Architectural Trends to Face Climate Change

Fathea. A. Gumma
Department of Architecture and Urban Planning,
Faculty of Engineering, University of Benghazi

Abstract:

In the context of ongoing climate change on Earth, architecture faces significant obstacles and tremendous challenges in addressing this phenomenon. Numerous studies and research indicate that human activity, coupled with technological advancements, is one of the main drivers of climate change. Buildings, in particular, contribute significantly to energy consumption, leading to carbon emissions that cause global warming. This necessitates that specialists in architecture and related fields reconsider and reformulate architectural concepts and reshape the built environment to align with indicators of life quality and sustainability on Earth. These concepts should be flexible and adaptable to climate changes while mitigating their adverse impacts.

Based on this perspective, the study aims to shed light on a range of architectural trends designed to confront and adapt to climate change, which could serve as foundational principles and criteria for building healthy and safe urban communities.

Keywords: Climate Change, Human Activities, Global Warming, Architectural Trends,, Green Architecture.

الملخص:

في ظل التغير المستمر للمناخ على كوكب الأرض تواجه العمارة عقبات كبيرة وتحديات عظيمة لمواجهة هذا التغير المناخي. حيث تشير العديد من البحوث والدراسات الي ان النشاط الإنساني في ظل التقدم التكنولوجي هو أحد الأسباب الرئيسية في التغيرات المناخية، حيث تساهم المباني في استهلاك الطاقة بمعدلات كبيرة مما ينجم عنها انبعاث الكربون المسبب لظاهرة الاحتباس الحرارى. الأمر الذى يلزم المتخصصون في العمارة ومجالاتها المختلفة إعادة التفكير والنظر الي تغيير المفاهيم الخاصة بصناعة العمارة وإعادة تشكيل البيئة المبنية بما يتوافق مع مؤشرات جودة الحياة واستدامتها على كوكب الأرض. بحيث

تكون هذه المفاهيم مرنة وقابلة للتكيف مع التغيرات المناخية والتخفيف من تأثيراتها السلبية. من هذا المنطلق جاءت الدراسة لتسليط الضوء على مجموعة من التوجهات المعمارية لمواجهة التغيرات المناخية والتكيف معها، والتي من الممكن أن تكون بمثابة أسس ومعايير لبناء مجتمعات عمرانية صحية وآمنة.

الكلمات المفتاحية: التغيرات المناخية- الأنشطة البشرية- الاحتباس الحرارى- الاتجاهات المعمارية- العمارة الخضراء.

Introduction:

The architecture of our planet faces immense and critical challenges amidst continuous climate changes. Climate change refers to significant alterations in the metrics of climatic elements, such as temperature, precipitation, or wind patterns, persisting for decades or longer. Earth's climate has changed multiple times throughout the planet’s history. According to the latest report by the Intergovernmental Panel on Climate Change (IPCC), the world could reach a global warming threshold of 1.5°C as early as 2030. Beyond this point, conditions are expected to deteriorate unless collective efforts are made to address climate change and mitigate its severe impacts (IPCC, 2020).Scientists warn that the consequences of climate change—extreme temperature increases worldwide, excessive rainfall in some areas, and heightened drought risks in others—will affect various aspects of life, including health, food production, the environment, urban areas, society, and the economy (The Royal Society and The US National Academy of Sciences, 2020). This is evidenced by the growing frequency and intensity of natural disasters such as wildfires, superstorms, droughts, floods, mass extinctions, and pandemics, all threatening life on Earth.

Human activities, particularly with technological advancements, are among the primary contributors to climate change. Buildings alone account for approximately 33% of global energy consumption, leading to significant carbon emissions and making them the largest source of sectoral emissions globally (Walsh, 2021). These ongoing climate changes present an urgent challenge that already impacts people and the environment worldwide. This situation compels specialists in architecture and its related fields to rethink and reformulate architectural concepts and reshape the built environment to align with life quality and sustainability indicators on Earth. These concepts must be flexible, adaptive to climate changes, and capable of mitigating their negative impacts. The architectural community, in its various disciplines, is deeply intertwined with the flows of materials, energy, and ideas related to climate change—both as a cause and a solution.

Study Objectives

The primary aim of this study is to highlight a range of architectural trends designed to confront and adapt to climate change, serving as foundational principles and criteria for creating healthy and safe urban communities.

Study Structure

The study is organized as follows:

1. Climate Change: Concepts, Indicators, and Causes.
2. Risks and Impacts of Climate Change.
3. Architectural Trends for Addressing and Adapting to Climate Change.
4. Conclusion.

1. Climate Change

Climate change describes variations in key climatic elements—temperature, rainfall, wind, and humidity—that have occurred recently compared to long-term averages, whether daily, monthly, or yearly. It is primarily linked to rising temperatures (Al-Sayed, 2019). Climate change is defined as an imbalance in the typical climatic conditions of any part of Earth, involving changes in temperature, humidity levels, rainfall, and wind speeds. Since the Industrial Revolution, greenhouse gas emissions have increased significantly beyond pre-industrial levels, raising Earth's average temperature by 0.76°C from its pre-industrial level of 18.5°C (IPCC, 2020). This has caused thermal imbalances, leading to global warming and the subsequent impacts on various aspects of life on Earth.

Greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and water vapor, form a protective atmospheric layer that maintains Earth's thermal balance essential for life. These gases trap some of the Sun's energy, warming the planet and moderating its climate. While these gases are not pollutants per se, they significantly contribute to global warming (Agency, 2018). Carbon dioxide is the most influential greenhouse gas, primarily produced by burning coal, oil, and natural gas in construction activities, energy plants, and vehicles. Deforestation exacerbates the issue by reducing the planet's capacity to absorb CO_2, as forests play a vital role in purifying the atmosphere of gas pollutants, especially carbon dioxide (Al-Sayed, 2019). Methane, another potent greenhouse gas, is emitted from rice fields, livestock farming, landfills, and gas pipeline operations. Nitrous oxide, released from fertilizers and other chemicals, also contributes to heat retention (Ahmad Salahuddin Shiba Al-Hamd, 2021).

1.1. Indicators of Climate Change

The recent United Nations climate report confirms that climate change has become rapid, intense, and widespread. It is expected to continue on an upward trajectory, further impacting human life by increasing the frequency of extreme weather and climatic events. According to a study conducted by the World Meteorological Organization (WMO) on climate change, new records were set in 2021 for key climate indicators such as greenhouse gas concentrations, temperatures, extreme weather, sea levels, ocean warming and acidification, glacial retreat, and ice melt. The study also highlighted the socio-economic impacts of these changes (World Meteorological Organization (WMO), 2021). One of the report's key findings is that the past seven years, including the current one, are on track to be the warmest seven years since the beginning of weather record-keeping in the 19th century. Based on data from the first nine months of 2021, it is anticipated that the year will rank among the warmest on record (Al-Gharbi., 2021). The most significant climate indicators can be summarized as follows:

- ✓ **Rising Greenhouse Gas Concentrations to Unprecedented Levels:** The Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report emphasizes that future greenhouse gas emissions from human activities will determine the extent of temperature rise, climate change intensity, and associated risks. The report indicates that greenhouse gas concentrations reached unprecedented levels in 2021. Consequently, the global average temperature (based on data from January to September) rose by approximately 1.09°C above the 1850–1900 baseline (IPCC, 2020). If this trend continues, the impacts on natural water cycles, vegetation cover, and oceans could be catastrophic, leading to accelerated ice melt, rising sea levels, extreme heatwaves, droughts, heavy rainfall, tropical cyclones, and floods (National Centers for Environmental Information, 2020).
- ✓ **Rising Sea Levels**: The WMO report also highlights an increasing rate of sea-level rise since the early 1990s. The average global sea-level rise was approximately 2.1 mm annually between 1993 and 2002 but doubled to 4.4 mm annually between 2013 and 2021. This rise is largely attributed to the accelerated loss of ice mass from ice sheets and glaciers caused by global warming, which adds substantial amounts of water to the oceans. For instance, the Arctic Sea ice extent in March (when it typically reaches its maximum) was below the average recorded during 1981–2010 (World Meteorological Organization (WMO), 2021).
- ✓ **Ocean Warming and Acidification**: Studies have shown that oceans, which absorb about 23% of human-induced carbon dioxide emissions annually, have become more acidic. The pH of the oceans has decreased to its lowest level in at least 26,000 years

over the past four decades. This reduces the oceans' ability to absorb atmospheric carbon dioxide, presenting another clear sign of how human activities are causing planetary-scale changes on land, in oceans, and in the atmosphere, with harmful and long-lasting implications for sustainable development and ecosystems (IPCC, 2018).

- ✓ **More Heat, Drought, and Wildfires**: Nearly all regions outside the polar areas have experienced an increase in extreme heatwaves since the 1950s. These events now occur five times more frequently than they did between 1850 and 1900 (Al-Gharbi, 2021). Recent unprecedented heatwaves in North America and the United Kingdom exemplify this trend. Studies confirm that such extreme events would not have occurred without greenhouse gas emissions resulting from human activities. Additionally, warming has exacerbated drought in some regions. Droughts that previously occurred once per decade now happen 70% more frequently compared to the pre-industrial era. Moreover, studies have established a link between climate change and the rising frequency and scale of wildfires around the Mediterranean, southern Europe, North America, and Australia (World Meteorological Organization (WMO), 2021).
- ✓ **Severe Storms and Floods;** Storms and severe flooding are becoming more frequent compared to past heavy rainfall events, which used to occur once a decade. This phenomenon is now 30% more common, leading to urban drainage systems being overwhelmed, rivers rising, and flooding occurring more often. Such events result in loss of life and extensive damage to infrastructure (IPCC, 2018).

1.2. Causes of Climate Change

Numerous studies identify both natural and anthropogenic factors as drivers of climate change. However, most of the changes in the current era are attributed to human activities. Understanding the causes of climate change is critical to raising public awareness, conducting theoretical research, fostering feedback mechanisms, and simulating models. Furthermore, it facilitates the exchange of information among experts and policymakers to develop applicable and effective adaptation and mitigation strategies (David R. Easterling, 2018).

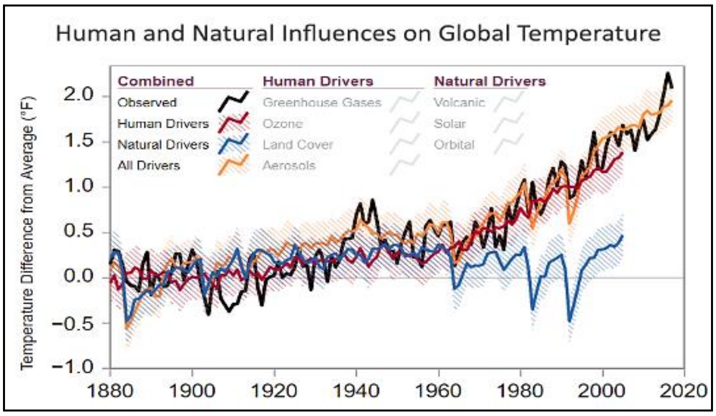

Figure 1: Human and Natural Influences on Global Temperature

1.2.1. Anthropogenic Causes

Human activities have significantly altered the Earth's surface composition, releasing large amounts of greenhouse gases into the atmosphere and substantially contributing to climate change. The main human-induced causes include:

- ✓ **Deforestation**: Forests play a vital role in the Earth's climate system, primarily by capturing atmospheric carbon dioxide through photosynthesis. Acting as natural carbon sinks, forests absorb more carbon than they emit. However, deforestation for agriculture, pastures, infrastructure, or urban expansion halts the net carbon flow from the atmosphere to forests, leading to carbon emissions stored in trees and forest soil (Food and Agriculture Organization of the United Nations(FAO), 2011). This has resulted in unprecedented increases in atmospheric carbon dioxide in recent years, directly affecting surface temperatures and causing catastrophic phenomena such as extreme rainfall followed by prolonged droughts (IPCC, 2020).

- ✓ **Land-Use Changes:** Changes in land use and intensification of land utilization have contributed to desertification and land degradation. Unsustainable land management and usage have also caused adverse economic effects. Converting forests and peatlands into emission zones for stored carbon in biomass and soil contributes an additional 10–15% of total global carbon dioxide emissions (Fakana, 2020).
- ✓ **Urbanization**: While urbanization drives economic development, unplanned urbanization can negatively impact economies, lead to deforestation, and exacerbate global warming and climate change. Urban expansion intensifies warming in cities (urban heat islands), enhances extreme rainfall events, and alters wind patterns in urban areas, increasing associated risks. Major urbanization-related contributors to climate change include:
- ✓ **Energy Production;** Although alternative energy sources are emerging, most electricity is still generated by burning coal, oil, or gas, which emits significant greenhouse gases like carbon dioxide and nitrous oxide. Globally, over a quarter of electricity is derived from renewable sources like wind and solar power, which emit minimal greenhouse gases compared to fossil fuels (United Nations Human Settlements Programme, 2011).
- ✓ **Industry:** Manufacturing industries are among the largest contributors to global greenhouse gas emissions due to their reliance on fossil fuels for energy production in the creation of materials like cement, steel, plastics, and electronics. Construction and mining activities also release significant amounts of greenhouse gases (United Nations, 2022).

- ✓ **Transportation:** Transportation is a major source of greenhouse gas emissions, primarily from road vehicles, ships, and airplanes. It accounts for nearly a quarter of global carbon dioxide emissions related to energy use, with trends indicating increased energy demands for transportation in the future (Met Office, 2020).
- ✓ **Agriculture:** Food production processes, including deforestation for agriculture, livestock rearing, and fertilizer use, release substantial amounts of carbon dioxide, methane, and other greenhouse gases (Fakana, 2020).
- ✓ **Energy Use in Buildings:** Increased energy demands for heating, cooling, lighting, and appliance use have led to higher carbon dioxide emissions from buildings. Residential and commercial buildings consume over half of global electricity, much of which relies on fossil fuels (United Nations, 2022).

1.2.2. Natural Causes

Although human activities are the primary driver of climate change, several major natural factors also influence the climate system, including:

- ✓ **Solar Intensity:** Climate is affected by natural variations in the amount of solar energy reaching Earth's surface. Changes in the Sun itself can alter the intensity of sunlight that reaches the planet. The amount of thermal energy received at any location on Earth directly depends on the angle of the Sun, which varies by location, time of day, and season due to Earth's orbit around the Sun and its axial rotation (Fakana, 2020). Variations in solar energy output can influence our climate directly, by altering Earth's and the atmosphere's heating rate, or indirectly, by affecting cloud formation processes. Increased solar intensity can lead to warming, while decreased solar intensity can result in cooling (IPCC, 2018).

- ✓ **Volcanic Eruptions:** Volcanoes emit some greenhouse gases, such as carbon dioxide (CO_2), but the amount is 50 times less than that produced by human activities, making them a minor contributor to global warming. Conversely, volcanic eruptions can have a cooling effect on Earth's climate. Small particles known as aerosol particles released during eruptions contribute to cooling the planet. Hence, the predominant effect of volcanic eruptions is cooling rather than warming (Met Office, 2020).
- ✓ **Milankovitch Cycles**: These are slight changes in Earth's axial tilt and orbital path around the Sun. These variations affect the amount of sunlight received by Earth, causing temperature changes. However, these cycles occur over tens or hundreds of thousands of years, making it unlikely that they are responsible for the rapid climate changes observed today (The Royal Society and The US National Academy of Sciences, 2020).
- ✓ **Southern Oscillation Phenomenon:** This climatic cycle results from the variable temperature patterns of the Pacific Ocean. The warming phase is known as El Niño, while the cooling phase is La Niña. These patterns affect global temperatures for short periods, lasting months or years, but do not explain the ongoing warming observed today (Met Office, 2020).

2. Risks and Impacts of Climate Change

Recent reports on climate change emphasize that continued global warming, altered precipitation patterns, and increased drought frequency will have significant social, economic, and environmental impacts, threatening life on Earth (National Centers for Environmental Information, 2020).

2.1. Risks of Climate Change

- **Persistent Temperature Rise**: As greenhouse gas concentrations increase, Earth's surface temperatures continue to rise. The decade from 2011 to 2020 was the warmest on record, with each decade since the 1980s being warmer than the one before. Almost all land regions are experiencing more hot days and heatwaves. High temperatures exacerbate heat-related illnesses, make outdoor work more challenging, and intensify wildfires, which spread more rapidly in hotter conditions (World Meteorological Organization (WMO), 2021).

- **More Intense Storms:** Destructive storms have become more frequent and severe in many regions. As temperatures rise, more moisture evaporates, leading to heavier rainfall and worsening floods, contributing to more devastating storms. The frequency and intensity of tropical storms are influenced by rising ocean temperatures. Warm surface waters fuel hurricanes, cyclones, and typhoons, which often destroy homes, displace communities, and cause fatalities and significant economic losses (United Nations Human Settlements Programme, 2011).
- **Increased Drought:** Global warming raises the risk of environmental drought, weakening ecosystems and transforming many areas into deserts. Recently, 1% of the total land area was classified as experiencing extreme drought, a figure projected to rise to 30% by 2100. Water stress is also expected to intensify due to changes in precipitation patterns, reducing water supply and quality while increasing demand. These challenges negatively impact agricultural land and food production (IPCC, 2020).
- **Ocean Warming:** As oceans absorb most of the heat from global warming, their volume increases due to thermal expansion. Melting ice sheets also contribute to rising sea levels, threatening coastal and island communities. Additionally, oceans absorb carbon dioxide, preventing it from entering the atmosphere. However, increased CO_2 levels make oceans more acidic, endangering marine life and coral reefs (IPCC, 2020).

2.2. Impacts of Climate Change

- **Loss of Biodiversity:** Climate change poses significant risks to the survival of biodiversity on land and in oceans. These risks are exacerbated by rising temperatures, changing rainfall patterns, and increased drought frequency. Scientific studies highlight that numerous plant and animal species will face extinction in the future, as the rate of biodiversity loss is occurring 1,000 times faster than at any other time in recorded human history. While some species may adapt and migrate to survive, many others will not be able to do so (United Nations, 2022).
- **Food Scarcity:** Climate change has contributed to rising food shortages, leading to increased hunger and malnutrition, particularly in poor countries lacking the means to mitigate its effects. Growing sufficient food will become increasingly challenging in some areas, with climate shifts altering which crops can thrive in different regions. While some areas may benefit from the ability to grow new crops, many regions—particularly in warmer countries—are expected to experience declines in crop yields, severely impacting social stability.

Additionally, the acidification of oceans threatens marine resources that billions of people rely on for food. Changes in Arctic ice cover have disrupted food supplies from grazing, hunting, and fishing activities. Heat stress will also reduce available water and grasslands for grazing, leading to lower crop yields and negatively affecting livestock production (Food and Agriculture Organization of the United Nations(FAO), 2011).

- **Health Risks:** Climate change is the most significant health threat humanity faces today. Air pollution, disease outbreaks, extreme weather events, forced displacement, mental health pressures, and increased hunger and malnutrition in areas struggling to produce sufficient crops contribute to this crisis. Annually, nearly 13 million deaths are attributed to climate change-related causes. The World Health Organization (WHO) estimates that climate change will cause approximately 529,000 deaths by 2050. Furthermore, 2 billion people will be at risk of climate-related diseases, and 600 million more will suffer from malnutrition by 2080 (World Meteorological Organization (WMO), 2021).

- **Poverty and Displacement**: Climate change exacerbates poverty rates by destroying urban slums, homes, infrastructure, and livelihoods through flooding. Water scarcity from droughts further compounds the issue. Over the past decade (2010–2019), weather-related events displaced an average of 23.1 million people annually, leaving many more vulnerable to deeper poverty. Most refugees originate from countries that are least prepared to adapt to the impacts of climate change (United Nations Human Settlements Programme, 2011).

3. Architectural Approaches to Address and Adapt to Climate Change

Current projections indicate that climate changes will continue and intensify in the future, necessitating urgent global action to mitigate risks such as extreme heat, droughts, floods, and poverty. Architecture, as one of the leading contributors to emissions and resource consumption, must evolve to confront these challenges. The industry accounts for 33% of global CO_2 emissions, consumes 50% of raw materials, 40% of energy, 25% of timber, and 17% of water (Smith, 2005). This significant impact underscores the need for architects and related professionals to rethink conventional practices, redefine architectural principles, and reshape the built environment to align with sustainability and adaptability standards. The focus should be on creating flexible and climate-resilient designs that mitigate adverse effects and minimize the root causes of climate change. With the 2018 UN report warning humanity of less than 12 years to slow down global warming ((United Nations, 2022), architecture is among the industries pushed to reassess its practices. Efforts include reducing waste, maximizing urban green spaces, and advocating for systemic change (IPCC, 2018). Below are key architectural approaches for tackling climate change:

3.1. Retrofitting Existing Buildings

Retrofitting focuses on improving energy efficiency and thermal performance in existing structures while reducing reliance on heating and cooling systems. It also extends the life of a building, keeping embodied carbon in use longer and delaying emissions from demolition. This approach prioritizes enhancing existing building stock over new construction, reducing the carbon footprint associated with demolition and rebuilding (Melton, 2020). Architectural strategies for retrofitting emphasize reducing operational energy consumption, as demolition and reconstruction have significant carbon footprints. According to (Walsh, 2021) upgrading existing buildings to meet high energy performance standards is one of the most effective short- and medium-term solutions for reducing carbon emissions.

– **Moonshine House as a Retrofitting Model**

Originally built in 2002 as a traditional school in a rural setting, the Moonshine House was converted into a home by architect Taylor. The house underwent a comprehensive retrofit to improve its environmental performance while retaining its historical character. The Key retrofit measures included: Replacing the timber extension's exterior cladding, adding layers of insulation to walls and covering several large windows with plywood replacing the remaining windows with high-performance glass and using black corrugated steel for external cladding and roofing. Despite living in the house for over two decades, Taylor recognized the need for substantial updates to align with sustainable practices and materials suited to the natural environment. Upon completion in 2020, the British architectural journal Architects' Journal recognized the project as the Small Project of the Year, praising its sustainability improvements (Melton, 2020). This example demonstrates how retrofitting can transform existing buildings into more sustainable structures while preserving their cultural and historical significance.

Figure 2: Moonshine House as a Retrofitting Model

3.2. Rebuilding Approach

Rebuilding refers to the creation of buildings that can be dismantled, meaning their components can be reused in other projects. This approach aligns with the goals of the circular economy — a closed-loop system where all materials are reused to eliminate waste (Smith, 2005). In recent years, rebuilding has gained significant attention as awareness grows about the disappearance of natural ecosystems due to increasing climate change, along with the biodiversity that sustains life on Earth. Rebuilding is seen as a way to restore ecosystems, allowing nature to function with minimal human intervention. For architects, this approach offers an opportunity to consider biodiversity in their designs and material choices, ensuring that extraction and manufacturing do not deplete natural resources. Urban rebuilding strategies aim to enhance biodiversity while improving the health and well-being of citizens (Crook, 2021).

– **Dut18 Project as a Rebuilding Model**

The Dut18 Project involves the transformation of a Dutch agricultural barn into a holiday home in the English countryside. Architect Carl Turner, in collaboration with the creative agency Accept & Proceed, undertook this project, which features a repurposed barn surrounded by rebuilt wildflower meadows. The barn, designed to accommodate large groups and families, provides expansive living spaces and views of the surrounding landscape.

The layout includes: Ground floor: Divided into three main areas — a yoga-cinema zone, an open kitchen-dining room, and a living room. These spaces are interconnected with the outdoors, offering a large surface area for socializing and relaxation. A spacious double bedroom, a wet room, and utility areas are also on this floor. The First floor: Features six large bedrooms, arranged around a central hallway, along with three large bathrooms. Two of the bedrooms are double-height, and there is also a large rest area at the top of the stairs, with stunning views of the surroundings. The Dut18 Project demonstrates how an existing building can be transformed into a sustainable, multifunctional space, incorporating the principles of rebuilding and enhancing both human and ecological well-being (Crook, 2021).

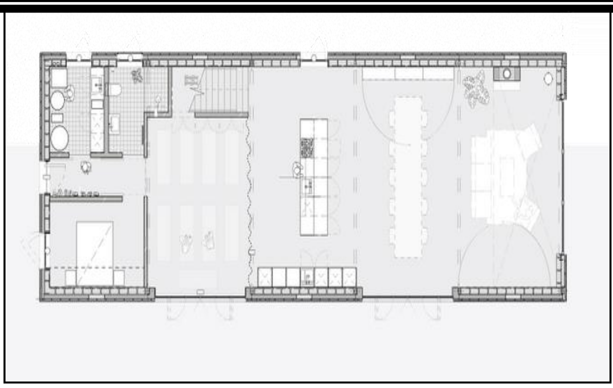

Figure 3: Dut18 Project as a Rebuilding Model

3.3. Use of Carbon-Neutral Materials in Construction

The production of steel and concrete has a significant impact on global warming, with the carbon footprint of these materials being referred to as the embodied carbon of the building (Walsh, 2021). Reducing the embodied carbon of buildings in the coming years is one of the key architectural trends, as it will help achieve the broad emission reduction goals recommended by global organizations. The simplest and most effective way to reduce embodied carbon in the short term is to choose an existing building and renovate it rather than demolishing and rebuilding it. In 2017, architects who tracked energy use in buildings managed to reduce expected carbon emissions by 17.8 million metric tons of CO_2 annually, which is equivalent to planting 21 million acres of forest ((Crook, 2021). To reduce embodied carbon in new construction, we need to minimize our use of the materials that emit the most, such as concrete, steel, aluminum, and insulation materials. This can be achieved by optimizing construction systems to ensure that more materials are not used than necessary, and by opting for alternatives such as smart carbon materials (Melton, 2020).

– **Zero Carbon Park as a Model for Carbon-Neutral Construction**

The Zero Carbon Park by Ronald Lu & Partners is Hong Kong’s first project to achieve zero carbon emissions, a challenging feat in a hot, humid climate while ensuring the comfort of its users. The project addresses the urgent need for action to reduce greenhouse gas emissions and is designed specifically for the subtropical, high-density, hot, and humid urban conditions of Hong Kong. Zero Carbon Park includes a visitor education center, a green office for the Hong Kong Construction Industry Council, a low-carbon living house, a multi-functional room, and Hong Kong’s first local urban forest. The park also features outdoor spaces designed for events and landscaping.

This park serves as a global example of energy-efficient, low-carbon buildings, acting as both a living sustainability platform and an educational tool for the public. The park's design and implementation demonstrate how cities can move toward carbon-neutral construction while enhancing urban environments.

Figure 4: Zero Carbon Park as a Model for Carbon-Neutral Construction

3.4. Green Architecture

Green architecture, also known as sustainable architecture, is the science, method, and system of designing and constructing buildings in ways that respect the environment and value natural resources. Its goal is to reduce the negative impacts on the health of building occupants and the surrounding nature (Ahmad Salahuddin Shiba Al-

Hamd, 2021). Although the concept of green architecture may seem new, it has been present for centuries, especially in ancient cities. This can be observed in traditional Arab architecture through design elements used to mitigate and adapt to climate conditions, such as courtyards, wind towers, and built mashrabiyas that provide natural ventilation and cooling for indoor spaces. However, in recent years, the concept of sustainability has gained popularity, with serious attempts to build energy-efficient buildings that are more desirable to live in. Many believe that simply using green roofs and placing solar panels on a building's roof makes it a "green building." Green architecture reflects buildings that last a long time without consuming large amounts of natural resources and energy, whether in construction or operation (El-Shimy, 2016). Sustainable building processes often incorporate passive design, which takes advantage of the climate to maintain a comfortable indoor temperature range and reduces or eliminates the need for additional heating or cooling. This not only saves money and energy but does so without the need for additional technical costs. One of the key resources to conserve when designing an eco-friendly building is water. An innovative way to conserve water is through rainwater harvesting systems, where containers are used to capture rainwater, which is then recycled. Additionally, attention must be given to using natural ventilation and daylighting techniques to enhance indoor environmental quality, as a good indoor environment protects the health of the building's occupants, reduces stress, and improves their quality of life (Altomonte, 2008).

- **The Sustainable Landscape Center as a Model for Green Architecture**

The Sustainable Landscape Center is a significant example of green architecture. It is a facility for education, research, and management at the Phipps Conservatory and Botanical Gardens in Pittsburgh. The project has received four green building awards: the Building Vitality Challenge, LEED Platinum, Platinum Award for Good Buildings, and a Four-Star Certification for Sustainable Sites. By employing site studies, the design maximizes natural daylighting, solar energy, and ensures natural ventilation across all seasons. The building is distinguished by zero water waste, utilizing both rainwater and wastewater that are recycled through underground systems. This makes the project an excellent example of integrating sustainability principles into architectural design while ensuring resource conservation and enhancing environmental performance.

Figure 5: The Sustainable Landscape Center as a Model for Green Architecture

3.5. Architecture mitating Nature

Another approach architecture can take to combat climate change is biomimicry, a design approach that imitates natural systems, such as coral reefs. This method can lead to highly efficient structures that reduce the use of energy-consuming materials, while also enabling the replication of beneficial processes, such as how plants use photosynthesis to convert atmospheric carbon into cellulose and other compounds (Melton, 2020). According to architect Michael Pawlyn, entire cities could help combat climate change by removing carbon from the atmosphere by mimicking the process of biomineralization, through which life forms like marine microorganisms transform carbon into limestone and other carbon-rich minerals. Pawlyn stated: "We need to find ways to use materials that remove carbon from the atmosphere. Can we learn from biology to design a built environment with a net positive impact?" (Melton, 2020).

– **The Algae Curtain as a Model for Biomimetic Architecture**

The Algae Curtain is a form of nature-inspired design. It was developed by EcoLogicStudio, a London-based architectural firm, which harnessed the process of photosynthesis in algae to purify air using a living curtain or urban curtain designed for attachment to building facades. This innovative curtain functions as a biophotovoltaic reactor—a habitat for algae that naturally sequesters carbon through photosynthesis. The microalgae feed on sunlight and air, capturing carbon dioxide particles and storing them within the curtain while releasing oxygen back into the atmosphere. This curtain enhances this natural process, capturing approximately one kilogram of carbon dioxide per day, which is equivalent to the carbon absorption of 20 large trees. EcoLogicStudio envisions the integration of the algae curtain into both new and existing buildings, where it can also function as a sunshade. The firm presented a prototype of this model at the Climate Innovation Summit in Dublin in November 2018, where the installation was displayed on the first and second floors of the main facade of the Printworks Building in Dublin Castle (Melton, 2020). This project exemplifies how architecture can be inspired by natural processes to create structures that contribute positively to the environment by capturing carbon and reducing pollution.

Figure 6: The Algae Curtain as a Model for Biomimetic Architecture

Conclusion

From the above, we can conclude that climate change is one of the major challenges facing the world today, as it poses a significant threat to livelihoods, ecosystems, water resources, infrastructure, and the global economy. Governments, businesses, and communities must collaborate to control global greenhouse gas emissions in order to limit and mitigate the future impacts of climate change, avoiding the severe expected consequences that could undermine development in all its aspects. It is now more certain than ever, based on numerous previous studies, that human activity is the primary cause of the climate changes occurring on Earth. Atmospheric and ocean temperatures have risen, accompanied by rising sea levels, a significant decline in sea ice, and other climate-related changes. In return for the devastating damage caused by human activity to the climate, humans will face the consequences in the form of food shortages, additional health risks, and an increase in the number of climate change victims. Cities will face significant challenges in providing even basic services to their residents due to climate change, including water and energy shortages, industrial and service sectors, as well as stripping people of their assets and livelihoods, which could lead to mass migration in some cases. It is likely that the impacts of climate change will not be distributed evenly across different regions, cities, sectors, and social and economic groups, contributing to increased inequality. As a result, climate change will likely disrupt the social fabric of cities and exacerbate poverty.

The architecture industry plays a vital role in addressing the impact of the built environment on the planet and climate change through several strategies, including:

- **Community and Grassroots Initiatives:**
  - ✓ Forming climate action groups that bring together architects and environmental advocates.
  - ✓ Raising awareness about climate change and its effects through educational activities, lectures, and workshops.
  - ✓ Encouraging communities to demand sustainable architecture that aligns with environmental challenges and minimizes negative impacts on the environment.
- **Providing Environmentally Compatible Architectural Solutions:**
  - ✓ Adopting eco-friendly architectural trends that include the use of sustainable materials and innovative building techniques.
  - ✓ Designing buildings capable of adapting to changing environmental conditions and reducing carbon emissions.
  - ✓ Focusing on resource efficiency, such as optimizing water and energy usage, while promoting reliance on renewable energy sources.
- **Conducting Future-Oriented Research:**
  - ✓ Studying the impact of architecture on climate change through in-depth research.
  - ✓ Developing new construction techniques and materials that can adapt to future climatic challenges.
  - ✓ Exploring ways to enhance climate resilience for cities and urban communities.

Through these strategies, architecture can effectively contribute to mitigating the effects of climate change and promoting the sustainability of the built environment.

References:

Agency, E. E. (2018). *Climate Changes.* Cairo: The Ministry Of Environment.

Ahmad Salahuddin Shiba Al-Hamd, A. B. (2021). *The Impact of Climate Change on Future Architecture and the Contribution of Developing Countries in Mitigating and Preventing Damage.* Journal of Architecture, Arts, and Human Sciences.

Al-Gharbi., A.-S. M. (2021). Indicators of Climate Change. *Arabian Journal of Scientific Research*.

Al-Sayed, H. A. (2019). *"Climate Change: Its Causes and Consequences." Academic Journal of Research and Scientific Publishing.* Salmiya, Kuwait: Academic Journal of Research and Scientific Publishing.

Altomonte, S. (2008). *Climate Change and Architecture: Mitigation and AdaptationStrategies for a Sustainable Development.* Journal of Sustainable Development . doi:10.5539/jsd.v1n1p97

Crook, L. (2021). *Ten ways in which architecture is addressing climate change*. Retrieved from Ten ways in which architecture is addressing climate change.

David R. Easterling, D. W. (2018). *Our Changing Climate. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate.* Washington, DC, USA: Global Change Research Program. doi:doi: 10.7930/NCA4.2018.CH2

El-Shimy, A. R. (2016). *GREEN ARCHITECTURE: A CONCEPT OF SUSTAINABILITY.* doi:https://doi.org/10.1016/j.sbspro.2015.12.075

Fakana, S. T. (2020). *Causes of Climate Change.* Global Journals.

Food and Agriculture Organization of the United Nations(FAO). (2011). *State of the World's Forests.* Rome,: United Nations Food and Agricultural Organization.

IPCC. (2018). *Global Warming of 1.5°C.* The Intergovernmental Panel on Climate Change. doi:doi.org/ 10.1017/9781009157940.

IPCC. (2020). *Climate Change and Land.* Intergovernmental Panel on Climate Change. Retrieved from https://www.ipcc.ch/srccl/.

Melton, P. (2020). *Four ways architects can fight climate change.* The American Institute of Architects (AIA).

Met Office. (2020). *https://www.metoffice.gov.uk/weather/climate-change/causes-of-climate-change*. Retrieved from Causes of climate change.

National Centers for Environmental Information. (2020). *Global Climate Report – Annual 2020.* Retrieved from National Centers for Environmental Information: https://www.ncei.noaa.gov/

Smith, P. F. (2005). *Architecture in a Climate Change.* Burlington: Architectural Press.

The Royal Society and The US National Academy of Sciences. (2020). *Climate Change-Evidence & Causes.* Washington, DC: The National Academies Press. doi:DOI: https://doi.org/10.17226/25733

United Nations. (2022). *Causes and Effects of Climate Change.* Retrieved from https://www.un.org/en/climatechange/science/causes-effects-climate-change.

United Nations Human Settlements Programme. (2011). *Cities and the Phenomenon of Climate Change: Public Policy Directions.* London • Washington, DC: United Nations Human Settlements Programme.

Walsh, N. P. (2021, 18 Augs 2021). The Facts about Architecture and Climate Change. *archdaily*. Retrieved from https://www..com/.

World Meteorological Organization (WMO). (2021). *State of the Global Climate 2021.* Geneva: World Meteorological Organization.