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CHAPTER 2

Green Building in the Context of Climate Change

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ABSTRACT

The desire to address climate change, both from mitigation and adaptation perspectives, remains a central matter when considering green building. From the mitigation side, climate actions that include the use of renewable energy, energy efficiency, waste minimisation and choice of location (particularly in relation to amenities and transportation networks) are key focus areas. From the adaptation side, climate actions that include water efficiency, rainwater harvesting, and water recycling technologies as well as site selection (to avoid physical damage to buildings) are important. This chapter, therefore, presents perspectives of green building in the context of the climate change phenomena, starting with a brief focus on the concept of the built environment. Work associated with initiatives of the C40 Cities Climate Leadership Group (C40) on climate action and global megacities is also deliberated upon as a case study bringing it all together. The chapter concludes that the desire to address climate change remains central in green building. The chapter recommends that more should be done to scale up climate actions related to green building.

INTRODUCTION

The experienced and anticipated adverse impacts of climate change on societies has elevated the priority of managing this phenomenon in both the private and public sector. Such intervention is taking place at various spatial scales, including the sub-national, national, regional and international levels. The burning of fossil fuels to generate electricity and the use of liquid petroleum fuels to power modern means of transportation generates the greatest amounts of greenhouse gases (GHGs).[1] The accumulation of these gases in the atmosphere leads to global warming, which in turn, results in climate change. Consequently, the grand focus of managing climate change has been, and remains focused on, reducing both the direct and indirect human activities that emit 'avoidable' GHGs into the atmosphere. Efforts to this end include resource efficiency, i.e., burning less fossil fuels to generate large amounts of energy, mainly electricity using renewable energy that emits less or no GHGs. Simultaneously, there is a focus on learning to cope with the inevitable adverse impacts of climate change and exploiting the opportunities that this phenomenon avails.

As the world routinely engages with managing the climate change challenge, an important realisation is that while there are big GHG emitters that need targeting, there is also a need to examine all the other 'small' sources of such. The premise of this focus is that the cumulative savings of GHG emissions from the not so obvious sources have a significant impact on reducing the overall concentration of GHGs in the atmosphere. An important and growing focus of such efforts is how the built environment fits into the broader discourse of managing climate change. This chapter examines the dynamics of climate change in relation to the built environment. The focus on the built environment is deliberate as buildings contribute about 19 per

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attributes climate change to internal natural processes or external forces, or to persistent anthropogenic effects that change the gaseous composition of the atmosphere or land use. The UNFCCC's article 1(2) defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over a comparable time period'.[5] These definitions suggest that although there can be natural changes or variabilities in climate patterns, the currently observed changes have been largely influenced by human activity through various means, most notably the use of fossil fuel sources to generate electric energy as well as to power transportation, agriculture and operations in the built environment (the last item forms the focus of this chapter).

The most notable anthropogenic drivers of global warming that lead to climate change are the burning of fossil fuels to generate electricity, the powering of modern means of transportation, and the clearing of land for both agriculture and settlements, which reduces the GHGs sinks that could mediate the accumulation of these emissions in the atmosphere.[6] The consequence of identifying GHG emissions as the main course of climate harm or to exploit opportunities.[8] Given the foregoing, climate adaptation remains a critical local government matter.

Although climate mitigation and adaptation may appear to be incongruent, they are, in fact, complementary approaches to managing the climate change menace. Klein *et al*[9] identifies three such complementarities as follows:

i. There are adaptation actions that have consequences for mitigation. These actions have energy use implications that present challenges to activities traditionally dependent on fossil fuels. For example, the need for artificial cooling because of climate change induced heat waves may avoid drawing fossil-based energies and opt for renewable energy or other systems that mimic natural cooling systems.

ii. Mitigation actions that have consequences for adaptation are illustrated in cases where hydropower facilities like dams and/or lakes may also serve as water sources when other sources dry up or have less water for domestic and commercial uses due to climate change induced droughts.

iii. Simultaneously considering both climate change mitigation and adaptation applies when, for example, the construction of a dam or lake considers both the generation of hydropower to avoid fossil fuel generated electricity as well as storing water to adapt to climate change linked water shortages.

and exploiting any opportunities that it may present. These actions form the essence of green building.

The built environment comprises residential and commercial buildings as well as related supporting infrastructure: transportation networks and other social amenities, among others.[12] These environments vary from small, isolated settlements with a minimal modification of the landscape to large and highly modified landscapes such as towns and cities. The built environment, cities and towns in particular, is exposed to the adverse impacts of climate change. This exposure presents potential adverse effects that relate to the urban heat island effect, the effects of extreme precipitation that include droughts and flooding, and poor air quality, among others. In this space, the construction industry has realised that it needs to play a role in both mitigating and adapting to climate change.

As highlighted earlier in Chapter 1, the construction industry should actively seek to deliver building designs, construction, maintenance and demolition/renovation processes (inclusive of the supply of materials and services) that reduce the carbon footprint of the industry. The essence of this focus is resource efficiency. On the adaptation side, the construction industry should focus on ensuring that the built environment can withstand the adverse impacts of climate change whenever they arise as well more common, as energy is a major operational cost and can tax the environment even more if not obtained from clean resources. However, regulations around grid connection for both residential and business buildings have proved to be a challenge. Bulkeley[14] notes that 57 per cent of the world's megacities have a strong influence when it comes to building regulations. To this end, the world's mayors can set standards, benchmarks and regulations for buildings. The key challenge is to choose renewable energy for the building. Solar technology has been growing and has gained favour with governments, households and businesses.

Solar technology generally comes in two forms: concentrated solar power (CSP) and photovoltaic (PV). The latter has been more popular, mainly due to technological advancement, the lowered costs of various components (mainly the solar modules), ease of installation and options for various installation locations.[15] The price of solar generated energy measured in $/gigajoule has declined from US$1 100 per gigajoule in 1980 to around US$80 per gigajoule in 2010.[16] However, the major drawback of solar PV has been its incapacity to maintain energy supply in unfavourable weather conditions. This challenge has arguably resulted in a less-than-desired for the penetration of natural light as much as possible, albeit without compromising on aesthetics as well as the need for privacy in both private and public buildings.[18] In South Africa, the extensive use of glass is seen in green buildings such as Tshwane House in the capital city, Pretoria and the University of South Africa's Parow Building in Cape Town, among other buildings designed *de novo* or renovated to deliver this appearance.

Green building designs realise that there are times when natural light is insufficient, even during the day. In such cases, artificial light becomes a necessity. In green buildings this is addressed uncompromisingly through energy efficient means. Typically, fluorescent and light-emitting diodes (LEDs) – lights that use electronic ballasts – provide the lighting in green buildings.[19] These energy efficient lights can be supplemented through the use of motion sensors that switch on the lighting in an occupied room and switch it off when it is not occupied. These sensors remove the need for deliberate and sometimes unreliable human interventions in switching lights on or off.

The cooling and heating of a building is often a function of the orientation, materials used in the construction process and its operations. The green concept seeks to ensure that a building is oriented in a manner that allows that go into the construction industry are also produced in a manner that contributes to the management of climate change in a narrow sense and that also advances the sustainable development agenda in a broad sense. The production of glass, bricks, cement, paint, tubing, piping and other fittings is slowly but inexorably moving in that direction. Chapter 5 outlines some important advances to this end. Pragmatism is important in this space. For example, while production of the 'green' glass that dominates the architecture in green building may be carbon intensive, the energy savings of building with this glass, instead of bricks for example, offset the related carbon emissions.[21] Glass for Europe posits that the total GHGs emitted by the manufacturing of glass by an energy efficient double glazing unit is offset within three-to-ten months by the energy savings in green buildings, compared to similar buildings with inefficient glazing installations or other alternatives.[22] In addition, glass is made of abundant non-polluting raw materials. Further, its manufacturing process is energy efficient, consuming relatively less water and producing less waste that the production of clay bricks, for example.[23] As laws around both direct and indirect GHG emissions become stringent, energy efficiency will become an integral part of all human activities. The construction industry cannot avoid some of the forthcoming stringencies, and it needs to ensure that all its activities meet sun and sunlight as well as wind flow for passive lighting as well as heating and cooling. Ideally, a location has to avail itself of these advantages based on the local climate.[25] Indirect intervention pertains to locations that present minimal destruction or removal of vegetation and use existing infrastructure, thus avoiding new development that could prove to be carbon intensive. Consequently, an ideal green building location is one that is well connected and close to amenities such as places of work and recreation.[26] Thus, the greening of old buildings promotes the development of green built environments.

GREEN BUILDING AND CLIMATE CHANGE ADAPTATION

As highlighted earlier, climate change adaptation in green building focuses on major actions that include water efficiency, use of rainwater harvesting, water recycling technologies and site selection to avoid physical damage to buildings.

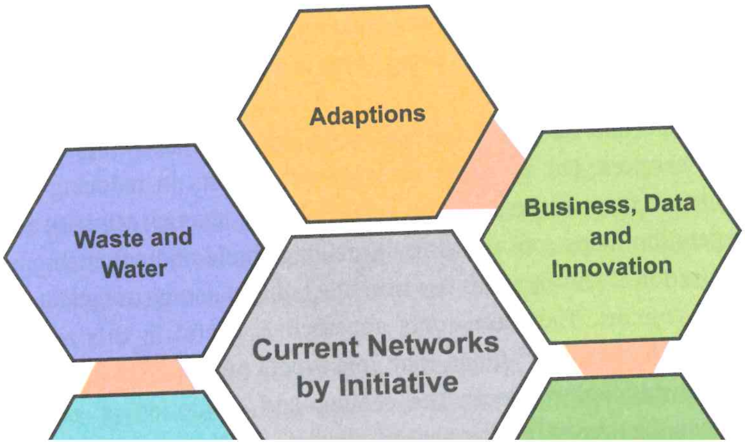
In the green building movement, increasing water use efficiencies employs two approaches: one seeks to ensure that routine operations in any built environment use minimal quantities of water without compromising from kitchen sinks, dishwashers, showers/baths, and laundry facilities for a purification process that includes mechanical and biological filtration to removed solid and dissolved waste before disinfection.[28] This treatment renders the water safe for both indoor and outdoor uses. Previously, the city of Bulawayo in Zimbabwe harvested and treated grey water from its sewerage works. This was put to good use watering plants and grass in city parks, stadiums, sports grounds, schools and hospitals. This system has since collapsed in Bulawayo. The urgency of water conversation as the effects of climate change take hold makes it imperative to revive the system. Where the systems are not in place, there is a need to develop and maintain them.

An important adaptation of the green building concept applies to ecosystem services. For example, the approach assists in reducing high air and surface temperatures resulting from climate change. Minimal removal of vegetation helps cool the air by providing shade and enhancing evapotranspiration.[29] This provides two benefits: reduced energy use and improved thermal comfort. The green roofs approach is useful in this regard. For example, Santamouris[30] found that green roofs often reflect more sunlight than conventional rooftops. The cooling and insulation of green roofs depend on the time of the day, season, climatic conditions and the volume of

C40 NETWORKS BY INITIATIVES AND GOOD PRACTICE CASES

As highlighted in Chapter 1, the C40 network is one of the global players in the climate change space. A number of C40 networks are available and those that were active at the time of writing are reflected in Figure 2.1.

Figure 2.1: C40 Current Networks by Initiative



At the time of this writing, there were 17 networks with a mandate on climate mitigation and adaptation as well as other sustainability topics, as prioritised by the C40 network. The mandate was based on concerns that have the potential to significantly intervene in cases of adverse climate impacts. These networks aim to further the mission of the C40, as outlined in Chapter 1. At the time of writing, there were six active networks (Figure 2.1):

i. The Adaptation Initiative with sub-initiatives focusing on Climate Risk Assessment, Connecting Delta Cities and Cool Cities;
ii. The Energy and Building Initiative with Municipal Building Efficiency and Private Building Efficiency as sub-initiatives;
iii. The Business, Data, and Innovation Initiative with the single Green Growth sub-initiative;
iv. The Transportation Initiative driving sub-initiatives that include Bus Rapid Transit (BRT) systems Low Emissions Vehicles and Mobility Management;
v. The Waste and Water Initiative focusing on Sustainable Solid Waste Sys-

under the Adaption Initiative and cities where some of the practices are in place.

Table 2.2: Good Practices in the Adaptation Initiative

Adaptation Initiative/Network	***City and Nature of Good Practice***
Connecting Delta Cities	• **Rotterdam:** Climate Change Adaptation Strategy • **Ho Chi Minh City:** Triple-A Strategic Planning • **Jakarta:** Socially Inclusive Climate Adaptation for Urban Revitalisation Project • **Copenhagen:** Cloudburst Management Plan • **Hong Kong:** Storm Water Storage Scheme • **New Orleans:** Greater New Orleans Urban Water Plan • **Jakarta:** Jakarta Coastal Defence Strategy and Flood Mapping • **London:** Optimised Portfolio of Water Supply Options • **Singapore:** Marina Barrage • **Tokyo:** Super Levees • **London:** Thames Estuary 2100 Plan • **New York:** Mitigation Banking Program • **Melbourne:** Coastal Adaptation Pathways Project • **Copenhagen:** Public-private Finance Scheme
Cool Cities	• **London:** Greening the BIDs • **Tokyo:** Thermal barrier Coating and Water-retentive

Table 2.3: Good Practices in the Energy and Buildings Initiative

Adaptation Initiative/Network	*City and Nature of Good Practice*
Municipal Building Efficiency	• Houston: Open energy performance data – municipal buildings • New York City: Data-driven approach to municipal building efficiency • Toronto: Energy Conservation and Demand Management Plan; • Hong Kong: Energy Saving Plan 2015-2025+ • Washington DC: Green Code and energy efficiency certification • Houston: Open tender Energy Savings Performance Contracting • Paris: Public-private co-management ESPC for school retrofits; • London: ESPC co-ordination by a dedicated RE:FIT programme delivery unit • Wuhan: Wuhan New Energy Research Institute • Stockholm: Green IT Strategy • Tshwane: Specialist Assistance Sustainability Unit • Stockholm: Energy centre for expert support to energy efficiency measures • City of Cape Town: Customised training and awareness raising

Table 2.4: Good Practices in the Transport Initiative

Adaptation Initiative/Network	*City and Nature of Good Practice*
Bus Rapid Transit	• Rio de Janeiro: TransOeste BRT • Guangzhou: BRT Corridor • Istanbul: Metrobüs system • Buenos Aires: Stakeholder management for BRT Corridors • Tshwane: Stakeholder engagement in A Re Yeng (BRT system) • Curitiba: BRT Modernisation • Johannesburg: Green Bond
Low Emissions Vehicles	• Shenzhen: New energy vehicles (including electric buses) • Kyoto: Managed charging • Koto City: Electric vehicle (EV) ready buildings • Amsterdam: Battery sizing • Hangzhou: Battery swapping • US Cities: International Council on Clean Transport Report • Oslo: Incentives programme • London: Charging zones to promote ultra-low-emission vehicles (ULEVs); • Paris: Autolib • Brussels: Logistics

Table 2.5: Good Practices in the Waste and Water Initiative

Adaptation Initiative/Network	***City and Nature of Good Practice***
Sustainable Solid Waste Systems	• Durban: Buffelsdraai landfill closed loop system • Wuhan: Jinkou landfill restoration • Delhi: Energy recovery • Dhaka: Composting project • Bogota: Zero Waste Programme • Lagos: Private sector participation • Mexico City: barter market for recyclables • Bengaluru: Digital mapping in waste collection • Buenos Aires: Municipal Solid Waste Reduction Project
Waste to Resources	• San Francisco: Zero Waste by 2020 • New York City: Zero Waste NYC • Milan: Integrated Waste Collection System 2012-2014 • Oslo: Waste Management Strategy • Berlin: Sustainable public procurement • Oakland: Zero waste programme; private-public partnership • Houston: Reuse Warehouse • Yokohama: 3R Dream Plan • Hong Kong: Food and Yard Waste Plan • London: FoodSave scheme

The last sub-initiative and network is Transit Oriented Development (TOD), which 'supports city efforts to deliver compact, walkable, mixed-use communities centred on high-quality public transport'.[53] There are four focus areas for this initiative led by the City of Tshwane: financing, social equity, public engagement and active mobility. The Institute for Transportation and Development Policy has produced a TOD standard identifying eight urban design and land use principles for cities planning on delivering TOD. These principles are walk, cycle, connect, transit, mix, density, compact and shift.[54] Some of the good practices profiled by the C40 in this main initiative are shown in Table 2.6

Table 2.6: Good Practices in the Urban Planning and Development Initiative

Adaptation Initiative/Network	*City and Nature of Good Practice*
Climate Positive Development	• Stockholm: Royal Seaport • London: Elephant and Castle • Sydney: Barangaroo South • Jaipur: Mahindra World City

Table 2.7: Carbon Dioxide Equivalent Emissions (CO_2e)

City (Year)	*Population (Millions)*	*CO_2e (Million tonnes/ year)*	*Sources of Carbon Emissions*		
			Station-ary (%)	Trans-port (%)	Waste (%)
Accra (2015)	2.27	2.321	27	31	43
Addis Ababa	3.27	-	-	-	-
Cape Town	3.84	-	63	26	12
Dar es Salaam	4.36	-	-	-	-
Durban (2010)	3.56	25.962	70	28	2
Johannesburg (2014)	4.76	24.72	64	29	7
Lagos (2014)	17.6	29.43	-	-	-
Tshwane (2014)	3.2	15.24	45	16	39

Source: Authors, based on C40 data[57]

From Table 2.7 it emerges that Durban is one of the advanced cities in terms of its carbon accounting. Its baseline was set in 2010 as 25.962 million

CONCLUSION

It is indisputable that altering the nature and scope of anthropogenic activities is key to retarding the rate and even halting climate change. The desired alterations cover a range of human practices and require adopting and learning new ways of living. In this chapter, we examined the practices in a built environment, adopting a lifecycle approach to enable a systemic analysis. What emerges is a world that acknowledges the role of the built environment in the space of managing climate change from a narrow perspective and advancing the broad objectives of sustainable development from a broad perspective. The world not only acknowledges the influence of the built environment in these regards but also increasingly ensures that acknowledgements move beyond mere rhetoric and become routine in both policy and practice. Moving beyond rhetoric is important because climate change threatens almost all key areas of human existence. Consequently, all the facets of human existence should adjust to deliver a systemic change. It is important that the appropriate adjustments be pragmatic so as to deliver an environmentally, socially and economically viable green construction industry that in turn gives rise to greater sustainable built environments.

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