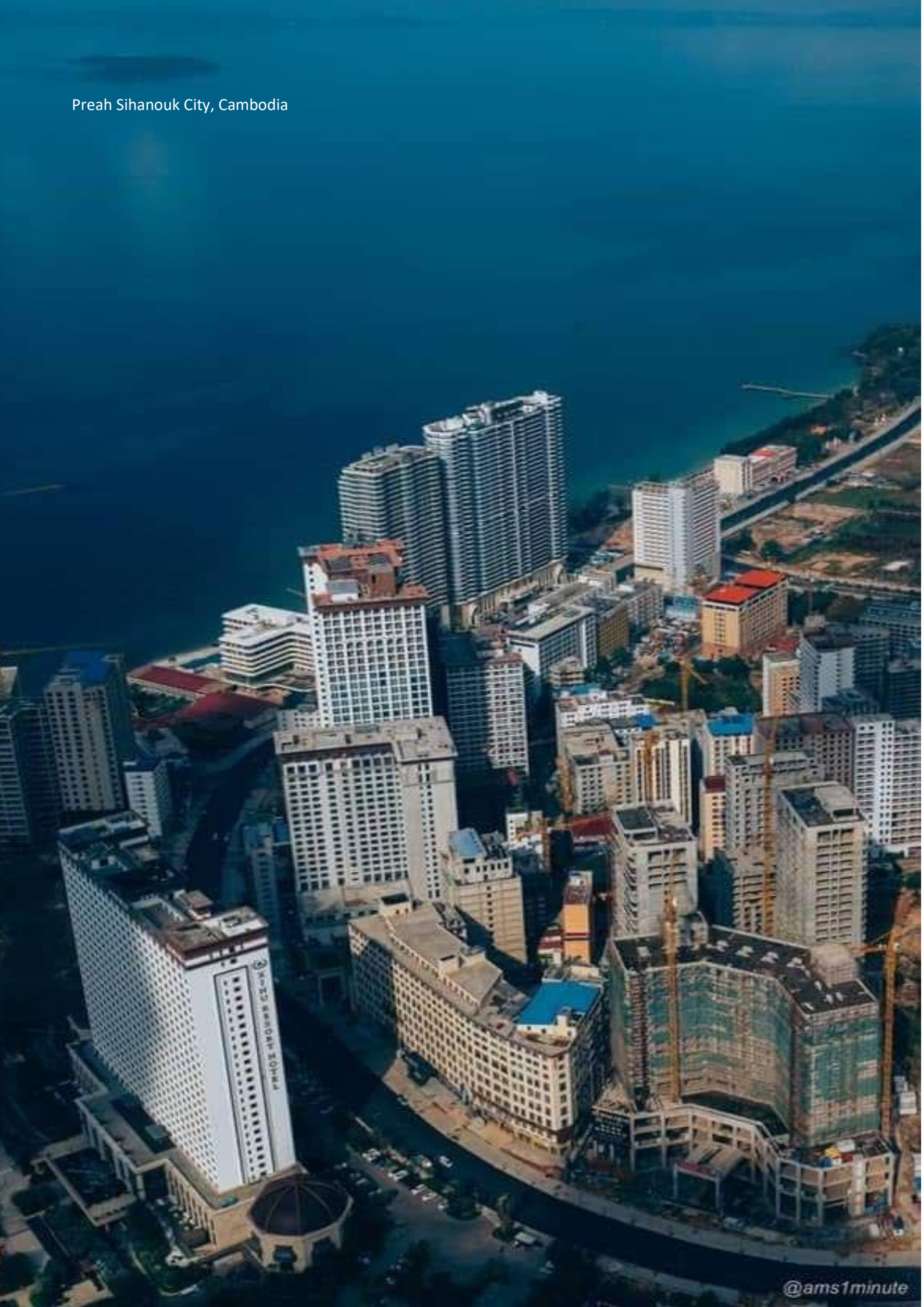
Suggested citation:

General Secretariat of the National Council for Sustainable Development (GSSD) (2021) *Stocktaking and Analytical Options for Green Buildings in Cambodia*, Ministry of Environment, Phnom Penh, Cambodia.

List of Abbreviations

ASEAN	Association of Southeast Asian Nations
BAC	Board of Architects Cambodia
BEC	Building Energy Code
BoEC	The Board of Engineers Cambodia
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Methodology
BTR	Building Technical Regulation
C&D	Construction and Demolition
CAMEEL	Cambodia Energy & Environmental Leadership
CamGCGB	Cambodian Guidelines and Certification for Green Buildings
CCA	Cambodia Constructors Association
CFLs	Compact Fluorescent Lamps
CamGBC	Cambodia Green Building Council
CoP	Conference of Parties
DGNB	German Sustainable Building Council
DGNG	German Sustainable Building Council
EDGE	Excellence in Design for Greater Efficiencies
EE	Energy Efficiency
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
ESMAP	Energy Sector Management Assistance Program
GBI	Malaysian Green Building Index
GDP	Gross Domestic Product
GHG	Greenhouses Gas
G-SEED	Green Standard for Energy and Environmental Design
HDPE	High Density Polyethylene
HVAC	Heating, Ventilation, and Air Conditioning
IAO	Indoor Air Quality
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
KGBC	Korea Green Building Certification
KITC	Korea Institute of Construction Technology
LEDs	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
MI	The Mekong Institute
MLMUPC	Ministry of Land Management, Urban Planning, and Construction
MME	Ministry of Mine and Energy
MoE	Ministry of Environment
MRA	Mutual Recognition Agreement
NCSD	National Council for Sustainable Development
NDC	National Determined Contribution
PRA	Professional Regulatory Authority
PSI	Poison Standard Index
PWG	Project Working Group
RGC	Royal Government of Cambodia
ROK	Republic of Korea
SCP	Sustainable Consumption and Production

SDGs	Sustainable Development Goals
TREES	Thai's Rating of Energy and Environmental Sustainability
TWG	Technical Working Group
UNEP	United Nation Environment Program
WGBC	World Green Building Council



Preah Sihanouk City, Cambodia

1. Background and introduction

This first section provides a general background of green building concepts in the international context and experiences. It introduces an overview of Cambodia's geography and climate. The second section presents the project background of green building intervention in Cambodia and elaborates on the key prospects of green buildings in the following section, which include various definitions, rationales, and benefits, and provides a global view of green building certification and rating systems.

1.1. Cambodia geography and climate

The Kingdom of Cambodia is a member of the Association of Southeast Asian Nations (ASEAN), located in the Southwestern part of Indochina peninsula with a total landmass of more than 181 thousand square kilometres and accommodates over 16 million population (see **Figure 1**). This nation has achieved annual economic growth over 7% for more than a decade, while obtaining total national GDP over USD 27 billion.[2] Its administrative boundary is bordered to Thailand about 805 kilometres (west), to Lao PDR about 540 kilometres (north), and to Vietnam about 1270 kilometres (east). The capital city is Phnom Penh, which is situated on a relatively lower land areas, accommodating more than 2 million residents. Cambodia is dominated by tropical monsoon climate consisting of two main season, such as dry season from November to May and rainy season from May to October. The average temperature is range from 27.7 ^{o}C to 30 ^{o}C annually, while enriching atmospheric humidity.

Figure 1. Map of Cambodia[3].

[2] See World Bank (2019). https://datatopics.worldbank.org/world-development-indicators/
[3] See nationalonline.org. https://www.nationsonline.org/oneworld/map/cambodia-political-map.htm

1.2. Project background

To promote Sustainable or Green Buildings in Cambodia, the Royal Government of Cambodia (RGC) through the Ministry of Environment (MoE) and National Council for Sustainable Development (NCSD), launched a green building project, called "Guidelines and Certification Standards for Green Buildings in Cambodia" in early 2019. The project aims to develop guidelines and certification standards for constructing green buildings (residential and commercial) in Cambodia. These guidelines and certification processes should be based on international experience and international standards, such as green building indices or rating systems (e.g., LEED (US), DGNB (Germany), LOTUS (Vietnam), or Excellence in Design for Greater Efficiencies (EDGE) supported by International Finance Corporation (IFC)), but adapted to the context of Cambodia. The guidelines and certification standards shall be designed to reduce energy consumption, water consumption, increase more efficient use of natural resources, and make improved living environment or quality of life.

The implementation of Green Building Design will result in reduced energy consumption, reduced water consumption, more efficient use of natural resources, and an improved living environment for residents of Cambodia. The target beneficiaries of the project will be the small to medium enterprises (SMEs) working on improvements to the design of buildings (who will have more commercial opportunities and green jobs), and the residents of Cambodia's cities, which will have improved working and living environments as the green building design is integrated into Cambodia's construction sector. It will support the creation of green jobs, helping to alleviate poverty by supporting the creation of a local building material industry with low embodied energy consumption and with energy efficiency applications in building design. The construction sector is the fourth largest economic sector in Cambodia, and it has the potential to further contribute to economic development and poverty alleviation, if the concept of Green Building Design is integrated into Cambodia's Building Construction Code through this project. The Green Building Design guidelines will be applicable to low-income housing, helping to alleviate poverty for the low-income residents through generating savings in utility bills (electricity and water supply). As Cambodia's urban population continues to grow, the introduction of Green Building Guidelines and Certification processes in Cambodia would support Cambodia's urban population to transition to more sustainable lifestyles, and support businesses to save costs for utility bills through green building design for commercial buildings.

The project will produce five key outputs as follows:

1. Green building design guidelines and certification process for Cambodia are developed.
2. Establishment of an interim operational body or inter-ministerial working group for Green Building Certification in Cambodia.
3. The guidelines and certification process for green buildings are piloted in Phnom Penh.
4. Awareness of Cambodian industry on green building design is improved.
5. Improved knowledge sharing between Cambodia, the Mekong region and the ROK on green building design.

According to the project outcome, the green building rating system could be used as a marketing tool and would increase competition among building and architectural companies. This will help to create new green jobs in the building and construction sector, as well as improve the living

standards for Cambodian residents[4]. The proposed Guidelines and Certification Standards will be promoted through industry-specific training and awareness raising workshop, particularly for architects and construction companies in Cambodia. The project will also facilitate knowledge exchange with other Mekong countries through a regional workshop that will help to potentially facilitate the development of a regional standard for Green Building Design and Certification.

1.3. An overview of Cambodia's construction sector

Cambodia has had a fast-growing economy with an annual economic growth rate of 7% for almost two-decades and an individual income of USD 1,679 a year in 2019 (GDP per capita),[5] before the COVID-19 pandemic. Construction is one of the main economic sectors in Cambodia, with thousands of buildings having been built the main cities, such as Phnom Penh, Sihanoukville, Siem Reap, and other important cities of Cambodia. According to the National Strategic Development Plan 2019-2023, the country construction from 2000 to November 2018, the government issued 43,559 construction permits with a total construction area of 115,248,551 square meters and a total estimated cost of 43,896,500,976 USD. In 2020, in Cambodia's construction a total of 4,841 projects were approved in total, which accounted for almost 30 million floor areas and over USD 1.7 billion of investment cost (see **Table 1**). However, most of the buildings have little consideration or an absence of green building integration concepts.[6] For instance, the proportional division for land plot of construction projects are largely allocated for concrete, while green spaces or permeable surfaces are insufficiently acknowledged. The buildings continue to be used and will be operated for many years. Additionally, most architects and contractors have little knowledge or capacity to integrate energy efficiency and resource efficiency measures in building design. Moreover, conventional buildings require using a large amount of energy, water, land, raw materials for their construction and operation. As a result, they produce greenhouse gas (GHG) emissions, air pollution and particulate matter. Furthermore, the construction and demolition of buildings creates other adverse impacts on public health, urban ecology, and the city environment.

Table 1. List of building construction projects

Building types	Number of projects	Number of buildings	Total floor areas (sqm)	Total investment costs (USD)
High rise building (Total)	-	470	-	-
5 – 9 storeys	-	258	-	-
10 – 19 storeys	-	133	-	-
20 – 29 storeys	-	45	-	-
30 – 39 storeys	-	25	-	-
> 40 storeys	-	9	-	-
Residential building (Total)	4086	-	7 822 493	3 042 943 106
Gated community (Borey)	79	16 308	3 935 618	1 377 316 987
Flat houses	-	21 072	6 335 395	2 168 872 506

[4] See Waibel et al. (2020)
[5] See MEF (2019)
[6] See Construction & Property (2019). https://www.construction-property.com/green-building-a-solution-for-a-sustainable-construction-sector/

Apartments	-	126	1 487 098	874 070 601
Hotels & guesthouses	36	-	364 082	215 149
Commercial buildings	487	-	5 385 163	197 637 381
Industrial and factory buildings	96	-	2 066 088	712 959 646
Multiple purpose buildings	88	-	4 314 581	2 588 846 114

Note: the table is adapted from annual report of operating result for 2020 and future workplan for 2021 of the Ministry of Land Management, Urban Planning, and Construction[7].

The concept of the green buildings covers the efficient use of energy, reducing greenhouse gas emissions and air pollution (including indoor environment quality), reducing water consumption, efficient land use, environmentally friendly construction materials (resource efficiency), waste minimization, and management of community impacts during construction and operation of buildings. While the construction boom is taking place in Cambodia, these green building concepts, while new for Cambodia, are becoming increasingly important. Thus, it is important to integrate the green concepts into the building design, construction, and operation in Cambodia, as there is currently no guidance from a green building perspective on constructing or retrofitting homes and building. The *Phnom Penh Sustainable City Plan* 2018-2030 identifies the willingness of Cambodia's authorities to develop a green building guideline and certification system, aligned to its sustainable city vision of developing a cleaner, greener, and more competitive urban environment, with resilience, sustainable lifestyles and social welfare.

1.4. Introduction to green buildings

Today, over 50% of the world's population lives in urban areas. It is also expected that the urban population will increase by 1.5 times to 6 billion in 2045.[8] With 80% of global GDP centred in the cities, sustainable management of metropolitan areas should prioritise creating new ideas, encouraging innovation, and increasing productivity, which can potentially lead to sustainable growth. The global trend of urbanization has been caused mainly by the increase in migration flows to the cities. This trend has put pressure on the economy, society, and environment, as evident in, for instance, the increased demand for housing and construction in cities and towns.[9]

The construction industry is economically, socially, and environmentally significant, as its output which is the building, has both negative and positive impacts during their lifecycle. The adverse effects of the building construction process include dust, noise, water pollution, traffic congestion, waste disposal, and the tremendous consumption of human resources and natural resources. The building sector accounts for 40% of global carbon dioxide (CO^2) emissions, which exceeds all of the transportation sectors' carbon footprint combined.[10, 11] According to the Centres for Disease Control and Prevention, climate change, resulting from increased CO^2 emissions, causes injuries and premature deaths related to extreme weather events, respiratory and cardiovascular disease, changes in the prevalence and distribution of food and water-borne illnesses and other infectious

[7] See Annual Report (MLMUPC, 2021).
[8] See World Bank (2020).
[9] See World Bank (2021).
[10] See World Business Council for Sustainable Development (2019).
[11] See Architecture2030 (2020).

diseases, and threats to mental health.[12] On the other hand, the positive impacts of buildings include their contribution to economic growth, provision of jobs, and habitats, comfort, and facilities.

The adverse impacts of the building and construction industry are now being acknowledged at international levels. There are shifts and movements in designing, procuring, building, and operating the building in a more sustainable way. The most crystal-clear one is the United Nations Sustainable Development Goals (SDGs) that came into effect in 2016. Its goals 11, 12, and 13 predominantly focus on Sustainable Cities and Communities, Responsible Consumption and Production, and Climate Action. These three SDGs especially bring attention to the building sector.[13] Such commitment was followed by the international GHG emissions reduction initiatives such as the Paris Agreement signed in 2015 and a dedicated "Buildings Day" for the first time at UNFCCC Conference of Parties (CoP) 21. These global initiatives signal a clear commitment of the international community to recognise the built environment's impact and engage meaningfully with the built environment community in combating the rise of GHG emissions and putting policies in place to reduce these GHG emissions through innovation in the building sector.

Cambodia, a lower-middle-income country, has also experienced the impacts of the urbanization trend. The capital city of Phnom Penh became a primate city by the new millennium, as its population accounts for more than half of the total urban population of Cambodia.[14] The World Bank has reported that Phnom Penh has witnessed significant urban growth over the last 10 years, with its population rising to 2.1 million in 2019.[15] As identified by the RGC, rapid urbanization has led to many issues such as traffic congestion, unregulated parking, waste management, pollution, and flooding, and most prominently, unregulated construction. These issues are further intensified by the problem of climate change impacts[16,17].

With the growing population in the cities of Cambodia, there is no doubt that the demand for housing is undeniably high. There is a significant construction boom and high urbanization level in Cambodia, resulting in high demand for new commercial and residential buildings, especially in the capital city. In 2015, Cambodia has the second-highest rate of urbanization in Southeast Asia with urban growth rate of 4.3%[18] and needs to manage the influx of residents to the cities in a sustainable manner. The construction boom is driving up GDP growth in Cambodia. According to Minister of Land Management, Urban Planning, and Construction, H.E. Chea Sophara (2020), the demand for new housing is estimated to be 1.5 million units from 2015 to 2030. The demand in Phnom Penh alone stands at 800,000 units, which equals to around 50,000 units per year to supply the growing population. Based on this figure, the Ministry of Land Management, Urban Planning and Construction (MLMUPC) has responded by approving licenses to the private sector to construct houses to fulfil the needs. The construction focuses further on condominiums, trade centres, and other high-rise buildings[19,20].

[12] See CDC (2021).
[13] See United Nation (2021)
[14] See Sheng & Thuzar (2012).
[15] See Ministry of Planning (2019).
[16] See NCSD, MOE, PPCA & GGGI (2018).
[17] See World Bank (2019).
[18] See NCSD, MOE, MOI & GGGI (2021).
[19] See Construction Property (2020).
[20] See Bunthoeun (2020).

Due to a large-scale construction boom in Cambodia, the building sector has become Cambodia's largest energy consumption sector, accounting for 52% of the total consumption in 2017. In the same year, residential and commercial buildings consumed 77% of the final electricity.[21] Based on the national forecasts, by 2040, energy consumption in the building sector will be more than double that of the current consumption rate. Cooling of buildings also presents a significant challenge. As climate change progresses, air temperatures become more extreme, access to cooling, such as energy-intensive air conditioning, will be required to maintain living conditions.[22] Despite this increase in energy intensity, the country still does not have guidelines for constructing new buildings or retrofitting existing buildings in an energy-efficient and resource-efficient manner. With this gap, most architects, contractors and other building profession or practitioners do not integrate energy efficiency and resource efficiency measures into building design. To date, the problem has been assessed as a priority under the *Phnom Penh Sustainable City Strategic Plan* 2018-2030 developed by the RGC's National Council for Sustainable Development and the Phnom Penh Capital Administration. The legal framework supporting this is the draft *Environment and Natural Resources Code*, which has a chapter on Sustainable Cities, including a requirement for the capital city and cities over 200,000 people to develop a Sustainable/Green City Strategic Plan and identify sustainable/green city development projects. Urban development is a significant source of GHG emissions. Cambodia is committed to reducing its GHG emissions under its Nationally Determined Contribution (NDC) to the UNFCCC and under its *National Green Growth Policy* (2013) and *National Green Growth Strategic Plan* (2013-2030). Green building design can significantly reduce energy demand and carbon emissions, contributing to Cambodia's NDC targets for greenhouse gas mitigation.

1.4.1. What is green building?

There are many definitions of green building from organizations all around the world. Those definitions mainly concentrate on four pillars: economic, environment, society and health. The summary below gives a few definitions to describe green buildings.

1. *World Green Building Council: 'Green Building' is building approaches, such as design, construction, or operation, which aim to improve quality of life, create positive impacts, and reduce or eliminate negative effects on the environment while representing the most efficient and least disruptive use of land, water, energy, and resources.*[23]
2. *US Green Building Council (USGBC): 'Green Building' is to significantly reduce and eliminate the negative impact of buildings on the environment and the building occupants.*[24]
3. *German Sustainable Building Council (DGNB) identifies the 'Green Building' as the sustainable building that consciously uses and introduces available resources minimizing energy consumption and preserving the environment.*[25]
4. *Malaysian Green Building Index (GBI): 'Green Building' is the building that focuses on increasing the efficiency of resource use—energy, water, and materials— while reducing*

[21] See IEA (2020).
[22] See GGGI (2021).
[23] See Worldgbc (2020).
[24] See USGBC (n.d.).
[25] See DGNB (2020).

building impact on human health and the environment during the building lifecycle through better design, siting, construction, operation, maintenance, and removal.[26]

Most definitions commonly acknowledge the building's design, construction, operation, and demolition with environmental and cost-saving concerns and improved safety and welfare of building users. Based on the reviewed definitions, a comprehensive definition of green building can be summarised as:

Green building minimises the negative impacts of buildings and construction on the environment, health, society, and economy, during their lifecycle, including during the phases of planning, design, construction, operation, maintenance, and demolition.

1.4.2. What are the benefits of green building?

Compared to contemporary design and construction, the components of a green building inevitably provide multiple benefits related to achieving a range of global goals such as driving economic growth, creating sustainable and thriving communities, and addressing climate change. They are categorised into three aspects—environmental, economic, and social benefits (see **Figure 2**).

Figure 2. Green building interventions towards sustainability.

[26] See Green Building Index for Malaysia (n.d.).

Environmental

The most outstanding and vital benefit of the green building component is its ability to impact climate and the natural environment positively. Green buildings likely contribute to maximizing energy and water efficiency, minimising waste, and utilising the optimum amount of natural resources with certain measures to ensure indoor air quality and surrounding biodiversity. These approaches could address climate change and positively impact the natural environment, leading to reduced greenhouse gas emissions at global and building levels. According to UNEP[27], fuel switching, use of renewable energy, and energy efficiency have the potential emission of 84 gigatons of CO^2 by 2050. The certified green buildings in Australia, India, South Africa, and the United States have been shown to produce less GHG emissions than average contemporary buildings and consume less potable water than if they had been built according to minimum construction requirements.[28]

Economic

Compared to conventional buildings, green buildings can offer significant economic savings directly from energy-saving and saving maintenance and operation costs. The most prominent is its ability to boost economic growth by reducing utility bills for tenants or households (through energy and water efficiency). Other benefits are lowering construction costs, increasing the occupancy rate in buildings, offering higher property value for building developers, and creating more green jobs. Empirical evidence of Canada's Green Building Council showed that the industry generated USD23.45 billion in GDP and represented nearly 300,000 full-time jobs in 2014.[29] Another indirect benefit of green buildings is associated with higher employee satisfaction levels. The employees working in the green building sector showed higher satisfaction and productivity levels, resulting in lower absenteeism and better results.[30]

Social

The social benefit of the green building looks at the comfort, wellness, and human behaviour gained by working or staying compared to a conventional structure. According to the Better Places for People project of the World Green Building Council, it is found that green buildings support healthier, happier, and more productive lives.[31] Other social benefits are associating with thermal comfort and indoor environmental quality. Workers in green and well-ventilated offices record a 101 percent increase in the cognitive score.[32]

1.4.3. How to make a green building?

The following four perspectives should be considered when aiming to achieve green buildings.

Environmental perspective

In green buildings, renewable energy and low-carbon technology should be used to maximise energy efficiency. At the same time, building users should be trained to be efficient in their energy use, too. In addition, there should be an effort to improve water usage in buildings by exploring

[27] See UNEP (2016).
[28] See Worldgbc (2020).
[29] See Worldgbc (2020).
[30] See Ries et al. (2006).
[31] See Worldgbc (2020).
[32] See Ries et al. (2006).

ways to have safe drinking water and effective wastewater management. It is essential that the buildings do not disrupt stormwater and drainage systems from doing their job. In terms of waste generation, green buildings should aim for less waste production and encourage users to reuse and recycle whenever possible.[33] Besides these considerations, the design ideas need to adopt sustainable construction materials, while intentionally minimizing resource consumption during construction and operation stage.

Building condition

Green buildings should be resilient to climate change and other natural disasters such as storms, flooding, fires, and earthquakes. Also, they should be built for long-term duration, taking into account and minimizing the needs for future change such as renovation and demolition. The location of the buildings should be as close to necessary amenities as possible so that it reduces the need for transportation and encourages more walking and cycling.[34]

Health and well-being of users

Users of green buildings should be able to feel comfortable, and this includes both seeing and hearing well. The building temperature should be kept optimal for all users. Moreover, the buildings should allow for fresh air through sufficient ventilation and enough natural light to reduce light energy consumption.[35]

Socio-economic effects

Green buildings should create an environment that connects and enhances communities. They should yield positive social and economic benefits to the surrounding communities and engage local citizens in planning. Additionally, there should be an effort to explore smart information communication technologies (ICT) to communicate better. For example, smart electricity grids can add to energy efficiency in buildings, because of their understanding of how to transport energy when and where it is needed.[36]

1.5. Global experience of Green Building Rating Tools

The rating system of the building is the tool used to assess and recognise buildings that meet specific green requirements and standards. The tools are created based on the criterion of each organization or country, according to their recognised definition of green buildings standards. The standard depends on many factors, ranging from energy and water consumption patterns, indoor air quality parameters, economic aspects, and social aspects. Each system's level of detail has set the standard and guidelines for developers and organizations to build and operate their buildings accordingly. The green building rating system has been an effective tool for the building industry to be innovative and push their boundary towards sustainability. The rating certification system is usually administered either by a government agency or private sector, which works wholly or partly on certifying the buildings or in some countries, awarding the neighbourhoods.[37]

[33] See World Green Building Council (2016).
[34] See World Green Building Council (2016).
[35] See World Green Building Council (2016).
[36] See World Green Building Council (2016).
[37] See World Green Building Council (2017)

In some cases, the system is incorporated into the building construction code so the government can positively impact the economy, society, and environment. Rating tools can be applied at all stages—planning and design, construction, operation and maintenance, renovation, and eventually the demolition stage. Rating tools vary depending on the type of building it is applied to, such as commercial buildings, homes, or neighbourhoods/districts.[38]

Globally, there are approximately 600 green building ratings systems.[39] Countries have their own green building rating system standards and guidelines, which comply with the local context, geography, regulations, and respect the building codes. To ensure the quality standard of green building tools, the World Green Building Council launched the Quality Assurance Guide for Green Building Rating Tools in 2016. This guide guarantees that the development and implementation of the newly emerging rating tools are robust, transparent, and provide a good standard and positively bring benefits to the three aspects of green building—economic, social, and environment. The United States (US) has the Leadership in Energy and Environmental Design (LEED) rating tools, developed by the US Green Building Council in 1993. South Korea has the Korean Green Building Certification (KGBC), developed by the Ministry of Environment and the Korean Institute of Construction Technology (KITC) in 2001.[40] Germany has the DGNB certification system developed by the DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen, German Sustainable Building Council) in 2009, emphasizing lifecycle assessment, a holistic approach and performance orientation. DGNB criterions highlight six characteristics: environment, economic, sociocultural, technology, communication, and site quality.[41]

In Cambodia green building is a new emerging concept for sustainable built environment and the national green building certification system have not existed yet. However, there has been a number of certified green buildings that are passed by LEED certification since 2007 by having 6 gold certified, one platinum, one silver and one certified accounting for 20 thousand square meters and 8 registered projects with more than 37 thousand square meters [42] (see Appendix 1).

2. Green building challenges and gaps

Currently in Cambodia green buildings do not yet feature prominently, partially due to the absence of laws and regulations to identify what it takes for buildings to be considered ‘green’. This provides the opportunity to establish and to identify the components/criteria of green buildings and the measures to achieve green building certification/rating tools. The guideline itself would be based on international experiences from DGNG certification but adapted to the context of Cambodia.

In Cambodia's construction sector, there is a lack of awareness of energy efficiency opportunities despite its potential opportunity to reduce high electricity costs. Significant new investments in high-rise apartments, entertainment complexes, commercial buildings, and satellite cities are energy-intensive and not currently using energy efficiency measures. Previous attempts to develop energy efficiency projects in the building construction sector have not been particularly successful, mostly due to the limited awareness of possible operational cost savings among building end-users. Research by Durdyev et al. (2018) shows that the main barriers to sustainability in the building

[38] See World Green BVuilding Council (2017)
[39] See Doan et al. (2017)
[40] See Energy Smart Communities Initiative (2014)
[41] See DGNB (2020)
[42] Phnom Penh :: Green Building Information Gateway (gbig.org)

construction sector in Cambodia are mainly associated with limitation of stakeholders' awareness, other economic priorities, and lack of certain legal framework (see **Figure 3**).

- Lack of awareness and knowledge
- Reluctance to adopt new sustainable technologies
- Lack of professional capabilities/ designers

- Higher cost of sustainable building options
- Other economic needs are of a higher priority
- Lack of client demand

- Lack of government incentives
- Lack of a statutory requirement that covers sustainable procurement

Figure 3. Challenges and gaps of green building intervention in Cambodia[43].

In the absence of a Building Energy Code (BEC) in the residential sector of Cambodia, building practices do not consider energy-efficient design measures, thereby leading to inefficient energy use. Although Cambodia does not currently have any guidelines for constructing new buildings or retrofitting existing buildings in an energy-efficient and resource-efficient manner, development projects like tall buildings or skyscrapers are required to conduct Environmental Impact Assessment (EIA) in advance. Yet, the requirements of green buildings are not found in the EIA.

Building design and construction practices in Cambodia do not fully address environmental issues. Cambodia's economic growth has mostly been centered on the capital city of Phnom Penh, with the construction of buildings driving foreign direct investment. While the construction boom is taking place, there is limited documented evidence that the concept of green building design is being integrated into architecture and property development plans. Cambodia's construction law includes quality requirements for building construction but does not focus on environmentally sustainable building design. Cambodia's *Law on Construction* (2019) No. NS/RKM/1119/019 determines the principles, technical regulations, rules, and procedures for the management of the construction sector in Cambodia.

[43] See Durdyev et al. (2018)

Many buildings are not resilient to climate change, particularly to increased temperatures and flooding. Vulnerable buildings could include residential and commercial buildings, which are designed and constructed without considering the potential impacts of natural disaster events. Without the proper use of green building design, Cambodia's GHG emissions from high energy use in buildings will continue to rise. Similarly, water consumption from buildings will also increase. Unemployment, particularly amongst youths in Cambodia, can be alleviated through the creation of green jobs, particularly in the green building design and certification process. The design and certification process will contribute to GDP growth and poverty alleviation.

3. Objective

This stocktaking report aims to provide the current state of construction and buildings with the examining green perspectives and gaps from the policy, legislation, strategy and plans to the actual practices in Cambodia and identify roles of ministries in the construction and building sector. Then the report will propose ideas of intervention to prepare the green building guidelines and certification for green buildings in Cambodia and way forward in the implementation.

4. Analytical method

The stocktaking paper has been conducted through qualitative research, which was fundamentally based on desk review method, and prepared by Green Building Project Team of the National Council for Sustainable Development (NCSD). Secondary data was utilised to garner both hard and soft copies of relevant government publications, international organization data, and other sources from educational institutions with reliability and credibility. This method contextualises associated planning policy frameworks in Cambodia, which reflect and contribute to promoting sustainable construction sectors. Moreover, the review explored different green building concepts in international and regional experiences, which include theorical perspectives and precedent practices, such as case studies and lesson learnt. The subsequent outcomes frame possible strategic intervention and option for green building practices in Cambodia. Once this stocktaking report was initially drafted, comments and feedback were sought from external reviewers, such as academia and development partner organizations.

5. Findings

5.1. Stakeholder analysis

Currently there is no government institution taking responsibility for green building certification and management in Cambodia. Since green building certification involves multiple disciplines and sectors, it is necessary to involve a range of relevant government stakeholders, academic, architect and engineer groups, and the private sector. However, one or two ministries can take the overall lead and management of the green building certification system in the country. It is proposed that the Guidelines and Certification for Green Building in Cambodia project will establish an interim body for the piloting of the green building certification system and then identify options and recommendations for appropriate institutions or a combination of existing institutions to lead, manage, and operate the green building in the country.

The implementation of Cambodia Green Building Certification system and Guidelines requires collaboration with multiple stakeholders, integrating their tasks, and managing their cooperation.

As stated in the *National Strategic Plan on Green Growth* 2013-2030, the relevant institutions include public institutions (MLMUPC, Ministry of Mines and Energy, NCSD, MoE, and other ministries) and private sectors.

5.1.1. Public institutions

The National Council for Sustainable Development (NCSD) is a policy-making and inter-ministerial coordination institution that promotes sustainable development across sectors, ensuring Cambodia's economic, environmental, social, and cultural balance. It coordinates Technical Working Groups (TWG) on Sustainable Consumption and Production (SCP), Sustainable Cities and Sustainable Energy, among other priorities. The council has a role in monitoring and reporting Cambodia's implementation of international commitments, such as its climate change commitments. With the Green Building Certification System and Guidelines, the council can ensure coordination and cooperation among relevant stakeholders from across sectors to support and implement the initiative.

The Ministry of Environment (MoE) is responsible for leading and managing the environmental protection, conservation of biodiversity, utilization of natural resources appropriately, and sustaining long-term benefits of the environment for the current and future generations of Cambodians. The ministry prepares policies, strategies, plan, programs, guidelines and regulations related to solid waste management and wastewater discharge management by coordinating, promoting and cooperating with relevant ministries and institutions at the international, national, provincial, municipal and local levels. For the Green Building Certification System and Guidelines, MoE contributes to the initiative through the existing regulations associating with air quality, solid waste management, treated wastewater discharge, importantly, EIA.

The Ministry of Mines and Energy (MME) is responsible for establishing policies and regulations related to mining and energy sectors and their implementations. The ministry has been preparing the *National Energy Efficiency Policy* (2021-2030) (draft), which is designed with the vision of enabling the energy sector in Cambodia to be more efficient and modern. MME is also in the final stage of consulting with relevant ministries and is expected to launch the Energy Efficiency in Building Guideline in early 2022.

Ministry of Land Management, Urban Planning, and Construction (MLMUPC) is responsible for governing land-use, urban planning, construction projects, and land-use dispute resolutions. For the construction and building sector, the ministry administers the *Law on Construction* (2019) and other relevant regulations and oversees technical professional capacity in the sector. The ministry issues permits to legal entities for housing, land use, construction, and architectural design business. Currently, the ministry is in the process of developing the building codes or the so-called building technical regulation (BTR) (Sub-Decree 62, 1999).

5.1.2 Other relevant government agencies

The Board of Engineers Cambodia (BoEC) was established in 2009 to develop engineering practices and protect the interest of registered members, the professional community, and society. BoEC has the vision to provide members professional qualification upgrades to an internationally accepted standard. BoEC handles Cambodia's Professional Regulatory Authority (PRA) mechanism in the Mutual Recognition Agreement (MRA) on Engineering Services signed by Ministers of Commerce of ASEAN Countries in 2005.

Board of Architects, Cambodia (BAC): established in 2011, the BAC is a state-run association aiming to group and manage architects in the country to ensure their professionalism levels and protect the practice of architecture. Architects need to register with BAC to be recognised by the government and have the opportunity to upgrade capacity and expand their career network.

5.1.3. Private sector

Cambodia Constructors Association (CCA): is a non-government association established in 2011 to leverage the national construction industry and help coordinate between the government and the private construction sector.

Cambodia Green Building Council was established in 2020 as a local non-profit organisation with the mission "to be the key driving force towards a sustainable built environment in Cambodia". This organisation has initiated the use of the Cambodia Energy & Environmental Leadership (CAMEEL) as a rating tool for green buildings and community programs. However, its website and publications do not provide information about how the rating system has been developed, and if it has been recognised by the RGC. This private-sector led Green Building Council aims to provide third-party credentialing and certification for several rating systems relating to the built environment. The council notes that these credentials will create leadership in green building and distinguish building professionals with the knowledge and skills. Certification will be performed through third-party technical reviews of CAMEEL-registered projects.

EuroCham Cambodia is a European business association representing the official chamber of the European business community in Cambodia. The association promotes and supports European businesses or professionals specializing in green building to present their works/concepts through knowledge sharing workshops in Cambodia.[44] The association has a GreenBiz working group and organises an annual green business forum, which has a focus on green buildings.

5.2. Construction and buildings related legislations and policies

This section uncovers associated legislations and planning policies in Cambodia, which intend to deal with cross-cutting sectors contributing to support green building design and practices. It will also discuss some policy gaps of sustainable building construction and implementation, which subsequently introduce opportunities for green building intervention in Cambodia. This section will touch on Cambodia's existing construction governance, built environment and design, energy consumption, urban land management, construction materials, solid waste and wastewater management, environmental impact assessment, and sustainable cities.

5.2.1. Institutional mechanism and governance on building construction

This section will describe the institutional arrangements associated with building construction, outlining the different roles and responsibilities of government institutions and their mechanisms to deal with construction in Cambodia. It bridges basic understanding of the link between contemporary institutional arrangement and legal documents on construction, which may facilitate green building implementation. In this regard, the following laws and regulations (sub-degrees) are highlighted in **Box 1**.

[44] See EuroCham-Cambodia (2021).

Box 1. Relevant legislations on institutional arrangement for building construction sector in Cambodia.

- Law on Management of Land Management, Urbanization, and Construction (1994)
- Sub-decree on Construction Permit (1997)
- Sub-decree on Urbanization of the Capital City, Towns, and Urban Areas (2015)
- Law on Construction (2019)

A committee for land management, urban planning and construction at national and municipal/provincial levels are required to establish pursuant to **Law on Management of Land, Urbanization, and Construction (1994) and Sub-decree on Urbanization of the Capital City, Towns, and Urban Areas (2015)**. Sub-committees are also established through the delegation of responsibility to the municipality and provincial administration, which include relevant technical departments. These committees and sub-committees intervene on the review and decide on approval of the proposed master plans for the respective administrative levels (including provincial, municipal, district/khan, Sangkat and commune levels). In this regard, the construction of settlement and renovation of a buildings must comply with the relevant master plan or land use plan and be approved by the relevant provincial and municipal administrations, except large scale projects by which the national authorities of the RGC administers, under the **sub-degree on Construction Permit (1997)**. Additionally, the Minister of Land Management, Urban Planning and Construction has the authority to manage construction sectors, and he/she could delegate this power to the lower levels if it is suitable, as mentioned in article 5 of **Law on Construction (2019).**

In general, building construction sector necessarily aligns with the master plan and land use plan of the administrative territory on which the proposal situates, while the plans are to be reviewed and approved by the committees. Therefore, the green building concept could be possibly incorporated into the plans by the intervention of the committee at the decision-making level.

5.2.2. Building design and built environment

The built environment refers to the architectural styles and housing types and urban density within an area. While in Cambodia there have been significant investments in high-rise luxury apartments, entertainment complexes, commercial buildings and satellite cities, the construction boom is taking place with a lack of green concept integrated into building design, construction, and operation. Moreover, with no guidance on constructing or retrofitting homes and building regarding green design, energy efficiency, and the use of locally available materials, electricity demand will continue to increase (mostly from non-renewable sources) and, therefore, contribute to rising GHG emissions from urban construction and operation as well.

Legislation on green buildings has not yet been created in Cambodia, although the commitment of improving the environmental sustainability of the built environment has been promoted in the places that people live, work, and recreational spaces, such as buildings, parks, multipurpose gardens, and wastewater treatment plants. Some legislation, policies and plans have been established to promote and encourage green design on building constructions (See **Box 2**).

Box 2. Relevant legislations on building design and built environment in Cambodia.

- Sub-decree on Construction Permit (1997)
- Sub-decree on Urbanization of the Capital City, Towns, and Urban Areas (2015)
- Law on Construction (2019)
- Sub-decree on the Management of Borey, Gated Community (2011)
- Draft Law on Urban Planning (2021)

For instance, RGC published Sub-Decree No. 42 on **Urbanization of the Capital City, Towns, and Urban Areas, 2015**. This sub-decree regulates land use within a construction plot and places limits on the construction footprint within a parcel of land to ensure that adequate open spaces remain for trees and gardens. Furthermore, a draft **Law on Urban Planning (2021)** determines that 30% of new proposed land use zone or development precincts should be allocated for green spaces. It encourages functionality of built environment to provide opportunity for on-site rainwater capture/infiltration to reduce flooding, less densely packed housing, and more open space. Moreover, the **Law on Construction** (2019) aims to assure the improvement of building quality, including for security and safety, property protection, public amenity, environmental sustainability, and sustainable lifestyles. Furthermore, the accountability and efficiency of construction works and investors' perspectives on social and economic efficiency are also promoted. For example, Article 6 of the law provides the principles to improve the sustainability of the construction sector by considering the concept of green development and environmental resource protection. Furthermore, public spaces and natural beauty are urged to be maintained within gated communities (borey), as mentioned in the **Sub-decree on the Management of Borey, Gated Community (2011)**. All building constructions, renovation, and expansion in urban areas require a construction permit, as stipulated in the Article 2 of the **Sub-decree on Construction Permit in 1997.** This intervention will contribute to ensure public safety and health and reserve critical public areas for urban planning. Additionally, Article 35 of this sub-degree determines the appropriate building ratio for green garden allocation for water permeability and natural beauty.

The allocation of green space for sustainable urban landscapes encourages resilience against climate uncertainty. This includes the design of buildings with reserved spaces to provide natural vegetation coverage and permeable surfaces to regulate urban runoff. The surrounding vegetation, such as trees and gardens, contribute to mitigate urban heat island effect on the buildings and urban neighbourhood as whole. These aspects closely align with the characteristics of green building's advantages and measures. Therefore, these contemporary practices should be encouraged and reflected in the design of Cambodia's green building certification systems and guidelines.

5.2.3. Energy in buildings

Building sector could be a good strategic intervention to deal with energy consumption and contribute to climate change mitigation. Globally, the building sector accounts for 40% of energy usage and 60% of electricity use.[45] International experience shows that about 25% or more energy savings in buildings can only be achieved by using energy-efficient building materials and

[45] See UNEP (2017).

effective equipment and design principles.[46] In addition, the international experience also shows that implementing and introducing energy labels for consumer products and efficient use of the product can save energy from 32% to 50%.[47]

Contemporary issues of energy for building sector have posed significant challenges for energy demand and supply. Like other developing countries, Cambodia experiences a growing building industry, with residential and commercial buildings as the second largest energy consumers, after transportation, and most buildings are in cities. Additionally, due to high urbanisation rates and lifestyle improvements, the use of electrical appliances such as refrigerators, air conditioners, cooking utensils, television, radio and washing machines are expected to dramatically increase in Cambodian households, which will be followed by large scale energy demand.

Furthermore, behavior change is required among building users, as unsustainable practices of energy savings is common, which is considered as a critical issue in energy sector. Majority of the appliances in Cambodia are imported, without energy performance checks. A mass bulk procurement programme to increase the uptake of energy-efficient appliances would help to address this challenge. However, past attempts to introduce energy efficiency (EE) projects (like replacing conventional lights with LEDs) in the residential sector were not successful, due to limited awareness of the possible operational cost savings among the residential users and a lack of behaviour change.[48] The current trends for Cambodia's residential sector in ownership levels of appliances and their technologies attributes are unknown.

The RGC has put its effort towards promotion of its Energy Efficiency Policy to improve energy efficiency through different legislations, policies, and strategies (See **Box 3**). To large extent, this policy intervention contributes to promote energy efficiency in buildings. Furthermore, the **National Energy Policy (1994**) was developed promote affordable and modern form of energy while reducing the dependences on imported fuels.[49] The draft **National Energy Efficiency Policy (2021 – 2030)** and **Cambodia's Basic Energy Plan (2019)** intends to provide reliable, affordable, transparent, and safe energy services. This policy aims to reduce the importation of fuel for energy generation and maintain the quality of natural capital of the nation. Furthermore, the draft **National Energy Efficiency Policy (2021 – 2030)** identifies buildings (Commercial and Residential) as a critical sector for achieving energy efficiency and sets the target of reducing energy consumption by 20% compared to the business-as-usual scenario[50].

[46] See GSA (2011).
[47] See IEA (2015).
[48] See ASEAN Centre for Energy (2018).
[49] See ASEAN Centre For Energy (2018).

Box 3. Relevant legislations and planning policies on building design and built environment in Cambodia.

- Law on Environmental Protection and Natural Resources Management (1996)
- Sub-decree on Electricity and Electronic Equipment Management (2016)
- Sub-decree on Energy Efficiency Standards and Labelling for Electrical Appliances and Equipment
- Guidelines on Promoting Energy Efficiency Lamps, CFLs and LEDs, Used, NCSD, MoE& MME for Government Buildings (2018)
- National Energy Efficiency Policy (2021 – 2030)
- Cambodia's Basic Energy Plan (2019)
- Energy Efficiency and Conservation Master Plan of Cambodia (2020)
- Draft Environment and Natural Resources Code
- Localised Energy Efficiency Design Guideline
- Draft NDC Roadmap for Low-Carbon, Climate Resilient Building and Construction 2050
- Circular Economy Strategy Action Plan (2021)
- Phnom Penh Sustainable City Plan (2018-2030)
- National Determine Contribution (2020)

The **Energy Efficiency and Conservation Master Plan of Cambodia (2020)** was also formulated to inform the relevant establishment of energy efficiency policies and programs in Cambodia while the draft **Environment and Natural Resource Code** includes provisions on sustainable energy. Within these documents, the **Ministry of Mines and Energy (MME)** highlights the challenges of energy consumption, which require increased energy efficiency interventions in buildings, industry and transport, through technological advancements. MME also led the development of a **Localised Energy Efficiency Design Guideline,** providing technical assistance in designing new residential and commercial buildings, which contributes to improved energy efficiency in buildings, reflecting the RGC commitment to combat climate change. Such interventions are also highlighted in draft **NDC Roadmap for Low-Carbon, Climate Resilient Building and Construction 2050**, **Circular Economy Strategy and Action Plan (2021), National Determine Contribution (2020)**, and **Phnom Penh Sustainable City Plan (2018-2030)** to boost practices of energy efficiency in the building sector.

In addition, the **Sub-decree on Energy Efficiency Standards and Labelling for Electrical Appliances and Equipment (Draft)** provides a framework for Minimum Energy Efficiency Performance Standards and Labelling for electrical appliances and equipment. The aim is to promote energy-efficient electrical appliances and equipment by monitoring energy performance, disseminating information, and raising awareness. For instance, Article 15 of Chapter 4 of the sub-decree sets the energy performance level and testing in five levels - performance graded from 1 to 5. Furthermore, the **Cambodia Energy Sector Assessment, Strategy and Roadmap**[51] determine

[51] See ADB (2018). https://www.adb.org/sites/default/files/institutional-document/479941/cambodia-energy-assessment-road-map.pdf

objectives to carry out a market assessment of energy demand underlying energy efficiency interventions and technology advancement in industry, buildings, appliances, public services, and transport in Cambodia. This report intends to develop a business model and investment pipeline for energy efficiency over a short-to-medium term (5-10 years).

The contemporary energy issues and existing legislation and planning policies in Cambodia may provide opportunities for green building practices and certification system formulation. The challenges of energy supply/demand, behavior of energy saving practices, and inefficient technological appliances could trigger urgent action and responses. While the existing planning policies and legislation do not directly acknowledge energy efficiency measures in green buildings, they will facilitate the transition from conventional practices of energy consumption and support the development of a green building certification system in Cambodia. This transition will contribute to providing effective solutions in reducing energy demand and improving energy efficiency behavior in the building sector. As building construction has experienced rapid growth, the potential for saving energy is attractive due to the great opportunities to incorporate energy efficiency practices at the planning and design stages of building construction, in addition to renovation of older buildings.

5.2.4. Land management

Due to an average of 7% economic growth in the last two decades, Cambodia's urban population has increased from around 2.2 million people in 2000 and to more than 4 million people in 2020[52], which was 18.6% and 20.7% of the total population, respectively. By 2050, this number is expected reach 36.2%.[53] Land management is an important component of effectively managing this rapid urban growth, underpinning clean and green/sustainable city concepts. Generally, the development of sustainable urban areas focusses on both building design and the surrounding environment. In Cambodia, urban development mainly concentrates on land administration governance, land use planning, zoning, land readjustment, urban redevelopment, urban infrastructure development, and efficiency of natural resources consumption. This land management sector also contributes to environmental quality promotion, socio-economic development, and inclusive growth in rural and urban areas by preventing and resolving disputes over land use, managing urban environmental degradation, natural resources extraction, managing informal settlements, and regulating construction. The existing relevant land management legislation and planning policies are importantly framing land use planning and zoning, which determine the purpose of land use and functions, supporting the design of buildings in appropriate and consistent manners.

The RGC has released the law and regulations (see **Box 4**) on land management, such as the **law on Land Management, Urban Planning and Construction[54] (1994)**, the law on **Environmental Protection and Natural Resources Management (1996)**, **Law on land (2001)**, **Land policy (2015)**, and **Sub-decree on Urbanization of the Capital City, Towns, and Urban Areas (2015)** to ensure the transparency and efficiency of land use.

[52] See World Bank, World Development Indicator 2021. https://databank.worldbank.org/source/world-development-indicators
[53] See UN (2014)
[54] Land management' includes land administration, land-use planning, zoning, and land readjustment. 'Urban planning' includes masterplan development, urban redevelopment, and urban infrastructure development. 'Construction' includes the development of building code and construction standards.

Box 4. Relevant legislations and planning policies on land management in Cambodia.

- Law on Management of Land Management, Urbanization, and Construction (1994)
- Sub-decree on Urbanization of the Capital City, Towns, and Urban Areas (2015)
- Phnom Penh Master Plan 2018 – 2030
- Land policy (2015)

The Law on Land Management, Urban Planning and Construction (1994) sets a legal framework for overseeing the construction sector, with an objective of maintaining the balance of urban and rural development, based on neighbourhood characters, and valuation of natural resources and environmental capital. In 1996, the RGC promulgated a **Law on Environmental Protection and Natural Resources** to protect the environment and promote the sustainable use of natural resources. The law emphasises on the environmental protection and natural resources conservation to ensure economic growth and social welfare particularly the development of clean and green city/urban area. This law attempts to protect environmental quality and resources in order to promote sustainable uses of natural resource without exclusion of urban areas. Both laws contain a consistent focus on natural resource protection and conservation underlying an extensive national geographical extent.

In 2015, the **White Paper on Land Policy** was created with the objectives of ensuring effective productive and sustainable land and natural resource management. The objectives of the policy are (i) strengthening efficiency in land governance, (ii) providing the right direction in land-use planning in both private and public sectors, and (iii) aligning the existing rules and regulations pertaining to land to be responsive to the pace of socio-economic development. This policy also promotes urbanisation and urban construction management to ensure balance between urban and rural areas. It also deals with urban issues including transport, construction, public space, and green space.

To promote land management, urban planning, and construction in Cambodia, the RGC released the **Sub-decree No. 42 on Urbanization in Urban, Municipality, and Capital City in 2015**. This sub-decree aims [1] to ensure the effectiveness, sustainability, and equity of urbanisation, [2] to contribute to reduction of climate change, [3] to promote the rights to public and private benefit, promote cultural assets and green growth and [4] to support human well-being and the public including children, older adults, and disabled people. It also identifies development and conservation strategies, such as [1] strategy on urban development and conservation, [2] strategy on land-use, [3] strategy on infrastructure development and economic development, [4] strategy on social development, environmental protection, waste management and disaster risk management. The objective of this sub-decree is to provide significant legal support towards sustainable urban development, which could potentially also support green building implementation in Cambodia.

Furthermore, this sub-decree 42 also promotes integrated green urban development concepts to ensure the effective mixed-use areas, such as [1] residential mixed-use areas, [2] commercial mixed-use areas, [3] industrial zones mixed-use, [4] mixed-use areas, and [5] public and green spaces. Article 21 of sub-decree 42 provides regulations on the maximum proportion of building floor areas compared with the total construction plot land size and total plot land in the

municipality. For example, Article 45 provides that public and green spaces for 1,000 people shall be provided per 1 hectare of construction land, or at least 5% of total construction land, especially special space for the elderly and disabled people. Furthermore, the parking lots in plot area, which aim to promote urban mobility are also required, to reduce air pollution and reduce urban traffic congestion. For example, residential areas of 100 m^2 are required to have at least one parking lot for car. Article 40 of this sub-decree also promotes green infrastructures to achieve the mitigation and adaptation plan and natural disaster risk management. For instance, some measures are identified, including for fire-risk preparation and other unexpected risks, including planning for public safety, public health, environment, natural resources, culture, and human well-being.

Proper land management in the city will create a more sustainable city and improve social equity and increase demand and access to poor and low-income people for affordable housing. Not only that, but it also offers other benefits such as job creation, multiple purpose gardens, sustainable lifestyles, safety, an improved environment, proper land-use planning, and urban green belts. These regulatory documents, particularly the **Sub-decree on Urbanization in Urban, Municipality, and Capital City (2015),** provides essential interventions to manage urban built forms to which architectural design of green building should be transitioned**.**

5.2.5. Construction materials

Since Cambodia's development has experienced a construction boom, this sector contributes approximately 60% of national GDP in 2018, and the local manufacturing and importation of construction material is increasingly growing.[55] **The Ministry of Land Management, Urban Planning and Construction** (MLMUPC) annual report of 2019 - 2020 indicates there were a total of 48,446 projects with construction permits, covering 136,660,070 square meters (m^2) in land, and about 53,118,694,121 USD in capital investment from 2000 to 2019. Imported construction material has been primarily sourced by foreign firms, such as from Korea, Thailand, Vietnam, China, and the United States, which largely supports commercial and residential buildings.[56]

Construction materials represent a significant approach to enhance the transition of conventional construction toward more sustainable or greener built forms. Advantages of green construction materials are cost saving through building's life cycle and extra economic benefit for building owners, such as a reduced cost of materials replacement and maintenance, energy conservation, improvement of occupant health and productivity, and optimization of design flexibility. Nevertheless, imported material lacked attention on promotion of green construction materials due to limitation of regulatory controls and policy on green development in building sector. Some regulatory frameworks, however, have been established to control the construction materials standards, but do not, to a large extent, focus on green building materials.

[55] World Bank Group (2019). https://www.worldbank.org/en/country/cambodia/publication/cambodia-economic-monitor-reports
[56] Cambodia - Construction, Architecture, and Engineering: https://www.privacyshield.gov/article?id=Cambodia-Construction-Architecture-and-Engineering

Box 5. Relevant legislations and planning policies on construction materials in Cambodia.

- Law on Construction (2019)

The **Law on Construction (2019),** as shown in **Box 5,** is intended to ensure the construction quality, security and safety of building construction projects, and the protection of property and well-being of construction owners, users, and the public. The law also aims to maintain the aesthetics and good environment for sustainable living in order to promote public well-being. Additionally, it provides accountability for and efficiency in working and practising professions in the construction sector. It promises to increase investors' confidence in the construction sector and the promotion of the economically and socially efficient real estate market.

The law provides that construction projects shall be accredited or certified for compliance with the building technical regulations by the Ministry of Land Management, Urban Planning and Construction or with Cambodian Standard by the National Standards Council by having the Cambodian Standard Mark affixed or printed on them and by having a license to use the Cambodian Standard Mark. In addition, construction materials and construction equipment which do not follow the construction technical regulations, shall be prohibited. The formal procedures for compliance certification and the types of construction material, equipment, and products required to assure construction quality and construction users' safety shall be determined by further Prakas by the Minister of Land Management, Urban Planning and Construction.

5.2.6. Environmental Impact Assessment (EIA)

The construction sector increasingly becomes detrimental to natural resources due to gradual increase in the use of construction materials, energy and water consumption, natural landscape degradation, and waste generation. Environmental assessment is generally applied to evaluate sustainable material chain in building and constructions (see **Box 6** for relevant regulations).

Box 6. Relevant legislations and planning policies on environmental impact assessment (SEA).

- Law on Environmental Protection and Natural Resources Management (1996)
- Sub-decree on the Environmental Impact Assessment Process (1999)
- Draft Environment and Natural Resources Code

The legal requirements for environmental impact assessments (EIAs) in Cambodia are set out in Chapter III of the **Law on Environmental Protection and Natural Resources Management in 1996** and the **Sub-Decree on Environmental Impact Assessment 1999**. EIA regulations on building construction projects require the developers to take into account other relevant planning policies, such as the sub-decree on water pollution control, sub-decree on solid waste management, sub-decree on air pollution monitoring and disturbance from sound, the law on Water Resources Management, the Law on Urban Planning, and Construction, Labour Law, the Land Law, Sub-

decree on Building Approval, Sub-decree on preparation and operating of Land Management, Urban Planning, and Construction Committee, the Law on Fire Prevention and Firefighting, and other relevant regulations related to commercial buildings. The **draft Environment and Natural Resources Code** sets out that the EIA must be conducted before the approval is granted for construction of a development project. It attempts to ensure that building construction is align to, and is consistent with, other regulations in controlling built environment and ensuring sustainable lifestyles, liveability, and resilience.

All major construction projects are required to conduct an EIA before requesting a construction permit license from the Ministry of Land Management, Urban Planning and Construction. For example, the buildings with a height of over 12 floors or up to 8,000 metres, restaurants with over 500 seats construction of hotels with more than 60 rooms, construction of beach hotels with over 40 rooms, construction of railway longer than 100km, construction of ports of all sizes, and airport facility construction shall be subject to apply for an EIA and shall be followed the General Initial Environmental Impact Assessment (IEIA) or EIA Guidelines (see **Table 2**). Additionally, a recent **Proclamation on the Process and Operational Guidelines and Checklist for the Environmental and Social Impact Assessment (ESIA) Report Preparation for All Building Construction Projects**, adopted in June 2021 by the Ministry of Environment, aims to facilitate the implementation of standards, and ensure consistency of building construction in Cambodia. This checklist consists of key green building criteria and indicators, including wastewater and solid waste management requirements, water consumption measures, ambient air quality standards, air quality and local climate standards, noise management provisions, requirements for protection of surrounding waterways and wetlands, urban forests and ecosystems, and soil quality. Though the checklist is formulated for the assessment in terms of construction impacts, it could provide a foundational understanding of the existing natural resources and landscapes where the building sites are located.

Table 2. Requirement of EIA/IEE in Infrastructure[57]

Type.	**size**
Urbanisation development	All sizes
Industrial zones	All sizes
Construction of bridge-roads	> 30 tons-weight
Building	Height > 12m. or floor > 8,000 Sq. m.
Restaurants	> 500 seats
Hotels	> 60 rooms
Hotels adjacent to the coastal area	> 40 rooms
National road construction	> 100 kilometres
Railway construction	All sizes
Port construction	All sizes
Airport construction	All sizes
Dredging	> 50,000 Cubic m.
Dumping site	> 200,000 people

The Ministry of Environment has established the minimum costs for EIA consultancy services. For example, the minimum cost shall be from 30,000 to 200,000 USD for EIA consultant services to develop the reports based on sectors. The cost of EIA consultant services for buildings (Height

[57] See Sub-degree on EIA process (1999).

> 12m. or floor > 8,000 sq.m) is at least 30,000 for IEEA and 50,000 for EIA. For EIA application, a consultancy company representing the project owner has to register and get approval from the Ministry of Environment. Furthermore, an application on working for rock conditions and other construction materials must follow all criteria such as project activities, size and methodology for developing IEE or EIA report or social impact assessment.

5.2.7. Solid waste management

Solid waste management in building construction can be divided into three stages: construction, demolition, and operation. Construction and Demolition (C&D) waste are industrial and hazardous waste which commonly include paper/cardboard, garden/ vegetation, wood/timber, carpets, other textiles, rubber, glass, plastics, metals, hazardous waste, ceramics, soil/rubble, cobbles/boulders, soil, concrete, plasterboards, bricks, asphalt/bitumen, cement sheet, insulation, and others. In Phnom Penh, it is estimated that the waste composition contains about 60% broken brick, rock, left-over cement and soil, 20% wood, 10% metal, 5% plastic, 5% paper and other wastes.[58] Household waste is generated during the operation of the building. General household waste was 0.487 kg a day at 63.3% which food waste is the predominant portion, followed by plastics waste at 15.5%, grass and wood waste at 6.8%, and paper and cardboard waste at 6.4%. The other remaining wastes include metals, glass, rubber/leather, textiles, and ceramic/ stone accounted for less than 3%.

As shown in **Box 7**, there are many solid waste management laws and regulations which cover the waste in construction sectors, ranging from the **Law on Environmental Protection and Natural Resources Management (1996), Sub-decree on Borey Management No. 39 (2011)** to specific legislation on municipal solid waste, industrial waste, hazardous waste, street dust, and e-waste.

Box 7. Relevant legislations and planning policies on solid waste management.

- Law on Environmental Protection and Natural Resources Management (1996)
- Sub-decree on the Management of Plastic Bags (2017)
- Sub-decree on Garbage and Municipality Waste Management (2015)
- Sub-decree on Solid Waste Management (1999)
- Sub-decree on Urban Solid Waste Management (2015)
- Sub-decree on Borey Management (2011)
- Sub-decree on E-waste and Electronic Equipment (2016)
- Proclaim on hygiene in construction site
- proclaim on construction material storage, waste and good environment of the construction site
- Proclaim on Waste and Solid Waste Management in Province/Municipalities of Cambodia

[58] See PPCA, IGES, Nexus, UN Environment, CCCA. (2018). https://www.unep.org/ietc/resources/policy-and-strategy/phnom-penh-waste-management-strategy-and-action-plan-2018-2035

The Sub-Decree on **Garbage and Municipality Waste Management in 2015** assigned the responsibility for garbage and solid waste management to the municipality, town, and district administrations, and identified the necessary measures to increase effectiveness and safety in the management of garbage, including through increased public awareness and people's participation. The sub-decree provides clear roles and responsibilities of the ministries, institutions, specialised units, sub-national administrations, and relevant stakeholders involving garbage and solid waste management in residential areas, services, or commercial activities (not contain toxic substances or hazardous waste) in urban areas. Additionally, urban gated community (i.e., Borey or residential development) is also required to design spaces for general waste management. For example, pursuant to the **Sub-decree on Borey Management, 2011**, Borey owners are required to keep and mark public space to maintain the beauty, public order, and solid waste storage in their plan. The **Waste Management Strategy and Action Plan of Phnom Penh 2018-2035 (2018)** intends to provide guidelines for local administration on promoting recycling practices, optimizing waste collection services, and design of waste disposal infrastructure and facilities. Additionally, **Phnom Penh Sustainable City Strategic Plan 2018 – 2030** highlights strategic interventions to address urban solid waste management underlying four objectives, which include (1) to expand quality solid waste management collection services (2) reduce organic waste going to the landfill or incinerator (3) enable waste separation recycling by households, markets, and commercial enterprises, and (4) implement the 4R principle (reduce, reuse, repair, recycle).

In 2015, **the Ministry of Interior and Ministry of Environment joint Inter-Ministerial Declaration/Prakas on Waste and Solid Waste Management in Province/Municipalities of Cambodia** to decentralised waste management roles and responsibilities to sub-national authority. Thus, local authorities' interventions are to (1) locate waste containers in suitable scenery and clean Environment (2) install the prohibition sign and educate on the storage and (solid) waste disposal, (3) assign and arrange temporary appropriate solid waste storage areas, (4) collect, clean and transport (solid) waste to disposed areas, (5) educate and disseminate knowledge to all citizens on the storage of waste disposal through hygienic and safe environmental methods.

The **Sub-Decree on Solid Waste Management (1999**) regulates solid waste management through requirements for proper technical management and safe handling in order to ensure the protection of human health and the conservation of biodiversity. It applies to all activities related to disposal, storage, collection, transport, recycling, dumping of garbage and hazardous waste. Household waste is the part of solid waste that does not contain toxic or hazardous substances and is discarded from dwellings, public buildings, factory, market, hotel, business building, restaurant, transport facilities, recreation site, etc. Construction waste was treated as the hazardous waste, and refers to radioactive substances, explosive substances, toxic substances, inflammable substances, pathogenic substances, irritating substances, corrosive substances, oxidising substances, or other chemical substances which may cause the danger to human (health) and animal or damage plants, public property and the environment. Furthermore, e-waste disposal is triggered under an alternative sub-decree on **E-waste and Electronic Equipment (2016)**, which is a mandate of the Ministry of Environment, and this type of waste is strictly banned in landfill sites.

Furthermore, **Sub-decree no. 168 on the Management of Plastic Bags (2017)** intends to deal with plastic waste management. It aims to define roles and improve responsibilities of concerned ministries, institutions, NGOs, and sub-national administrations to increase the effectiveness of plastic reduction on importation, production, distribution, and the use of plastic bags in order to

improve the public health, environment and landscapes. This sub-decree also encourages the private sector, residents, and building/project owners to reduce and recycle single-use plastic bags. **The Proclamation on Hygiene in Construction Sites and Proclamation on Construction Material Storage**, **Waste and Good Environment of the Construction Site,** determine the project owner's responsibility on labour law, hygiene, and safety of the workers. This includes the requirement of setting up toilets, bathroom, and water properly for the workers while managing solid waste and wastewater storage and discharge in the appropriate manner.

5.2.8. Wastewater management

The existing wastewater infrastructure in Cambodia's urban spaces are not responsive to current dynamic urbanization and climate change intensity. Over one million cubic meters of urban wastewater effluent have been discharged every day in Phnom Penh from households and over 3,000 small enterprises. Its compositions contain more than 200 tonnes of faeces, nearly 2,500 m^3 of urine and just over 8,000 m^3 of greywater.[59] However, drainage and sewage systems are insufficiently corresponding to contemporary wastewater generation in Phnom Penh besides urban natural wetlands and waterways are also being in-filled by construction projects reducing natural filtration and drainage. This is the consequence of conventional sewer systems, which have been inhabited from the colonial period while the amount of urban wastewater increasingly discharged due to population growth and industrial growth. Beside limited capacity of urban drainage and sewerage systems, climate change has intensified the demand of urban stormwater managements, particularly during heavy downpours. Furthermore, wastewater treatment facilities have not been yet adequately developed. For instance, only 9% of total urban wastewater effluent are treated before discharging into natural water environment in 2017.[60] As a result, urban floods are often emerged combining with wastewaters and remains posing critical challenges for Cambodia's contemporary urban development.

Associating to these issues, green building design could be an alternative approach to contribute to minimizing urban wastewater effluent and enhance behaviours toward sustainable water resource efficiency practices. Green building interventions introduce wastewater recycling and rainwater harvesting and capturing, which is beneficial to reducing urban runoff, as well as minimizing pressures on sewerage systems. Therefore, enhancing associated policies and legislation on urban wastewater management in buildings could be effective in reducing floods and reducing water pollution. The RGC has progressively adopted relevant regulations and policies to address urban wastewater management, as shown in **Box 8**. The following section will explore existing related regulatory interventions in building design contribute to reduce urban wastewater effluent in Cambodia.

[59] See Buth (2019), https://www.pic.org.kh/images/2019Research/20191014_Overview%20of%20Wastewater%20Management%20in%20Phnom%20Penh%20City.pdf
[60] See Buth (2019). As above.

Box 8. Relevant legislations and planning policies on wastewater management.

- Sub-decree on Drainage and Wastewater Treatment System (2017)
- Sub-decree on Water Pollution Control (1999)
- Sub-decree on Gated Community (Borey) Management (2011)
- Sub-decree on Building Permit (1997)

The **Sub-decree on the Management of Drainage and Wastewater Treatment System (2017)** is aimed to improve the management of drainage and wastewater treatment system in municipalities, provinces, districts, communes and resorts or recreation centres. This sub-decree encourages urban wastewater management efficiency, transparency, and accountability to ensure safety, public health, and enhanced biodiversity conservation. It also sets out the wastewater standard for Business Building, Residential Building, Satellite City and Resorts or Recreational Centre to the sewage system and the public waterbody system. The sub-decree also determines different wastewater parameters and standards for discharging wastewater from different types of buildings. For example, the Wastewater Discharge Standard from Business Building, Residential Building, Satellite City and Resorts or Recreational Centre to the Sewage System linked to Centralised Wastewater Treatment Plant are presented in **Table 3**.

Table 3. Parameters and standard of discharged wastewater to treatment plant[61]

No	Parameters	Unit	Permissible Standard Pollutant Level allows for discharging into the Sewage System
1	pH		5 - 9
2	Total Suspended Solid (TSS)	mg/l	< 150
3	Oil or Grease	mg/l	< 20
4	BOD5 (5 days at 20 0C)	mg/l	< 80
5	COD (Cr2O72-)	mg/l	< 120
6	Detergents -LAS	mg/l	< 15
7	Total Nitrate (T-N)	Mg-N/l	< 10
8	Total Phosphor (T-P)	Mg-P/l	< 1
9	Ammonia (NH3)	mg/l	< 8

This sub-decree differentiates pollutant levels and standards of releasing wastewater from buildings to open urban waster environment and treatment. In this regard, pollution standards for discharging to a treatment plant are relatively higher compared with discharged standards to an existing waterbody, as shown in **Table 4**. Additionally, the **Sub-Decree on Water Pollution Control (1999)** focuses on the routine monitoring of water quality at public water areas and effluent discharged from industrial and other pollution sectors. This sub-decree provides that properly treated wastewater is based on the effluent standards. If the wastewater is discharged into public water areas without treatment, the Ministry of Environment shall fine the person(s) who violates the legal instruments. Furthermore, the owner or manager of factories must ask for permission to discharge treated wastewater. However, regular monitoring processes on wastewater

[61] See Sub-degree on Water Pollution Control (1999).

discharged standards from building remains poor due to inadequate technological equipment, regulation enforcements, and expertise. Consequently, the administration of urban wastewater effluent standards from buildings, and from non-point sources, has led to difficulties in controlling and documenting pollution levels.

Table 4. Parameters and standards of discharged wastewater to urban water environment or sewerage systems.

No	Parameters	Unit	Permissible Standard Pollutant Level allows for discharging into the Sewage System
1	pH		6 - 8
2	Total Suspended Solid (TSS)	mg/l	< 80
3	Oil or Grease	mg/l	< 5
4	BOD5 (5 days at 20 0C)	mg/l	< 30
5	COD (Cr2O72-)	mg/l	< 50
6	Detergents -LAS	mg/l	< 7
7	Total Nitrate (T-N)	Mg-N/l	< 6
8	Total Phosphor (T-P)	Mg-P/l	< 0.5
9	Ammonia (NH3)	mg/l	< 5
10	Coliform	MPN/100 ml	500 - 2500

To improve urban wastewater management in building, the RGC also set out other regulations to enhance wastewater management at planning stage of building construction. To illustrate, the **Sub-decree on Borey Management (2011)** requires design of public sewage connection points for the disposal of dirty water, toilet reservoir location, dirty water treatment location, solid waste storage, flowing water system, and clean water system. Moreover, the **Sub-decree on Building Permit (1997)** establishes requirements for the distribution of drinkable water and sewer systems. In the absence of a sewer system, building owners shall make provisions to treat and evacuate sewage water through a septic tank and a sub-terrain filtering system. In urban areas, building owners shall make provisions to connect their septic tank to the sewer system. The height of the septic tank shall not be less than 1.5 m and must be appropriately ventilated. Under no circumstances may rain waters penetrate the septic tank. A construction permit shall be denied if it does not present sufficient assurance of the projected construction's hygiene and health.

Despite poor urban drainage and sewerage systems, some regulations have been adopted to address contemporary urban wastewater management in Cambodia, through building design and planning. These regulations enable opportunities for intervening green building practices to handle urban wastewater management. The green building implementation in Cambodia should mainstream legal standards and requirements of wastewater effluent and integrated water management into building design and planning.

5.2.9. Air quality in buildings

In 2003, Work Bank's report provided that urban air pollution has posed concern to Cambodian residents' public health, particularly PM10, though the problems related air pollution remained not critical due to light industrial development and relative fewer number of urban vehicles.[62] However, rapid contemporary urban development may have introduced a significant risk of urban

[62] See Dasgupta et al. (2003). https://documents1.worldbank.org/curated/en/992931468769884286/pdf/multio page.pdf

air pollution to public health, and new scientific studies are required to investigate on PM10 and PM2.5. For example, the Health Effect Institute highlighted that Cambodia's urban areas experienced average PM2.5 concentration over 15 ppb in 2017, while WHO's determine air quality standard for this parameter just below 10 ppb.[63] Furthermore, knowledge of indoor air quality in urban built environment remains limited in Cambodia, particularly its associated impacts on human health. A study suggests that the design of indoor ventilation in Cambodia's urban built form inadequately absorb less than 20% of indoor air pollution though the same study acknowledges that ventilation is effective and appropriate for Cambodia's households.[64]

The regulatory approach to address indoor air quality also remains limited in Cambodia. However, the Ministry of Environment is considering amending a sub-decree on **Air Pollution and Noise Disturbance Control (2000)** (see **Box 9**) to manage and provide indoor air quality (being drafted).

Box 9. Relevant legislations and planning policies on indoor air quality.

- Sub-decree on Air Pollution and Noise Disturbance Control (2000)

The RGC intends to promote good air quality management in every aspect for residential and office buildings with a start of issuing associating proclaims on air pollution in Cambodia. Improved indoor air quality (IAQ) is one of the critical components of green building design, and when we consider air quality in buildings, we need to increase the number of days of good or medium air quality in the Poison Standard Index (PSI) or IAQ based on PM 10 and/or M 2.5 measurement. To avoid and reduce toxic air in residential and office buildings, a few options have been identified. Several plants need to be in place indoors to absorb pollutants in the air and toxic infiltration depending on the size and space of the buildings, and natural ventilation is relied upon to bring outdoor air into the buildings through windows and doors.

5.2.10. Sustainable cities

Within the last two decades, Cambodian experienced a rapid growth of urban population – 24.23% of Cambodia's resident lives in urban areas in 2020[65] - and urban areas accounts for around half of Cambodia's economy while urban spatial expansion rate averages 4.3% a year. For example, Phnom Penh absorbs 12% of nation's urban population, and it is projected to reach 36.3% in 2030. Even though urban growth generates economic opportunities, innovation, and jobs creation, unstructured urbanisation can lead to socio-economic and environmental challenges, including urban sprawl, insufficient provision of basic services and infrastructure (e.g., housing, transport, energy, water supply and sanitation), traffic congestion, pollution, unemployment, and social inequality. Contemporary urban growth in Phnom Penh has encountered critical challenges, such as environment degradation, green space minimization, greenhouse gas emissions, unsustainable waste management, chronic urban flooding, and public health concerns.[66]

[63] See Health Effects Institute (2018). https://www.stateofglobalair.org/report
[64] See Shimizu & Takaguchi (2018).
[65] See World Bank. Retrieved on October 13, 2021 from https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2020&locations=KH&start=1960
[66] JICA (2015)

On the other hand, pathways towards sustainable urban management in Cambodia have been dramatically drawn to the attention of planners, policy makers, and academic institutions. The RGC demonstrates its commitment to encourage urban sustainability practices through various planning policies and legislation (see **Box 10**). Importantly, the National Council for Sustainable Development (NCSD) plays a significant role to enhance the sustainability of cities through policy development and mainstreaming the sustainability concepts into urban planning and legislation.

Box 10. Relevant legislations and planning policies on sustainable cities

- Draft Environment and Natural Resource Code
- Cambodia's Sustainable Development Goals 2016-2030 (2018)
- National Green Growth Policy and Strategic Plan (2013-2030)
- The Phnom Penh Sustainable City Plan 2018-2030
- Green City Strategic Plan Methodology (2018)
- Sustainable City Development Strategy 2020 – 2030 for 7 Secondary Cities (2021)
- Municipal Masterplan for Land-Use of 2035
- Transport Master Plan
- Drainage and Sewerage Master Plan

A draft **Environment and Natural Resource Code**, initiated by the Ministry of Environment and the NCSD, strengthens the integration of sustainable city concepts and practices into various planning policies and legal frameworks. The **National Green Growth Policy and Strategic Plan (2013-2030)** aims at enhancing the wellbeing and livelihood of all people in harmonization with ecological safety through green growth, basing on green economy, blue economy, environment protection, social safety nets system, and uphold of national cultural identity.[67] Green growth perspectives essentially contribute to framing Cambodian sustainable urban development program, generating outputs of various strategies including, **the Phnom Penh Sustainable City Strategic Plan 2018-2030, Green City Strategic Plan Methodology (2016),** and the **Sustainable City Strategic Plan for Seven Secondary Cities (2020-2030).** For instance, these strategic documents have supported Phnom Penh Capital Administration to achieve strategic goals set out within **Municipal Masterplan for Land-Use of 2035, Transport Master Plan, and Drainage and Sewerage Master Plan**[68], which intends to address contemporary urban land use challenges, reduce traffic congestion, and improve urban wastewater and flood management.

The **Phnom Penh Sustainable City Strategic Plan 2018-2030** provides key policy directions for eight components of green city planning themes: urban planning, urban vulnerability, energy, transport, built environment, manufacturing, solid waste management, and public spaces and cultural heritage. This strategy also encourages resilience to climate change and promotes low-carbon forms of city development that provide social development opportunities and ensure environmental quality. Furthermore, it supports the introduction of solar PV for households and commercial buildings, and the underlying concept of green building standards that will help ensure the development of sustainable energy demand in urban areas.

[67] See NCSD, MOE, PPCA & GGGI (2018).
[68] See NCSD, MOE, PPCA & GGGI (2018).

Conceptual alignment of sustainable city development policies and strategies provides opportunities for green building design practices. It is argued that urban sustainability transition is enhanced by improvement of technological facilities, sustainable construction materials, and resource efficiency.[69] For example, low carbon development could be achieved through the reduction of indoor energy and water consumption though sustainable design of green buildings. This will contribute to climate change mitigation and encourage the recirculation of urban resources in the urban economy. In this regard, Cambodia's existing sustainable or green urban development policies are introducing the need of green building design and certification.

5.2.11. Other legal documents toward green buildings

Indoor fire warning systems in Cambodia's urban areas remain quite conventional, which requires urgent action to improve and modernise. Particularly, indoor fire hazards and safety standards are critical to integrate into building design to ensure effective fire resistance and emergency response. Green building construction requires appropriate design, which modernises fire safety and evacuation in buildings. In this regard, the RGC released a law on **Fire Protection and Fire Fighting** in 2013. This law aims to promote prevention and firefighting and protect life, property, environment, social security, public order, and social safety. It also determines residents' responsibility and the conditions of fire and measures to prevent and extinguish fires. For example, Article 18 provides that every town should have a plan to keep a unit of fire prevention police and firefighters. All construction projects must have a prevention and firefighting system plan before construction starts. The sub-decree establishes construction categories and the locations required to have prevention and firefighting system plans, as requested by the Minister of Interior and Minister of Land Management, Urban Planning, and Construction. Moreover, Article 19 also prescribes inspection and certification requirements on quality and the effectiveness of prevention and firefighting systems, and certification is made for two years. If necessary, the owner of the location can request a review before the expiration of the certificate. The form and procedure of inspection, qualification certificate, the effectiveness of prevention and firefighting system are determined by Prakas (Declaration) of Minister of Interior.

6. Strategic interventions and Analytical options for green building in Cambodia

This section introduces a strategic approach of incorporating green building concepts into Cambodia's development context. It highlights green building benefits that contribute to Cambodia's sustainable development goals and strategic goals of sustainable development. Furthermore, this section discusses local priority sectors, including challenges and opportunities, which allow green building interventions to significantly contribute to improving local sustainable development goals.

[69] See Affolderbach, J. & Schulz, C. (2018).

6.1. Green buildings as pathway to sustainability

6.1.1. Toward sustainable development

The World Bank's estimation provided that over half of total global population (56.15% by 2020[70]) have settled in urban areas, and this number is projected to increase to 68% by 2050.[71] However, the global urban landmass and natural resources are very limited to accommodate such a large population. This matter has posed critical challenges for achieving sustainable settlement and urban land use planning. In this regard, the sustainable design of building construction could play significant role and green building design needs to be increasingly activated within urban areas. Successful practices of green buildings essentially contribute to increased urban density, with a good living standard and the improvement of lifestyles. Furthermore, this concept will enlarge the ability of urban space to accommodate a rapid growth of future populations, while addressing the risks of climate change, such as flood, storms, and urban heat island effects.

It is argued that green building initiatives intend to provide back more than it takes from the existing natural resources in urban neighbourhoods, and contributes to maintain and preserve nature and promote the public health of humanity.[72] Green building concepts are an obvious pathway to help achieving sustainable development through the alignment of the three spheres of sustainability. It is worth noting that, from Cambodian perspectives, the societal dimension of sustainable development vitally includes cultural values leading the significant consideration of culture integrated into planning policies as well as presented as in Cambodia's national commitments to international agreements. Therefore, it is critical that design of green buildings ensure the recognition of local culture and respect the existing Khmer traditional built environment characters. Architects and design firms need to incorporate Khmer architectural concepts into their planning, while modernizing build structure that promote new perspectives of sustainability and resource-efficient built environment.

[70] See World Bank (2018). https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS
[71] See United Nation (2018). https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
[72] See Henderson, H. (2012).

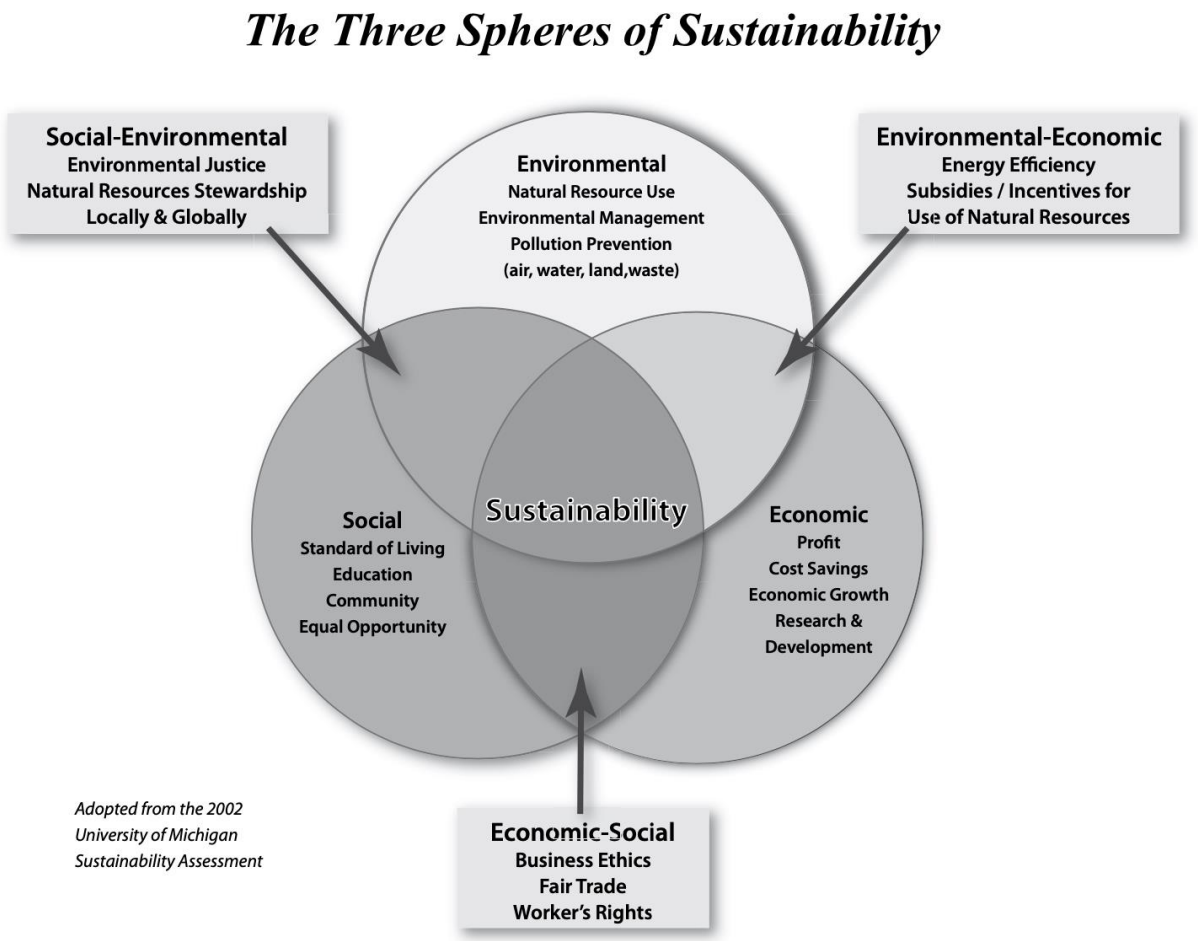


Figure 4. Green building practices toward sustainability.[7]

As shown in **Figure 4**, green building practices integrate the concept of sustainability into all phases of building's life cycle, from construction, demolition, renovation and occupation. Green building professionals – planners, engineers, architects, and designers – consider the benefits for building structures and construction that reflect on three areas, profits, people and the planet. For example, the consideration of environmental-economic factors in building sectors will encourage energy efficiency in buildings and involve government initiatives on subsidises and incentives for environmentally friendly natural resource consumption in building sectors. In the societal aspects, green buildings contribute to improved standards of living, community health, and promotion of indoor comforts. This concept could potentially generate economic profit through the cost saving of building lifestyle, energy and water savings through natural ventilation maximization, stormwater harvesting, and waste recycling (i.e., circular economy).

6.1.2. Alignment and contribution to the Sustainable Development Goals (SDGs)

The SDGs were adopted to enhance practices of decoupling economic growth from environmental degradation, climate change, social inequality, and poverty. The implementation of green building concepts may contribute to achievement of these goals throughout diverse approaches. To illustrate, this notion provides opportunities for practicing energy and water savings, carbon emission reduction, nature literacy, job creation, community resilience, and health and wellbeing promotion. These benefits are directly and indirectly contributing to improved urban livelihood through built design and planning. The following sections discuss the alignment of green building practices with the intended goals of SDGs in both global and local contexts (see **Table 5**).

Table 5. Green building contribution to SDGs

Indended goals	Alignment descriptions
	Green building life cycle will contribute to the goal of eliminating extreme poverty or reduce at least half of population in poverty, as reflected in SDG-1 on 'No Poverty' through reducing costs. The building's economic viability is generally associated with cost-efficient operation and solutions in terms of production and exploitation cost as well as building functionality.
	Green building concepts promote the improvement of public health and wellbeing underlying various interventions, such as improvement in the construction process, strengthening resilience of local environments, increased transport access, and provision of indoor air quality and fire safety. It will contribute to reduced mortality and illnesses due to non-communicable diseases (i.e., illnesses base indoor pollution and mental illness), accidents during construction, and reduced air and water contamination.
	Green building practices will increase social communication between users and the community. The communication during planning and design process will value building occupants' responsibility on decision making and minimise conflict of interests while encouraging the community to be involved in environmental education and planning. This process contributes to promoting community knowledge associated with sustainable built environment through informal systems and participation.
	Environmentally friendly practices during construction process are an essential component of green building interventions. This will routinely reduce environmental and social impacts on the site during the construction by taking water quality and wastewater on site into account.
	Energy efficiency and renewable energy practices for buildings are promoted throughout different interventions in green buildings, including facility management, building visual comfort, and building envelope.[73] For example, building design may maximise spaces for solar energy and good indoor ventilation reduce energy for air-conditioning. This will further reduce carbon emission through reducing fuel combustion in energy sector.
	The concept of construction, operation, and renovation of life cycle of a green buildings will importantly provide positive impacts on inclusive employment and encourage skilful employees in green building design and construction as well as in implementation of the rating system. The adoption of 'flexibility and adaptability' in the intervention of green building concepts importantly improves resource efficiency for consumption and production, while 'design for all' approaches acknowledge social equity, particularly people with disability and women, to fully access building that enlarges economic potential through inclusive involvement.

[73] Building envelope is defined that the enclosure of the building that protects the building's interior from outside elements, namely the exterior walls, roof, and soffit areas (Kubba, 2021).

	The intervention of green buildings enables the design of buildings that ensure climate resilience and adaptability. Therefore, sustainable, and resilient infrastructure concepts will be mainstreamed into transport and amenity access in green building design. The innovation essentially contributes to promoting clean and environmentally friendly materials on building construction and facilities.
	Equal access to public services and facilities remains a challenge in urban contexts. Green building operation and design will contribute to reducing inequality in the community. For instance, green buildings will maximise transport access through inclusive design of buildings and land use, which ensure that spaces are allocated with the recognition and acknowledgement of the poor, people with disability, women, aging people, and young children.
	Buildings are the foundations of cities, therefore the construction of green or sustainable buildings will importantly contribute to transform cities to become more sustainable, which could accommodate future urban population growth with a high quality of life. Green building design helps enlarge urban green spaces, increase community resilience and disaster risk reduction, improve energy efficiency, reduce urban emissions, and maintain a good quality of urban outdoor air quality. In Cambodia, green building interventions will critically help to manage urban waste generation and regulate urban runoff through sustainable rainwater harvesting and water retention.
	The circular economy supports the application of sustainability principles into consumption practices, for example, in green building design. Buildings have critical roles in facilitating and preventing waste generations via 3Rs initiatives (reduction, reuse, and recycling). The engagement from building users will enhance the transformation of domestic waste as a resource leading to reduced waste disposal in landfill and promote sustainable consumption and production.
	Over 40 percent of global carbon emissions are contributed by buildings, thus promoting green building practices will vitally contribute to combatting climate change. For instance, the improvement of energy efficiency in buildings and reduction of domestic waste generation will halve greenhouse gas emissions. Furthermore, green building design can improve building resilience to climate disasters. For example, installing green walls/roofing and planting trees surrounding the building can reduce the impact of urban heat island effects and flooding through impermeable surfaces.
	Green building certification tools acknowledge the needs of reducing water and timber consumption. Building spaces are allocated for natural vegetations and building construction and need to prioritise the protection of existing trees and natural wetlands. Urban biodiversity and natural habitats are promoted through sustainable building design by ensure that the buildings are well suited in the existing urban ecosystem and natural landscape.

6.2. Strategic interventions

Section 2 and 5 introduce various challenges and policy challenges in Cambodia to enhance practices of green building. Consequently, these challenges should be effectively addressed by a strategic approach, which directly reflect and fill those gaps. This section discusses strategic interventions of green building concepts and operations. Four main aspects are discussed, which

may appropriately fill the contemporary gaps as discussed in the above sections. These components include [1] planning policies and regulations, [2] institutional arrangement and operation, [3] green building and sustainable construction literacy, and [4] desires for a low carbon development society (see **Figure 5**), which envisage green building design practices in Cambodia toward the achievement of urban sustainability transitions.

Figure 5. Key components of strategic intervention towards green building transitions

6.2.1. Planning policies and regulations

Having discussed in **Section 2 and 5**, it was understood that the contemporary challenges of sustainable construction in Cambodia are leading to barriers of green building intervention due to lack of certain planning policies and regulations across a range of sectors. Therefore, it is desirable to establish specific regulation to frame the concept of green buildings for implementation in built environment sector (see **Figure 6**). The subsequent section will discuss the prospects of different sectors on which planning policies and regulations should focus, due to their vitality in contributing to green building practices. This section also embeds strengths and opportunities for each sector, while highlighting their functionality to accelerate green building transitions in Cambodia.

Figure 6. Cross-cutting sectors to be considered for planning policies and regulation formulation.

a) Climate and energy

Green building interventions enlarge capability of the built environment to combat climate change. Potential benefits are to reduce greenhouse gas emission through the replacement of conventional built designs by adopting modernised structures, technological equipment, sustainable construction materials and end-of-life recycling, and integrated green infrastructure.[74] Having improved these key components, energy consumption may be significantly reduced due to the promotion of energy efficiency, which respectively minimises emission sources of energy generation. For example, new green building design structures can maximise natural sunlight permeability and ventilation to improve indoor environmental quality without extra energy consumption. Additionally, sustainable construction material selection contributes to reduced maintenance and operation costs through the longer life cycles of buildings.

Alternative energy sources can be potentially generated and provide satisfactory demands due to geographical location of Cambodian region. Horizontal irradiation in Cambodia provides great opportunities for generating renewable and clean energy, and sunlight coverage predominantly appears on key urban areas (see **Figure 7**). Therefore, green building design could manipulate the benefits of solar power and radiation through adaptation of new perspectives of building structures, which allocate space for solar panels and permeable natural lights in buildings. Furthermore, due to rapid growth of building construction material demands in Cambodian urban development, technological transfers of energy efficient equipment for buildings could be prioritised and enhanced to fast track the energy efficiency transition in the built environment sector. For instance,

[74] See Huynh (2021). https://www.usgbc.org/articles/how-green-buildings-can-help-fight-climate-change

conventional lighting might be importantly replaced by LED lighting lamps. These interventions essentially enhance the urban built environment and largely reduce demand of energy consumption, supplied by the national grid, and significantly minimise urban emissions, which subsequently contribute to mitigating climate change.

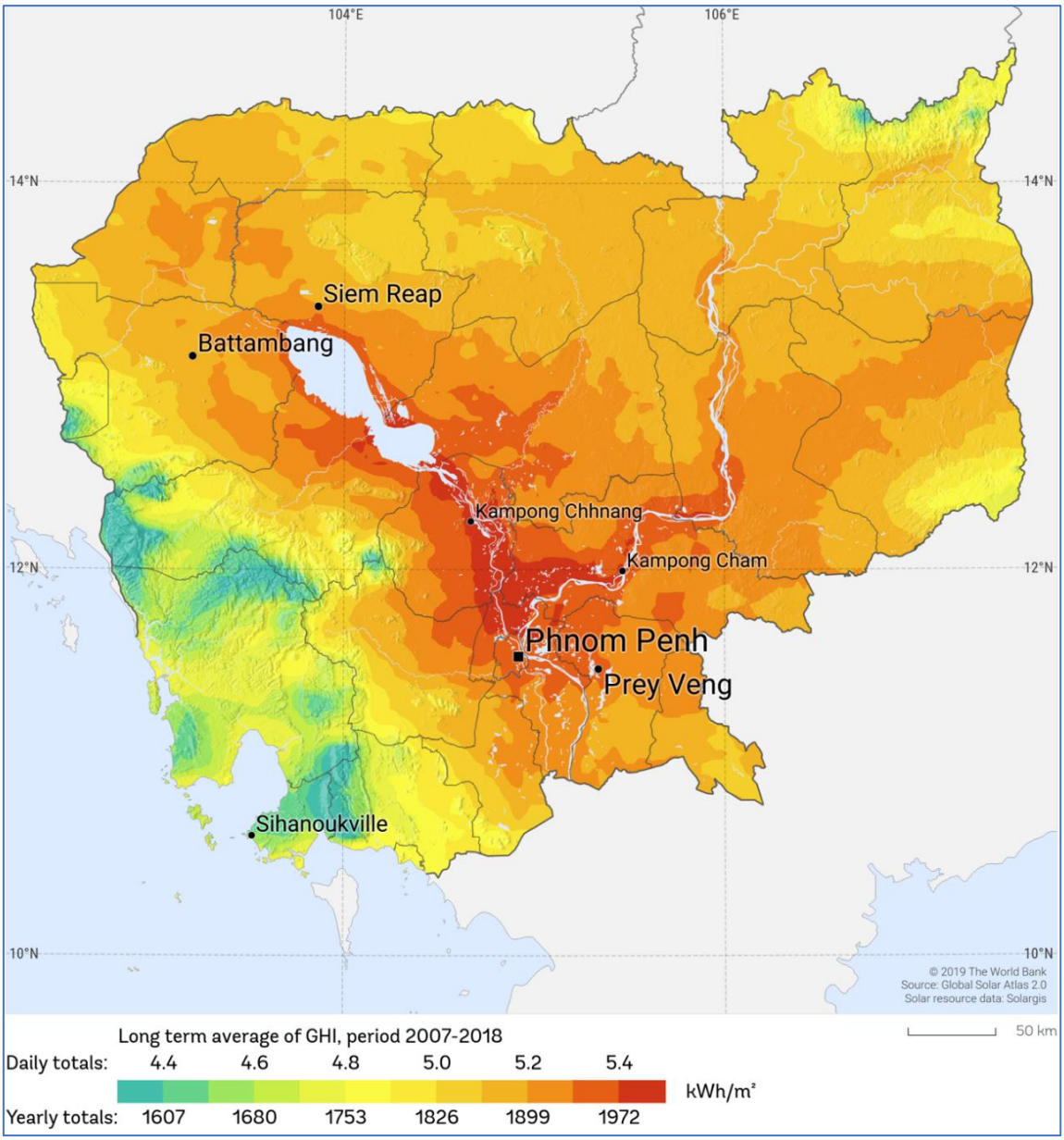


Figure 7. Global horizontal irradiation, Cambodia. Note: Map is published by the World Bank Group, funded by ESMAP and prepared by Solargis.[75]

b) Water consumption

Cambodia's region is influenced by tropical monsoon climates, which introduce high humidity in the atmosphere. It is argued that water security in Cambodia has been experiencing, is the result of too much rain in the rainy season and too little rain in dry season.[76] Cambodia is vulnerable to floods because of its urban geographical landscape in relatively lower flat areas, climate change intensity, and poor urban drainage and sewerage systems. Furthermore, urban water supply tends

[75] See Global Solar Atlas (2019). https://globalsolaratlas.info/download/cambodia
[76] See Mak, S. (2020). https://www.researchgate.net/publication/350063255_Water_Security_in_Cambodia_Between_Too-Much_and_Too-Little

to experience water shortages in dry season, particularly in peri-urban areas. These contemporary urban water management challenges urgently need effective interventions to change the attitudes and perspectives of associated policy makers, planners, and urban residents, toward new perspectives of resource-efficient and resilience practices. In this regards, green building implementation could have a significant role in transforming people's behaviours and ways of thinking to conform to sustainability concepts.

Water consumption conservation is one of primary goals of green building transitions, and involves occupants' behavioural changes, resource-efficient technological transfers in buildings, and architectural design of building structures. Multiple approaches of green building interventions toward sustainable water consumption are highlighted by researchers that, "Water conservation during the whole life span of a building can be achieved by designing dual plumbing that recycles the water used in water closets and the water used to wash cars, using water efficient fittings and fixtures such as ultra-low flushing toilets, bidets and low flow shower heads. Other technologies such as rainwater harvesting and recycling and reuse of grey water, etc. are also being used."[77] For example, construction materials such as plastic piping (i.e., High Density Polyethylene – HDPE)[78] could be used for plumbing system in building construction. This specific pipe prevents biological or chemical constituent being carried from adhering to the pipe. Plenty of advantages are obtained, including maintaining flow characteristics throughout their long life, preventing deterioration of inner surfaces, stabilizing energy costs for pumping, and providing water leakage zero.

In addition to water conservation measures through green building interventions, sustainable urban flood management are also positive outcomes of green building design. This solution particularly contributes to addressing Cambodia's contemporary urban flooding. For example, green building design allows natural drainage on sidewalks and self-infiltration roads in residential areas, permeable spaces (green areas) for draining urban runoff during rainy season, green rooftops and small indoor spaces for rainwater capturing and draining, and rainwater collection spaces between residential areas for irrigation[79] (see **Box 11**).

[77] See Das et al. (2015). https://www.researchgate.net/publication/310611986_WATER_CONSERVATION_ASPECTS_OF_GREEN_BUILDINGS
[78] See Green Building Solutions. https://www.greenbuildingsolutions.org/blog/water-efficiency/
[79] See Giang,. N.V. & Dat, N.T. (2020). https://iopscience.iop.org/article/10.1088/1757-899X/869/7/072001/pdf

Box 11. Green building design approaches contribute to addressing urban flood issues

The establishment of building which allows green spaces for draining rainwater during rainy seasons

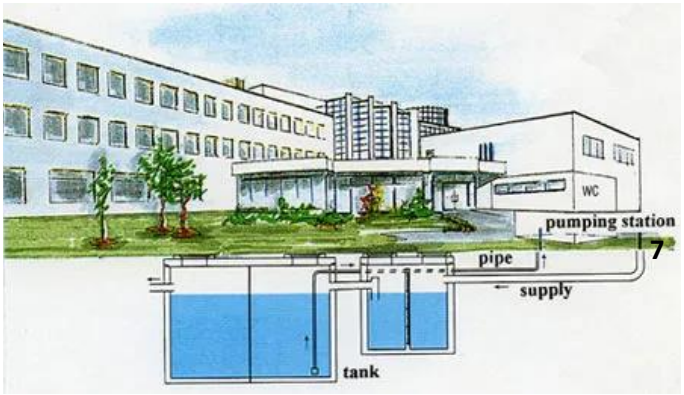
(1) Ditch drains next to the houses, creating a direct rainwater drainage from the roof to the infiltration area on the side of the house. (2) Planting boxes, helping drain rainwater from sidewalks, parking lots and on the street. (3) Green roof, designing green roof covered with growth vegetation allows for an amount of rainwater to enter and evaporation of stored water. (4) Self-absorbing pavement or sidewalk, introducing permeable road surfaces pace with materials that allow rainwater to be temporarily stored in the ground by natural blotting.

Introduction of small indoor scenes combined with partially draining rainwater from the roof

Integrating small green landscapes into building design, which contribute to building beauty and releasing building users stresses and tensions while draining and capturing rainwaters.

(5) A small scene in front of the house, and (6) a small natural landscape integrated into the bathroom.

Green building design allow spaces for collecting rainwater between buildings in residential zones for irrigation and other uses



Urban runoff is collected between buildings through pipelines into the rainwater harvesting tanks. This approach contributes to regulating stormwater and reducing cost of water consumption for irrigating, washing, cleaning, and other uses.

(7) Green building solutions for rainwater harvesting.

c) Resource efficiency

Resource efficiency in this section mainly discusses green building perception and performance to reduce solid waste generation from buildings during their use and construction. Having considered green building concepts being mainstreamed into green building construction, architectural designers and engineers could operate together to generate opportunities in reducing the usage of

construction materials, efficient consumption of energy, water and materials, and promoting domestic solid waste prevention through circular practices and the 3Rs.[80] For example, through the intervention of green building concepts for construction and demolition process, Australia's cities could reduce construction waste up to 40% dumped in landfill[81] through the reconsideration of recycling and reusing material, such as steel, aluminium, gybsum plasterboard, timber, concrete, glasses, bricks, and plastics. Moreover, green building design allows building space to be dedicated to waste management storage, including sorting and composting (see **Figure 8**).

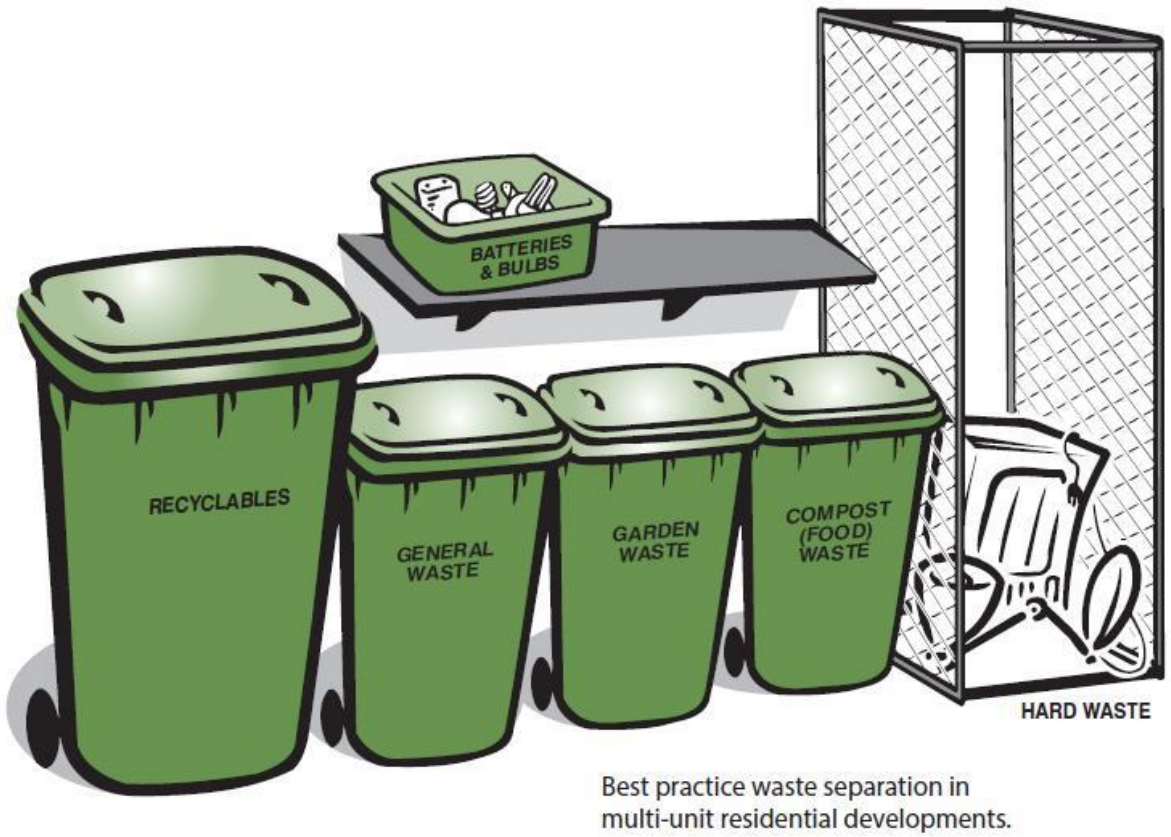


Figure 8. Best practice waste separation in multi-unit residential development[82].

This solution on urban waste management through the practices of green building design enables the achievement of domestic waste generation prevention and reduction. The RGC has adopted different regulations to address unsustainable urban waste management, which enlarge collaboration and partnership enhance operation. Furthermore, integration of green building concepts into domestic management aligns with decentralization of urban waste management, which building users and local authorities have responsibility to manage their own waste.

d) User comfort and satisfaction

Despite the consideration of resource-efficient building design, occupants' comfort and satisfaction should be prioritised in green buildings. Building structures, spaces and decoration, and indoor resources consumption should ensure optimal usage to facilitate the occupant's comfort and individual satisfaction. The Cambodian population has become increasingly knowledgeable

[80] See Akdag, H.C. & Beldek, T. (2017). https://ojs.excelingtech.co.uk/index.php/IJSCM/article/view/1600
[81] See City of Whittlesea. https://www.whittlesea.vic.gov.au/media/1823/sdapp-waste-management-accessbile-pdf.pdf
[82] See City of Whittlesea. https://www.whittlesea.vic.gov.au/media/1823/sdapp-waste-management-accessbile-pdf.pdf

regarding the benefits of good quality of indoor environment, where they are daily occupying. Self-decoration is interestingly appearing in personal residential unit/apartments and offices. These are the consequences of seeking to increase their satisfaction and comfort. However, other factors are also important in contributing to improved user comfort and satisfaction in green buildings, such as thermal comfort, natural and artificial light, acoustic comfort, comfort, and inclusive design comfort.[83]

Green buildings support design for user control of heating, cooling, and humidity to ensure optimal individual comfort in operational buildings, while maintaining energy efficiency with broad consideration of the environment. Sustainable master-planning mitigates community level thermal comfort issues, such as the (Urban) Heat Island effect.

Green buildings support the provision of adequate artificial lighting that is flicker free, meets minimum requirements for lighting colour, has little glare and ideally, has localised lighting controls and is appropriate for space use. All lighting should be energy efficient, for example LED lighting.

Green buildings support the mitigation of steady state noise exposure: this is defined as noise, the level of which does not change by more than 5dB at a given place and during a given time period. Continuous background sound in offices is mostly generated by heating, ventilation, and air conditioning (HVAC) equipment. External noise should be mitigated with building features as far as possible, as openable windows should be optimised for ventilation control and therefore not be relied upon as acoustic control.

Green building concepts support a built environment that incorporates strategies to improve occupant visual, olfactory and ergonomic comfort, whilst actively mitigating wider wellbeing risk to people. Visual comfort and interior design for aesthetics should be designed in accordance with guidance on hazardous chemicals.

Green buildings support inclusive design and must keep the diversity and uniqueness of each individual building occupant in mind, considering all people utilising a built environment, including those with mental and physical disabilities as well as vulnerable and ageing populations. An environment that is designed inclusively must apply to buildings, their surrounding open spaces, and local urban infrastructure and services.

[83] See World Green Building Council. Retrieved on September 12, 2021 from https://worldgbc.org/principle-2-prioritise-comfort-building-users

e) Optimal Cost for green buildings

The comprehension of a business case for green buildings is critical to determine the success of implementation due to its influences of discouragement and encouragement. As a least developed nation, Cambodian residents' incomes are relatively lower compared with neighbour nations, such as Thailand and Vietnam that may slowly transition to green building practices compared to counterpart nations. Increasing construction cost for transitioning to green building could result in resistance to adoption from Cambodian people's perspectives. Therefore, understanding a whole life cycle of green building performance, from construction to operation, is important to explain overall benefits of green buildings compared with conventional buildings. For instance, a study shows that having adopted green building concepts, the construction costs could increase from 12% to 15%, while improving indoor resource-efficiency and reducing building operation costs, such as from consumption of energy, water, and materials, can reduce costs by up to 19.23%, 40 – 60%, and 30 – 50 % respectively.[84] However, the construction and design costs are varied based on certification systems and local contexts, while the actual costs of construction of green buildings are commonly less than estimated cost at planning and design stage (see **Figure 9**).

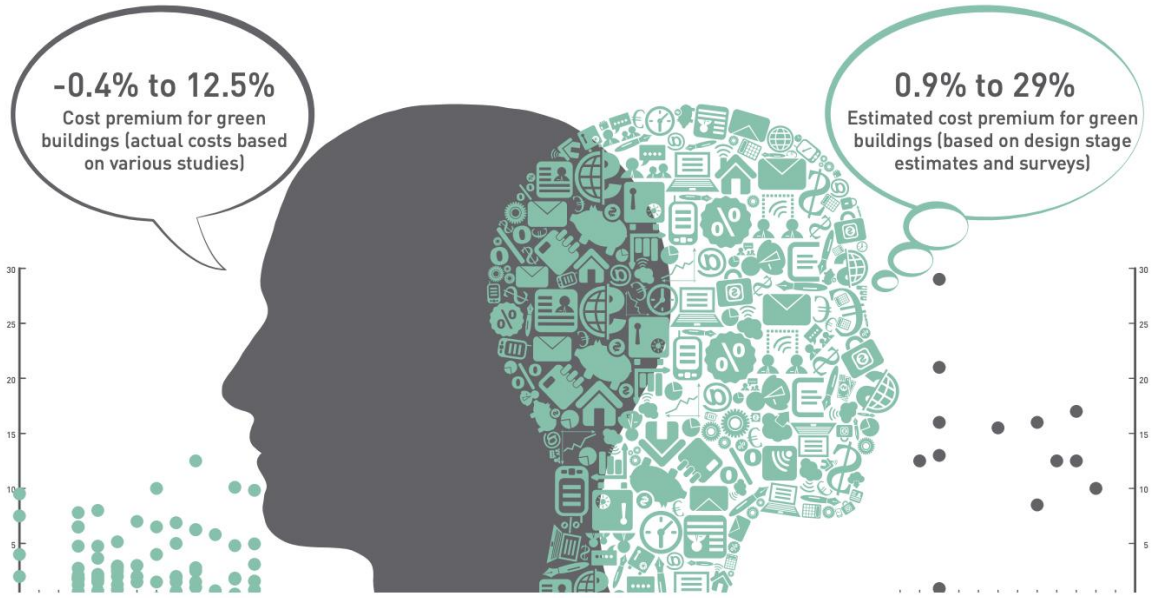


Figure 9. Comparison of green building costs based on actual construction and personal estimation at planning and design stages.[85]

Beside optimum construction costs of green buildings, building value added modernises satisfaction of various stakeholders. For instance, property construction firms could obtain higher sales prices with a quick sale, while occupants enjoy improvement of productivity and wellbeing (See **Figure 10**). Further, value added for green building adoption are found in the long-term benefits. Comparing to conventional building design, green buildings are more resilient, leading low maintenance costs, a high level of recyclable and reusable demolished waste, and low resource consumption costs, while obtaining short-term payback period. Furthermore, application processes of green building certification and rating systems should be proceeded simply with optimal

[84] See Yadav et al. (2018).
[85] See World Green Building Council (2013). https://www.worldgbc.org/news-media/business-case-green-building-review-costs-and-benefits-developers-investors-and-occupants

assessment fees. Simple approaches to certify green buildings could reduce extra cost and times of assessment processes, which facilitates an increase in productivity, people's satisfaction, and green building transition motivations.

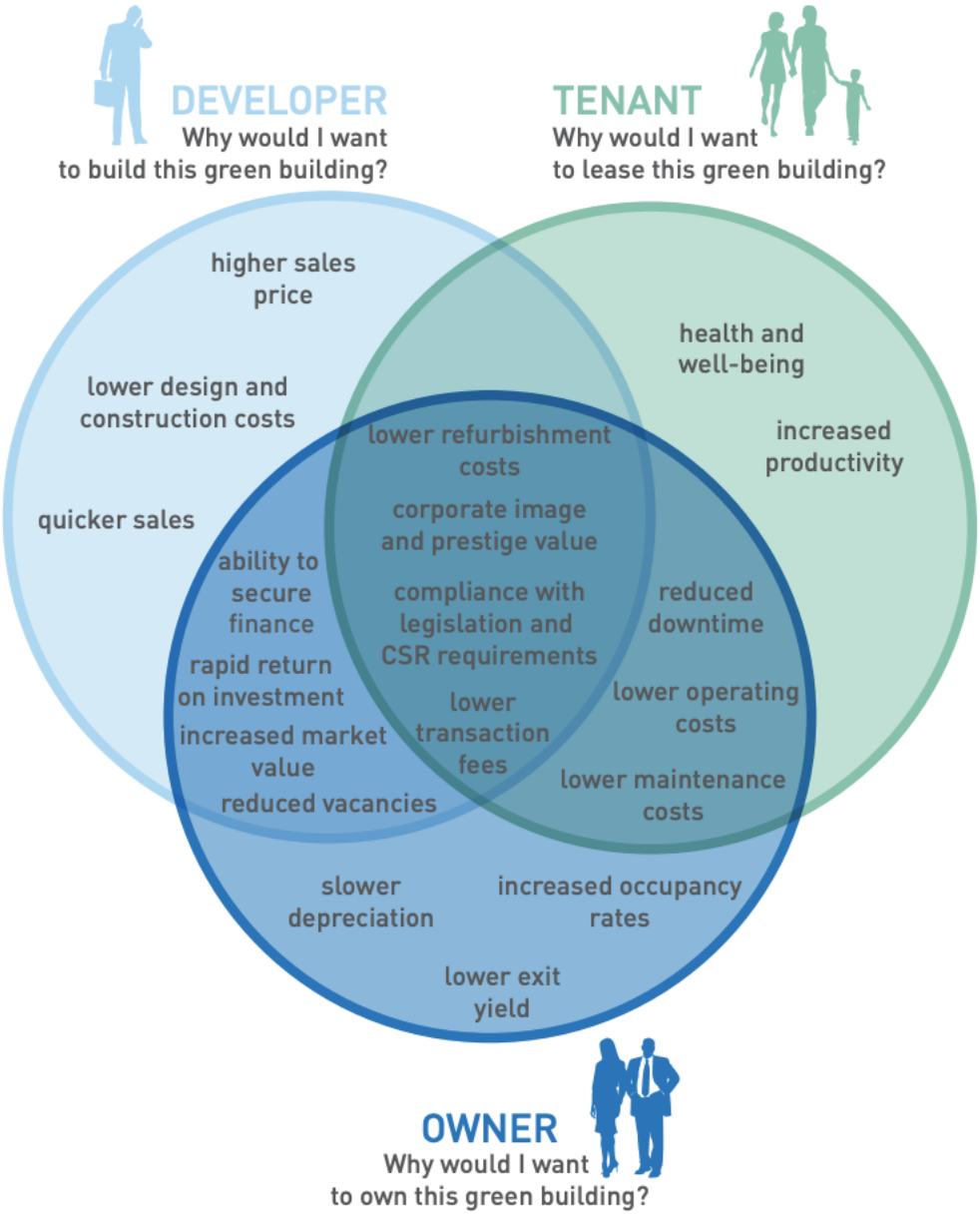


Figure 10. Various stakeholders' perspectives of green building adoption.[86]

f) Enhancing sustainable construction materials

Eco-friendly construction materials are critical to support Cambodia to achieving optimal green building transitions. Green building material or eco-friendly construction materials are generally defined as 'Green building materials that are composed of renewable, rather than non-renewable resources. Green materials are environmentally responsible because their impacts are considered

[86] See World Green Building Council (2013). https://www.worldgbc.org/news-media/business-case-green-building-review-costs-and-benefits-developers-investors-and-occupants

over the life of the product.'[87] The general characteristics and advantages of eco-friendly construction materials are highlighted in **Figure 11**.

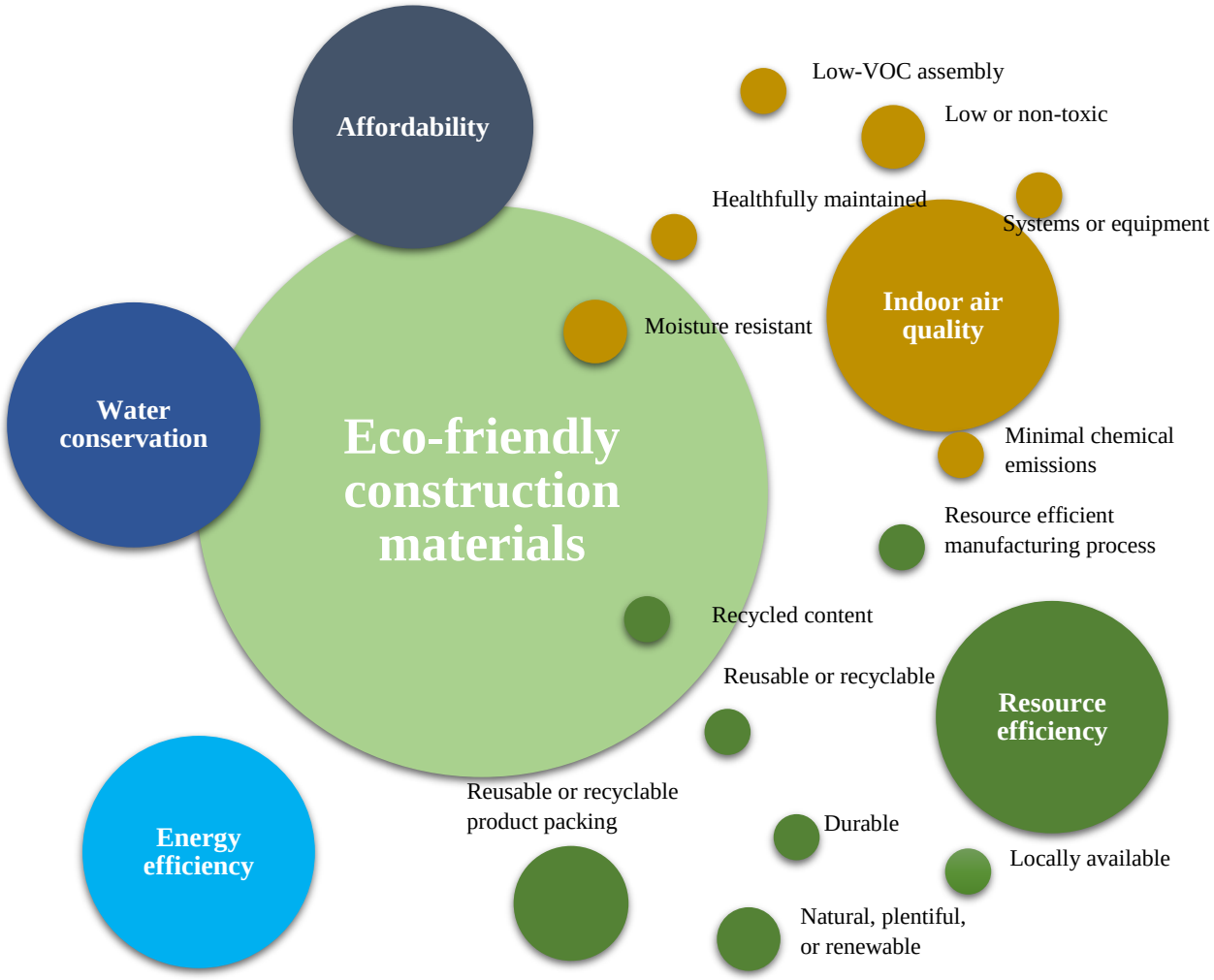


Figure 11. Characteristics of green building materials or eco-friendly construction materials

Sustainable construction materials need to strategically manage either cross-border importation and local manufacturing once green building policy and certification system in Cambodian take place. A well-controlled management of construction material may enhance consistency and more efficient technological selection across Cambodia's construction sectors, while supply chains are maintained adequately. Research on construction materials is required to understand the current context and community perceptions regarding willingness to adopt new technological equipment, despite a slight increase of production cost for construction materials. The evaluation of eco-friendly construction materials needs to consider the Cambodian climate, socioeconomics, and traditional cultural values, while also providing a laboratory for monitoring and assessing construction material quality standards. Subsequently, the appropriate selection of qualified construction materials might be done before certifying for importation or local manufacturing. It is critical to ensure that Cambodian local identities are well recognised while promoting sustainable built environment.

[87] See CalRecycle (2019). https://www.calrecycle.ca.gov/greenbuilding/materials

6.2.3. Green building and sustainable construction literacy

Conventional building design and construction dominantly appears across building use and new buildings of urban and peri-urban development in Cambodia. It is suggested that property development and architect firms in Cambodia poorly adopt sustainable construction practices due to lacking sustainability awareness and knowledge, while being reluctant to integrate new technologies, materials[88] and law enforcement. Furthermore, some property developers may find the adoption of new technological equipment and materials could increase construction costs, leading to difficulty in local market competition. Additionally, even though associated legislation and policies on building constructions are intended to improve environmental quality and standards in the built environment, certain regulations and guidelines on green buildings have remained limited and unclear. These factors limit construction sectors in achieving sustainability and green building transitions. Despite these challenges, the emergence of building occupants' interests in indoor environmental quality improvement and existing Khmer traditional design and construction with integration of additional greener features in design may present opportunities to encourage green building operations and practices and become increasingly tangible.

To extensively adopt sustainable building construction, strategic interventions are needed across relevant stakeholders. Green building strategies and policies initially introduce this concept with appropriate incentives (i.e., certification and subsidies) to enhance green building operation. Additionally, green building education and training requires appropriate techniques for different target groups, such as green building assessors, construction and architect firms, cross-sectoral decision makers, and local communities. Green building literacy should be promoted through young builders and architects with a great attention on sustainable and environmentally friendly design, incorporating new perspectives of resource-efficient practices, such as water consumption, energy saving, construction materials, and technological equipment advancement. A study in Oklahoma (in the United States) shows that public awareness and knowledge of sustainability or resource-efficiency catalyses people's willingness and commitment to adopt new perspectives toward sustainability transition.[89] Therefore, education on green building concepts is an influential factor to promote community awareness and encourage practices of green building adoption. Green building partnerships and collaborations are significantly improved through networking with regional and international green building experts. This importantly enables resource mobilization, including human resources, technical advice, and financial support. Appropriate strategic interventions should enhance the integration and adoption of green building practices into local planning and construction. Increased community knowledge of green building design will effectively reshape building construction and design towards sustainability.

6.2.4. Institutional arrangement and operations

As described in the section on stakeholder analysis at 5.1, the institutional responsibility for green building certification and management has not been appointed by the RGC. The institutional arrangement can be established by different mechanisms with participation of different key actors. To further discuss the roles and responsibility of government institutions, it is suggested that

[88] See Durdyev et al. (2018).
[89] See Wade et al. (2021).

proposed options for setting up this organisation should be discussed and decided by the government actors and relevant stakeholders. The options for establishing green building body or appropriate institutional mechanisms should be discussed according to their advantages and disadvantages for decision makers. From the stakeholder analysis, it is indicated that there are key actors that play important role in construction and building such as the Ministry of Land Management Urban Planning and Construction (MLMUPC), Board of Architects Cambodia, Board of Engineers Cambodia and key actors in environment and sustainable development including Ministry of Environment (MoE) and National Council for Sustainable Development (NCSD). These key actors can be working in collaboration to establish a green building operation and management body. The lead could be taken by NCSD/MoE and MLMUPC as the leading institutions and with the participation from relevant government ministries/agencies, private sector, NGOs and development partners. The government can lead in development policy and regulation framework and implement the guidelines and certification and private sector including individual professionals, developers, companies, and trade associations is important in green building movement through capacity building and awareness raising, green building assessment services, promoting green building market, and other actions towards sustainable development. Also, NGOs and development partners can play a supporting role in pushing green building in terms of shaping policy, feedback and innovation for the implement and advancement of green building system. All in all, they need to work together in the sphere (see **Figure 12**). In the first stage, government will take a bigger step in forming and governing the guidelines and certification, providing capacity building, and engaging private sector.

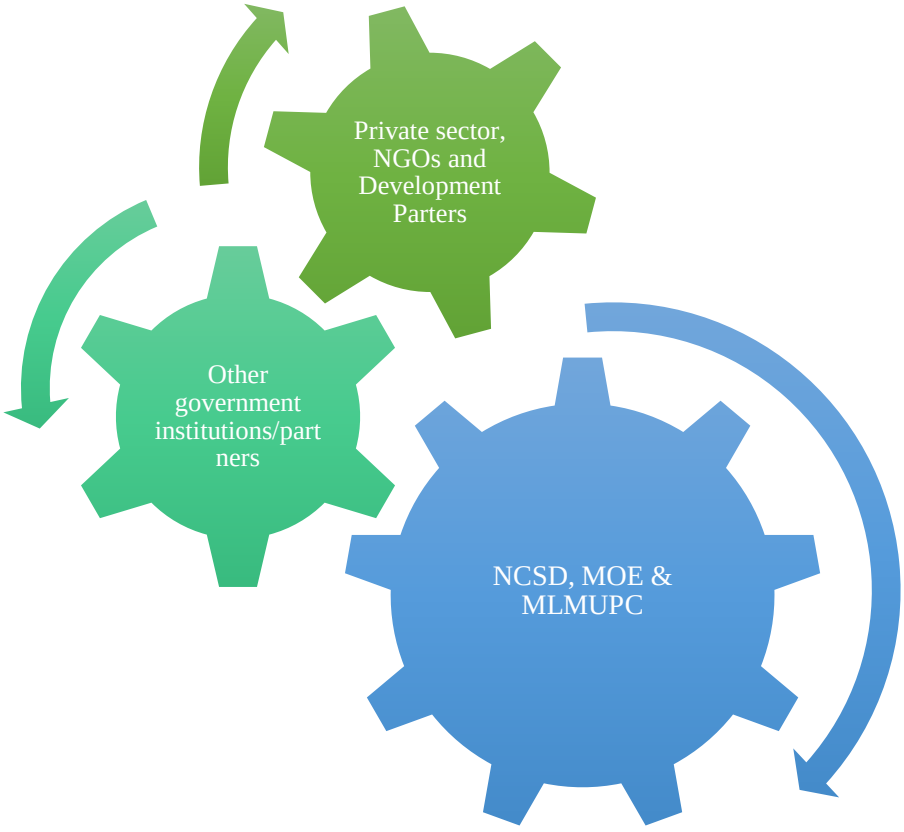


Figure 12. Possible green building stakeholders in Cambodia.

A green building project team under the General Secretariat of the National Council for Sustainable Development is implementing the project on 'Guidelines and Certification for Green Buildings' to deliver the mentioned outputs of the project. A Project Working Group (PWG) on Green Building was set up to provide technical comments on the outputs of the project, especially on the technical content of the guidelines and certification. This working group is overseen by NCSD, Ministry of Foreign Affairs and International Cooperation of Cambodia, Republic of Korea (ROK) and the Mekong Institute (MI) as an Executive Committee. NCSD and the ROK will co-chair this Executive Committee and will monitor progress and assess the results and outcomes delivered by PWG. The PWG consists of technical staff from NCSD, MoE, MLMUPC, other relevant ministries and representatives from the private sector and NGOs.

The Executive Committee of PWG meeting is be held at least at the start, middle, and end of the project in the NCSD office in Phnom Penh. The MI will join this meeting via Skype call/conference to reduce costs. The PWG meetings can be held at least twice a year on a basis and additional meetings if required. The PWG meetings will be hosted at the office of the NCSD. The NCSD's Technical Working Group on Sustainable Cities, which is a joint inter-ministerial working group, also plays an essential role as the advisory board of this project.

Collaboration and partnership could trigger execution of green building certification and rating systems in Cambodia. This is not limited to local private sectors, such as property and architect firms, but this needs to expand for the international collaboration that provides extensive networks with international green building firms or bodies, such as World Green Building Council (World GBC), Leadership in Energy and Environmental Design (LEED), German Sustainable Building Council (DGNB), Green Standard for Energy and Environmental Design (G-SEED), LOTUS, Thai's Rating of Energy and Environment (TREES) and others, as shown in **Figure 12**. Furthermore, banks, development partners and NGOs could provide significant technical and financial assistance to enhance green building certification and rating systems operation in Cambodia. This network also enlarges green building literacy through different public events, formal and informal education, and social media.

6.2.4. Visions for low carbon development society

Green building implementation is considered as another pathway to enhance Cambodia's commitments to achieve low-carbon society. The RGC has established various national planning policies and strategies to combat carbon emission, which contribute to reducing and slowing down intensity of global climate change. These planning policy documents include national SDGs, Sustainable Urban Development Program (see **Section 5.2.10**), National Determined Contribution (NDC)[90], National Green Growth Policy and Strategy[91] and other climate change mitigation strategies. Additionally, a prefeasibility study on low carbon development in Cambodia was conducted, which introduced key important strategies and policies to achieve a remarkable reduction of carbon emission by 2050 (see **Figure 13**).

[90] See RGC (2020). https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Cambodia%20First/20201231_NDC_Update_Cambodia.pdf
[91] See Green Growth Policy Platform (2013). https://www.greengrowthknowledge.org/national-documents/cambodia-national-policy-green-growth#:~:text=The%20national%20policy%20on%20green,and%20livelihoods%20of%20the%20population

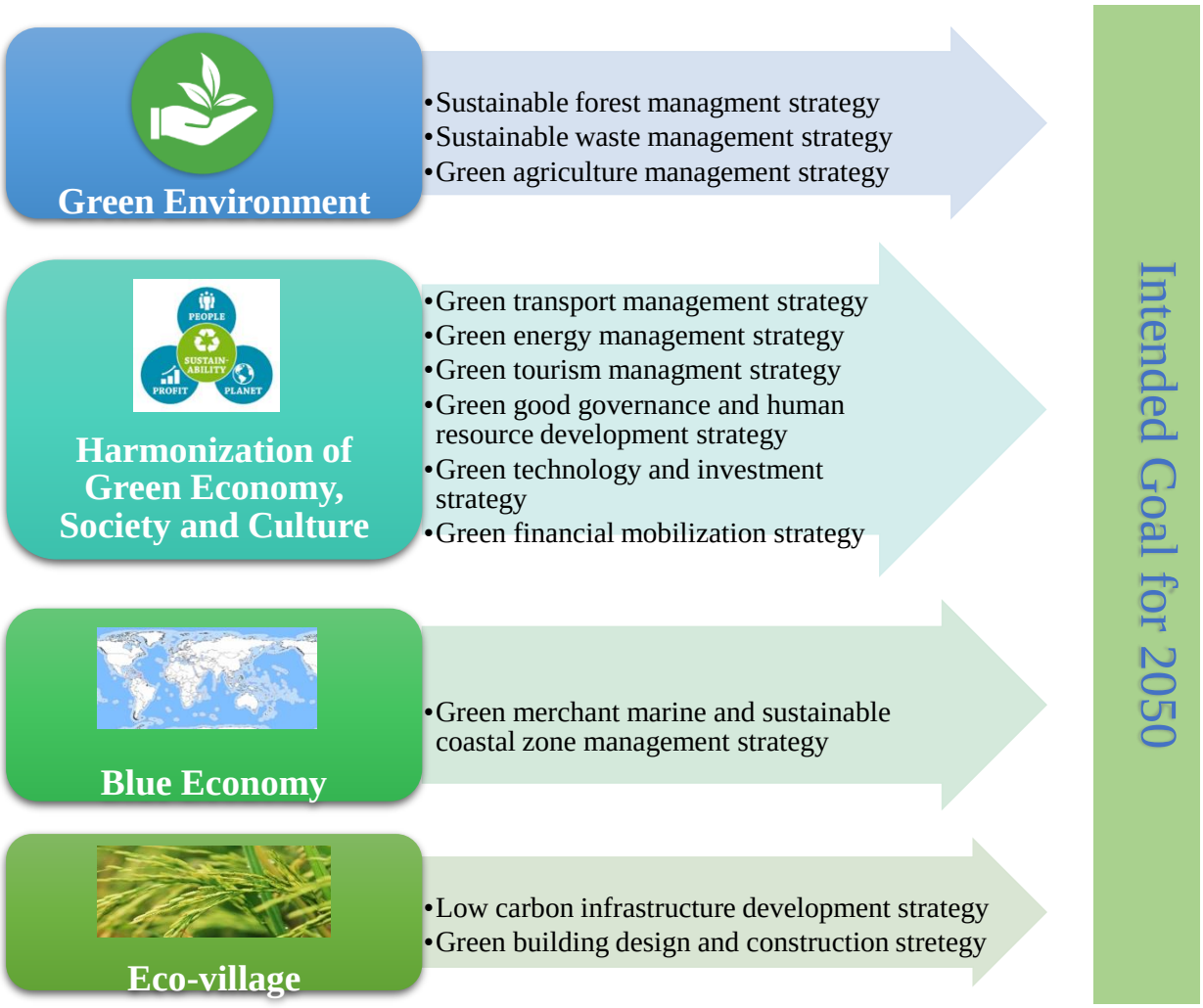


Figure 13. Proposed policies and strategies for low carbon development strategy for Cambodia toward 2050[92].

The green building initiative is introduced in Cambodia to promote a low-carbon development society through eco-village policies, while being reflected in other policies pillars in terms of sustainable waste management, green technology, green energy, and sustainable forest management. Indeed, green buildings are a holistic solution to deal with contemporary emissions trajectory and promote sustainable development through the contribution of a green built environment. To conclude, it is obvious that the implementation of green buildings would help accelerate Cambodian government's transition towards a low carbon development society.

6.3. Roadmap for developing guidelines and certification system in Cambodia

Green building conceptions and practices have been globally and regionally adopted to improve indoor environmental quality and resource-efficiency (see **Figure 14**). Various building rating tools and certification systems are developed to comply for different standards underlying individual organizations and agencies. For instance, Building Research Establishment (BRE) Global authorises green building rating and certification systems through onsite independent third-party verification against standards of compliance for new building construction, buildings in use, refurbishment and fit out, and community infrastructure. This system determines key building performance attributes, which include energy, health and wellbeing, transport, water, materials,

[92] See MOE, Toyo University, IGES, RUA & NIES Japan (n.d.). http://2050.nies.go.jp/report/file/lcs_asia/Cambodia.pdf

waste management, land use and ecology, and pollution.[93] This section will discuss green building guideline and certification system in the international context as well as Cambodian in general. A particular discussion of Cambodian certification or rating systems will be furtherly elaborated in a great detail in anther document, entitle Cambodia green building roadmap.

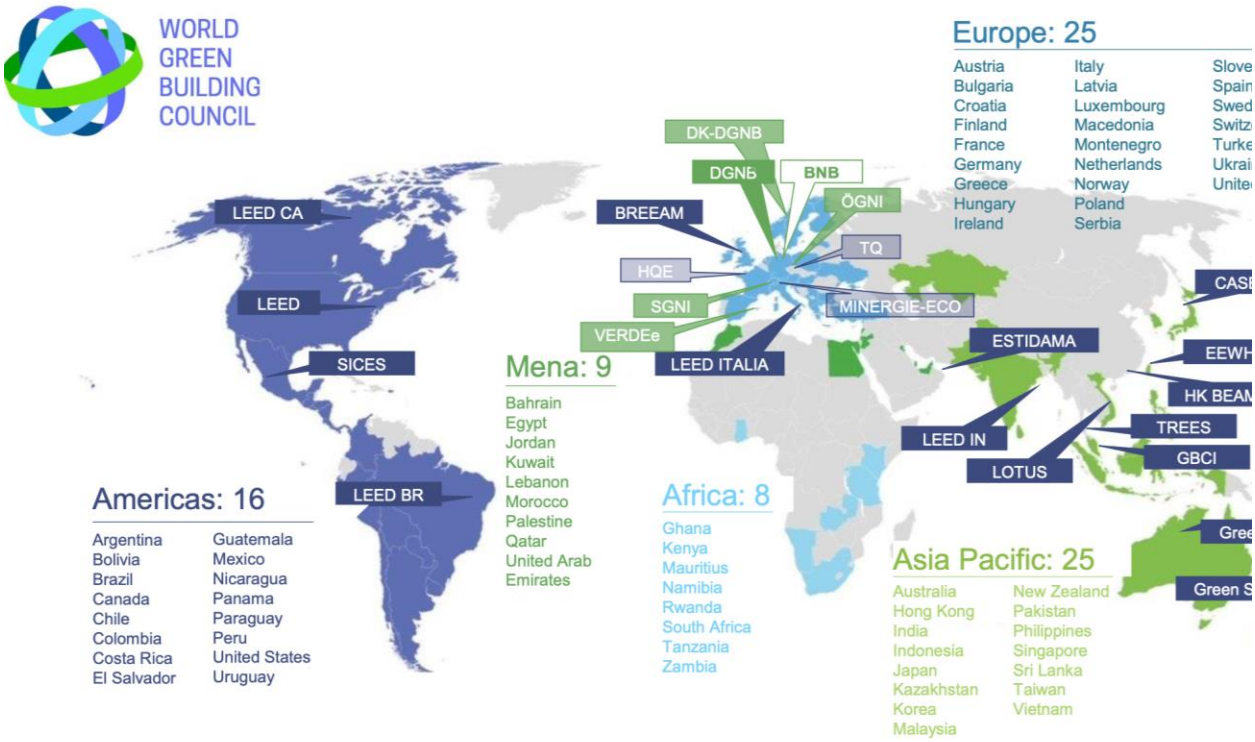


Figure 14. Overview of global green building certification and rating systems[94].

Within the ASEAN context, green building councils were formed in seven countries with their associated green building rating systems, including Brunei, Green Ship of Indonesia, Green Building Index of Malaysia, Thai's Rating of Energy and Environmental Sustainability (TREES), Building for Ecologically Responsive Design Excellence of Philippines, Green Mark of Singapore and LOTUS of Vietnam. In this region, green building certification and rating systems have been extensively practiced in many member nations. Most systems have been adopted from at least two western green building systems while contextualizing for their own sociocultural and economic contexts. To illustrate, Thailand has developed TREES as the national green building system, namely under the Thai Green Building Institute, while adopting other certification and rating systems, such as LEED, Green Mark, and TEEAM-DGNB. Similarly, LOTUS – Vietnam's certification and rating system, has progressively certified almost 30 green buildings while adopting standards from other systems such as LEED, Green Star, BREEAM, GBI, and Green Mark (see Appendix 2). These are best practices, which are useful to inform green building certification and rating system in Cambodia. In this regard, it is suggested green building rating or certification system for Cambodia can adopt from existing green building system where main features and criteria set can closely meet the Cambodia's context or existing practices in terms of social economic and culture and resource uses such as energy and water use, use of developed land, use of local construction material. Based on the partnership with KICT that owns G-SEED

[93] See **Appendix 2** for further information associating different global attributes of green building certification and rating systems.
[94] See World Green Building Council. https://www.worldgbc.org/news-media#media-publications

system, international consultant's expertise in DGNB system and accessibility of DGNB resources, it could be appropriate for Cambodia to make decision on adoption of German DGNB and Korean G-SEED.[95]

DGNB

Deutsche Gesellschaft für Nachhaltiges Bauen
German Sustainable Building Council

To make sustainable building applicable on a practical level, measurable and thus comparable, the DGNB has developed its own certification system. This system offers a variety of options for buildings, indoor environments, and districts – not only for new buildings but also for existing ones. The DGNB System works like a planning and optimisation tool, providing help with raising the tangible sustainability of building projects. It also fosters a shared understanding of the pertinent requirements of sustainable building methods, among all parties involved in development projects.

Certification should make an essential contribution to quality across the board in planning, construction, and actual use. By reducing risk and the costs associated with it, applying the DGNB System helps tailor building projects to needs on the horizon. An important part of this is our independent certification process, which adds transparency to quality controls. The DGNB Certificate is granted in Platinum, Gold or Silver, so it can also be used as an award and marketing instrument.

Assessments revolve around three core sustainability factors, each with an equal weighting: ecological, economic and sociocultural factors. The DGNB certification system is considered the most advanced system of its kind in the world and is internationally recognised as the global benchmark for sustainability. Applied outside Germany, the DGNB System is adapted to regional requirements. To this end, the DGNB works in close partnership with leading local organisations within individual countries.

[95] See Draft Roadmap for Cambodia's Guidelines and Certification for Green Building (CamGCGB).

About G-SEED

G-SEED is a system to certify the environmental performance of buildings by evaluating various factors of environmental impact, including energy and resource conservation, reduction of pollutant emissions, level of comfort, and harmony with surroundings, throughout the lifecycle of buildings from the production of construction materials, design, construction, maintenance, and management to demolition

G-SEED aims to reduce environmental burden, such as the use of energy and resources and the emissions of pollutants and offer a pleasant environment to residents through the establishment of eco-friendly buildings.

Key features of G-SEED

1. Energy system
2. Ecological design
3. Building load reduction
4. Adoption of eco-material
5. Reduction of final waste disassembly
6. Corresponding to the eco-friendly lifestyle

A simple, low cost and impactful green building system should be a big consideration for Cambodia. Furthermore, it is understood that the development of Cambodia's green building system can be a learning process and innovation to better improve the system step by step. In the early stage of the development, Cambodia can consider the reduction of carbon emissions as the global responsibility, making the Cambodian building sector and industry to be ready for the future and sustainable development and green growth into local development projects.

The incorporation of green building conception into Cambodia's development context is proposed to be undertaken through four main stages (see **Figure 15**). In the preparation stage, Cambodia's situation analysis is required for understanding the existing relevant legislation, policies, and strategies, which will promote sustainable buildings and construction. Consultation is also critical to gather information and stakeholders' interests toward the concept of green building in Cambodia. The planning stage will involve the development of green building guidelines, certification, and rating systems, which is contextualised for Cambodian uniqueness from the

adoption of international or regional standards. Furthermore, the planning stage will also propose different options for the institutional arrangements, for the implementation and maintenance on green building certification and assessment.

Training and awareness raising should be undertaken in the implementation or operation stage. This approach is important to promote green building literacy for the Cambodian public and stakeholders, such as the local community, government officials, architects and design industries, and construction companies. This is also important for bridging collaboration and building partnership with development partners, non-government organizations, and private sectors to enhance success in green building practices. For example, strengthening partnership may enlarge opportunities for implementing pilot projects on green building certification and assessment through financial or technical support. The pilot projects will be important for practical implementation under the project, which build a general understanding of the green building certification and assessment processes. These pilots should be documented for lessons learnt providing useful inputs for modification and replication as well as knowledge dissemination.

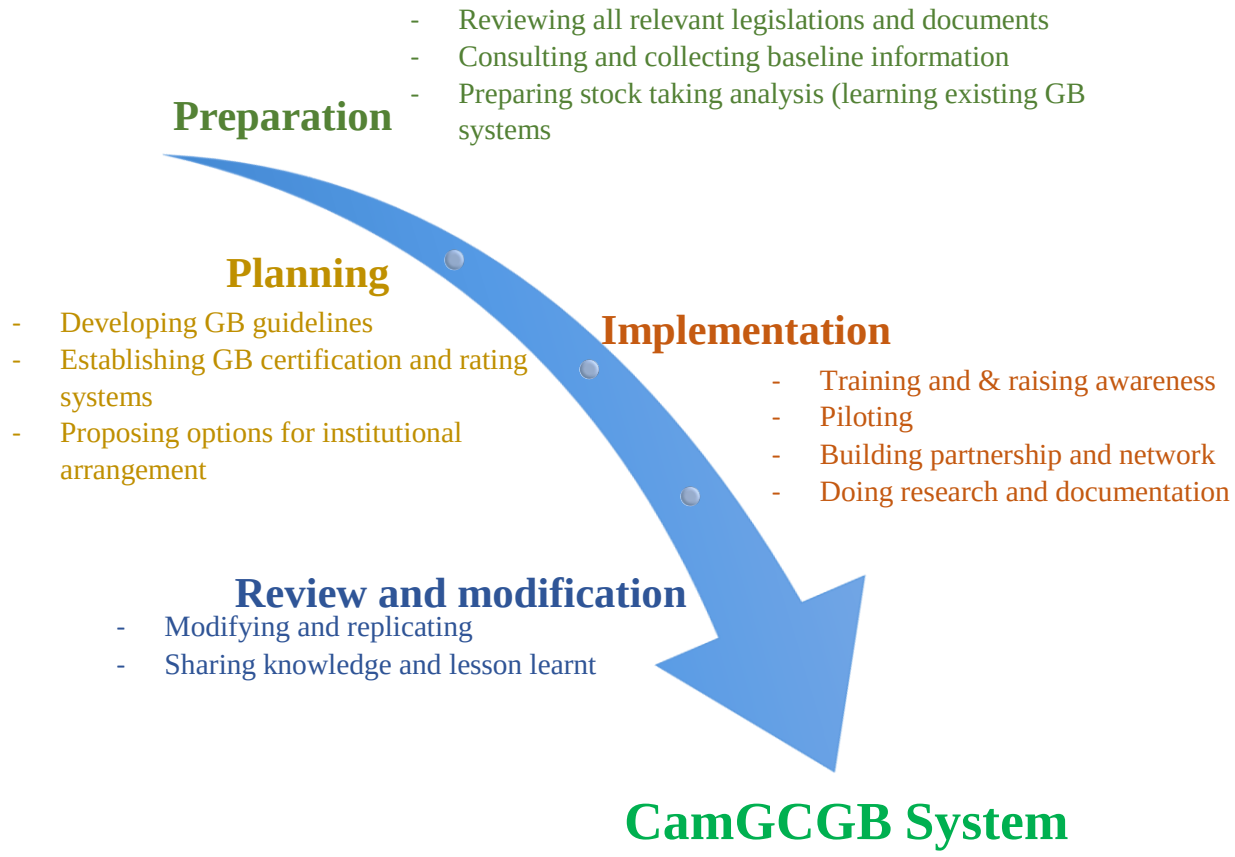


Figure 15. The proposed stages for incorporating green building concepts into Cambodia development

The development of Cambodia Guideline and Certification System for Green Building (CamGCGB) shall be introduced by a roadmap, produced to inform the contemporary development, status and potential of future green building certification, guideline, and operation in Cambodia. The CamGCGB system will raise awareness associated with green building practices, such as energy and water saving, sustainable materials and circular economy, among construction and property industries, local community, and businesses. Furthermore, this system

is expected to frame green building standards, which is applied for residential and non-residential building toward either new buildings or building in use.

The roadmap proposes to identify three temporal scales for operational targets (see **Figure 16**), such as short-term prospect (3 years), mid-term prospects (4-7 years), and long-term prospects (over 8-10 years). Voluntary measures will be applied for the short and medium-term prospects, which an expectation of less than 100 building certified or awarded for green building standard, while mandatory measure will take place in the long-term prospect through the introduction of mainstreaming CamGCGB into legislation.

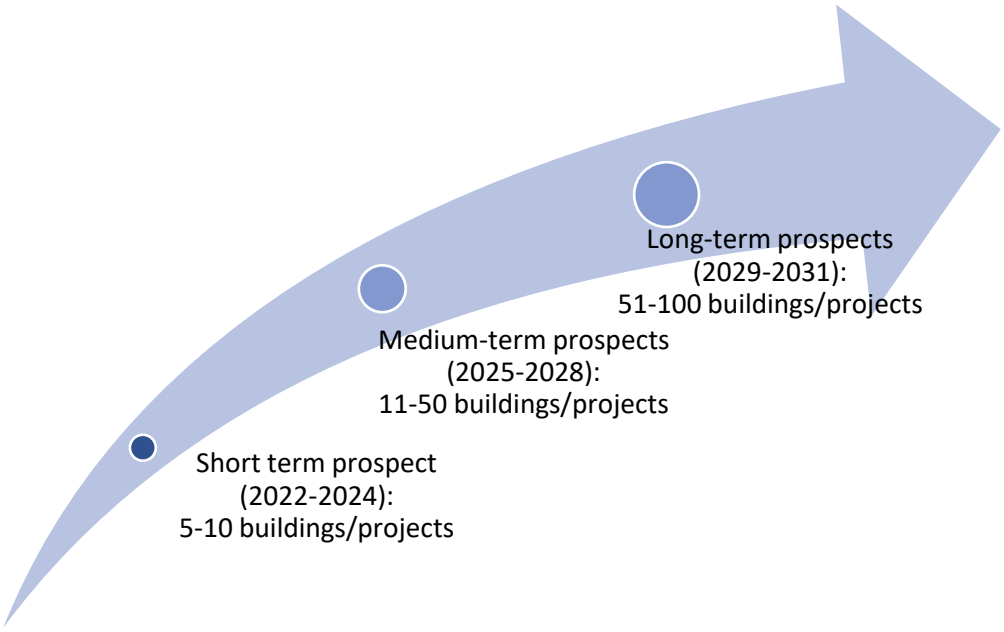


Figure 16. Temporal scales of green building practices in Cambodia.

Beside the timeframe set for operation, the proposed roadmap will introduce green building standards for both new building and existing buildings and include criteria and indicators for building assessment. These components shall be introduced to ensure that the transition of green building practices contribute to achieving the Cambodian sustainable development goals. The standards may carefully consider the benefits of green buildings for people, planet, and the economy. For example, the criteria set need to acknowledge environmental capital, social and cultural context, and monetary saving for building usages, such as reduced payment for energy, water, and building maintenance.

7. Conclusion

This current stocktaking analysis of green building concepts provides a critical understanding of the construction challenges through conventional practices of building design and material consumption, which have been understood to significantly contribute to unsustainable built environments. This document also contextualises the existing relevant planning policies and legislation in Cambodia associated with sustainable construction, particularly on land management, resource-efficiency and disaster risk management, and identifies a lack of specific regulations or guidelines related to green building concepts. Additionally, this stocktaking report discusses opportunities and possible benefits of green building interventions in Cambodia, while introducing the co-benefits of its implementations for enabling the implementation of the local and global SDGs. The analysis also discusses the institutional arrangements (CamGCGB) and

proposed roadmap for mainstreaming green building concepts into Cambodia's built environment sector.

It is worth noting that Cambodia's urban spatiotemporal and socioeconomic context have been dramatically changed due to engagement in globalization, which has led to a great demand of the construction sector for residential and commercial buildings, including for offices and industrial buildings. Local geoclimatic conditions in Cambodian urban areas provide opportunities to maximise solar energy and natural light permeability through sustainable design of buildings. The tropical monsoon introduces dry and rainy seasons for Cambodia, while maintaining humidity in the atmosphere, which increases the regularity of weather transition and encourages natural vegetation, despite too much and too little water in both seasons. In this regard, green building concepts and interventions in Cambodia will appropriately address these contemporary issues by promoting urban resilience, self-contained resources, indoor resource-efficiency, wellbeing and public health, and urban ecological quality through a sustainable built environment.

Regional and global practices and experiences of green buildings provides essential lessons learnt, and introduce different approaches for achieving green building developments, particularly in the initial stage of strategic interventions and planning policy formulation. Cambodia's green building guideline and certification systems require a careful approach to formulation by considering inclusive consultation with all relevant stakeholders, while implementation shall be voluntary rather than mandatory in the short-term. Technological and institutional advancement is essential to increase resource-efficient consumption through construction materials and modernised equipment utilization in buildings, supported by improved policies and controls. Understanding the business case (and support with incentive) of green building operation and construction costs might be a key approach to trigger community adoption of this new green design. Raising awareness is also an effective approach to increase people's willingness and commitment.

Lastly, the CamGCGB is required to develop and facilitate simple and least-cost operational processes for green building assessment and certification. It is worth emphasizing that green building concepts is new to Cambodia, and reluctance from the community might emerge due to the extra cost (upfront payment) of advanced technology and eco-friendly construction materials, in addition to the challenges of early operation and limitation of sustainable design knowledge. This system needs to simple and ensure that its process is comprehensive and understandable for relevant stakeholders, particularly non-expert groups. Additionally, optimal requirements and affordable assessment application processes are considerably important to attract customers and developers to get involved and enhance its progress.


@ Google Image)

Appendix 1

Certified green buildings in Cambodia

XO TEX INDUSTRIAL Co. LTD Phnom Penh, Phnom Penh KH	**2021-05-28** SUNNY FORCE LIMITED Industrial Manufacturing / 326,835 sq ft	GOLD CERTIFIED LEED v4 BD+C NC 65 pts
ODOM Phnom Penh, Phnom Penh KH	**2020-06-16** URBAN LIVING SOLUTIONS Office / 1,087,154 sq ft	REGISTERED LEED v4 BD+C CS
Morgan Tower-Office Wing Phnom Penh, Phnom Penh KH	**2020-03-30** Morgan Ford Group Office / 780,315 sq ft	REGISTERED LEED v4 BD+C CS
Grading and Medical Building Phnom Penh, Phnom Penh KH	**2019-05-06** Other / 4,704 sq ft	REGISTERED LEED v4 ID+C CI
Main Factory Extension Building Phnom Penh, Phnom Penh KH	**2019-05-06** Industrial Manufacturing / 140,006 sq ft	REGISTERED LEED v4 BD+C NC

Canteen building Penh, Phnom Penh KH	**2019-05-06** Other / 29,977 sq ft	REGISTERED LEED v4 BD+C NC
CAN SPORTS SHOES Plant B - Building A Sameakki Mean Chey, Kampong Chhnang Province KH	**2019-01-09** Industrial Manufacturing / 1,577,622 sq ft	REGISTERED LEED v4 BD+C NC
Mercedes-Benz Showroom & Service Center Phnom Penh, Phnom Penh KH	**2017-03-23** Star Auto (Cambodia) Company Limited Office / 50,333 sq ft	GOLD CERTIFIED LEED NC 2009 66 pts
Coca Cola Cambodia greenfield project Phnom Penh, Phnom Penh KH	**2017-02-10** CBC Coca Cola Cambodia Industrial Manufacturing / 324,821 sq ft	GOLD CERTIFIED LEED NC 2009 62 pts
Bowker Garment Cambodian Factory Phase 2 Phnom Penh, Kandal Province KH	**2016-09-11** Bowker Garment Factory Cambodia CO.,LTD. Industrial Manufacturing / 95,495 sq ft	GOLD CERTIFIED LEED NC 2009 60 pts

Bowker Garment Cambodian Factory Phase 2 Phnom Penh, Kandal Province KH	**2016-09-11** Bowker Garment Factory Cambodia CO.,LTD. Industrial Manufacturing / 95,495 sq ft	GOLD CERTIFIED LEED NC 2009 60 pts
Laurelton Cambodia Phnom Penh Special Economic Zone KH	**2016-09-01** Laurelton Diamonds (Cambodia) Co. Ltd Industrial Manufacturing / 93,421 sq ft	CERTIFIED LEED NC 2009 47 pts
Vattanac Capital Phnom Penh, Phnom Penh KH	**2016-04-28** Corporate / VATTANAC PROPERTIES LIMITED Office / 959,007 sq ft	GOLD CERTIFIED LEED CS 2009 64 pts
Bowker Garment Cambodian Factory Group P Phnom Penh, Kandal Province KH	**2015-05-12** Win Hanverky Holdings Ltd. Industrial Manufacturing / 235,730 sq ft	SILVER CERTIFIED LEED NC 2009 55 pts
Bureau Veritas Cambodia Limited Phnom Penh, Phnom Penh KH	**2015-01-09** Bureau Veritas Cambodia Limited Office / 18,500 sq ft	PLATINUM CERTIFIED LEED CI 2009 90 pts

Taieasy International 158 Factory KH	**2013-04-11** Taieasy International Co.,Ltd Industrial Manufacturing / 290,628 sq ft	REGISTERED LEED NC 2009
UN Common Premises, Cambodia Phnom Penh, Phnom Penh KH	**2009-03-11** Non-profit Office: Mixed Use / 72,000 sq ft	REGISTERED LEED NC 2.2

The table was obtained from Green Building Information Gateways[96].

[96] See Green Building Information Gateways. http://www.gbig.org/places/671

Appendix 2

Overview of global green buildings certification and rating systems.

BUILDING RATING TOOLS/ CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
Building Research Establishment Environmental Assessment Method (BREEAM)	Multi-Attribute	Green building rating and certification system through on-site independent third-party verification for: • New Construction • In-Use • Refurbishment & Fit Out • Communities Infrastructure	BRE Global	Performance in: • Energy • Health & Well-being • Transport • Water • Materials • Waste • Land Use & Ecology • Management • Pollution No prerequisites for In-Use
Leadership in Energy and Environmental Design (LEED)	Multi-Attribute	Green building rating and certification system through independent third-party verification for: • New Construction (NC)	U.S. Green Building Council	Performance in: • Sustainable Sites • Water Efficiency • Energy & Atmosphere • Materials & Resources • Indoor Environmental Quality

BUILDING RATING TOOLS/ CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
		• Existing Buildings, Operations & Maintenance (EB O&M) • Commercial Interiors (CI) • Core & Shell (CS) • Schools (SCH) • Retail • Healthcare (HC) • Homes • Neighborhood Development (ND)		• Locations & Linkages • Awareness & Education • Innovation in Design • Regional Priority through a set of prerequisites and credits
German Sustainable Building Council (DGNB)	Multi-Attribute	Green building rating and certification system through on-site independent third-party verification for: • Building includes new construction, renovated buildings/existing buildings, buildings in	DGNB GmbH	Performance in: • Environmental quality • Economic quality • Sociocultural and functional quality • Technical quality • Process quality • Site quality

BUILDING RATING TOOLS/ CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
		use, and deconstruction of buildings • District (Sustainable district) Interior		
Green Standard for Energy and Environmental Design (G-SEED)	Multi-Attribute	Green building rating and certification system through on-site independent third-party verification for: • New building Existing building	Korea Institute of Civil Engineering and Building Technology	Performance in: • Land use and Transport • Energy and pollution • Materials and Resources • Waste Management • Maintenance • Ecology Indoor Environment Quality
Green Globes	Multi-Attribute	Green building guidance and assessment program for: • Existing buildings	Green Building Initiative in the U.S. BOMA Canada	Environmental assessment areas to earn credits in: • Energy • Indoor Environment

BUILDING RATING TOOLS/ CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
		• New construction		• Site • Water • Resources • Emissions • Project/Environmental Management No prerequisites
Living Building Challenge	Multi-Attribute	Performance-based standard, and certification program for: • Landscape and infrastructure projects • Partial renovations and complete building renewals • New building construction • Neighborhood, campus and community design	International Living Future Institute	Performance areas include: • Site • Water • Energy • Materials • Health • Equity • Beauty All areas are requirements.

BUILDING RATING TOOLS/ CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
NZEB	Multi-Attribute	Certification program using the structure of the Living Building Challenge which can be applied to any building type.	International Living Future Institute	One hundred percent of the project's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion. NZEB certified buildings must also meet the following requirements of the Living Building Challenge: • the first half of Imperative One, Limits to Growth, dealing with appropriate siting of buildings • Imperative 19, Beauty and Spirit • Imperative 20, Inspiration and Education
Passive House Institute US	Multi-Attribute	Performance based passive building standard • Third-party RESNET approved quality assurance/quality control	Passive House Institute US	Any type of building. New focus areas include: • air tightness requirement • source energy limit • space conditioning criteria

BUILDING RATING TOOLS/ CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
		• Earns U.S. DOE Zero Energy Ready Home status • Includes HERS rating		
SITES	Multi-Attribute	Third party verified rating system for development projects located on sites with or without buildings.	Administered by GBCI	Performance criteria in the areas of: • Water • Wildlife Habitat • Energy • Air Quality • Human Health • Outdoor recreation opportunities
WELL Building Standard	Multi-Attribute	Performance based standard and certification program for • New and Existing Buildings • New and Existing Interiors	Administered by the International WELL Building Institute™ (IWBI)	Measures attributes of buildings that impact occupant health by looking at seven factors: Air, Water, Nourishment, Light, Fitness, Comfort, Mind

BUILDING RATING TOOLS/ CERTIFICATION SYSTEM	SINGLE- OR MULTI-ATTRIBUTE	TYPE OF STANDARD OR CERTIFICATION	MANAGING ORGANIZATION	ISSUES / AREAS OF FOCUS
		• Core and Shell Retail • Education Facilities • Restaurant • Commercial Kitchen • Multifamily Residential		

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