

Urban Setup in Developing Countries

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Introduction

According to NASA, without major change global average temperatures will rise from 2.5° C to 4.5° C (36.5° F to 40.1° F) by 2100, meaning significant changes to human life and the environment (NASA). Rising temperatures will cause these changes such as severe flooding, affected water availability, rising sea levels, and shifts in ecosystems. Yet the “urban heat island effect” demonstrates that average annual temperatures are 1-7°F higher in cities than surrounding suburban and rural areas (Gregory & Azarijafari, 2021, para. 1), emphasizing the greater effect climate change has on urban areas and denser cities. When looking at the literature on developing countries, it is clear that these countries are lacking greatly needed resources to confront climate change. Despite this, the level of urbanization in developing areas is expected to increase to 56.9% by 2025 (Harphan & Stephens, 1991). Through new design concepts including urban forms, sustainable transportation, and density in urban areas, there is a possibility of keeping global warming at just 2.7°F (-16.3°C), as long as gas emissions are down to roughly 43% by 2030 and carbon dioxide is no longer being emitted by the early 2050’s (Plumer & Zhong, 2022). In order to seriously address climate change, we must focus on solutions for urban areas in developing countries.

Moreover, as of 2017, only 45 of the 100 largest cities have made serious climate change pledges with two-thirds of those cities lacking in their targeted emissions cuts and the other 13 without available emissions tracking in place. Some of the 45 cities included London, Tokyo, Los Angeles, New York City, and Montreal. None of these cities are in developing areas, suggesting that those that are in developing areas do not have the resources needed to promise a climate change pledge or to be a serious part of the global effort to address climate change.

In this paper I focus on urban areas in developing countries looking through the lens of social sustainability. First, I will review current literature followed by innovative practices related to providing the help and infrastructure needed to approach climate change in urban areas. This is especially important because of increasing populations in urban areas amidst a lack of research focused on climate-change related to urban design in developing countries. Urban areas currently contribute to both increasing the effects of climate change while also experiencing greater effects from climate change. In this paper, I argue that with further research and investment in innovative design, urban areas could be transformed into a solution to addressing climate change in socially sustainable ways.

Background

Climate change used to be disregarded as a small issue that would get fixed in the future, yet average global temperatures have increased by 2.2°F since 1880, with the 20th century marking the greatest changes (ever) recorded (Rosen, 2021). Extreme temperatures have been fluctuating, and we see this continue to take place as time goes on with related effects such as heavy rainfalls and sudden floodings. Rising temperatures have been evident even in this current

summer of 2022. In June 2022, it was the sixth-highest in the 143 year record at 1.57°F (NCEI, 2022). Countless countries around the world felt the immense heat as Norway beat its 1974 record for being the highest June temperature along with Japan experiencing scorching heat waves in the middle of its rainy season marking the worst documented streak of hot weather in June since 1875. The whole of Asia as well as Europe had its second hottest June on record, and several other effects of climate change were shown when China experienced severe flooding and various locations felt the heaviest downpours in 60 years. While on the other side of the world, Monterrey, Mexico, was experiencing water shortages leading to persistent droughts.

With all these consequences of climate change happening around the globe, we must recognize the special impact it is having on urban areas. These dense cities are now being pushed more than ever to find solutions to infrastructure and housing in the face of a changing climate. With 80% of the US population living in urban areas, many cities depend on infrastructure, housing, and reliable transportation. Without reliable infrastructure such as electricity, this can and will affect water treatment, transportation, and public health. These problems of lacking infrastructure and its services are especially affected by climate change, where the interconnectedness of systems in urban areas combined with the particular fragility of those in developing areas lead to decline in the wellbeing of those living in those areas (Cutter et al.) Developing areas often have insufficient construction plans and designs, which lead to inadequate housing on exposed slopes, poor structural quality of community areas, and poor quality flooring and building. Therefore, heavy rains can result in flash floods that destroy countless homes and even whole neighborhoods without sufficient systems to address these issues as they arise—particularly as they arise more and more frequently in the face of climate change. For example, developing areas such as Caracas, Venezuela, suffered thousands of casualties where as many as 19,000 people died, due to flash floods that were the repercussions of Venezuela’s hazardous urban design (Campbell-Lendrum & Corvalán). In just two days on December 14 to 16 in 1999, the floods critically damaged electricity, water and whole sewage systems with climate change being the ultimate cause of all this damage.

As climate change becomes more prevalent in society, carbon dioxide emissions have increased and will continue to rise up to 600 ppm by 2050. Urban areas are the main contributors to Co2 emissions, making up roughly about 70% of the gas emissions (Ribeiro et al., 2019). Once we learn how to navigate through urbanization and turn it into a positive influence, we can learn to manage our emissions and ultimately help against climate change. Urban areas are one of our biggest problems and yet could become our biggest solution in addressing climate change as will be demonstrated in this paper.

Defining Social Sustainability

Social sustainability is often overlooked as a “less important” idea, and is most always placed below economic sustainability (referring to “practices that support long-term economic growth without negatively impacting social, environmental, and cultural aspects of the

community”) (UMW) and environmental sustainability (“the responsibility to conserve natural resources and protect global ecosystems to support health and wellbeing, now and in the future.”) (Sphera, 2020, para. 3). Once we take a look at some definitions and what it means for us, we can start to understand that the social aspect of sustainability is just as important. Social sustainability is an important word and topic for this paper because of the social nature of urban areas.

Social sustainability has been defined by multiple scholars. The Oxford Institute for Sustainable development (OISD) has a frequently cited definition which encompasses the meaning of social sustainability well:

OISD definition as cited in Ricee (2020).

“Social sustainability blends traditional social policy areas and principles, such as equity and health, with emerging issues concerning participation, needs, social capital, the economy, the environment, and more recently, with the notions of happiness, wellbeing and quality of life.” (para. 2)

To simplify, Agarwal (2021) instead states, “At its core, social sustainability means the aspects of sustainability that relate to people.” This definition holds the core meaning of social sustainability and what it means for the people involved. By using the term social sustainability in this paper based on these definitions, I am putting an emphasis on the connection between the environment and the people living in it, and the ability to make a change through being sustainable in ways that help our world and social relations.

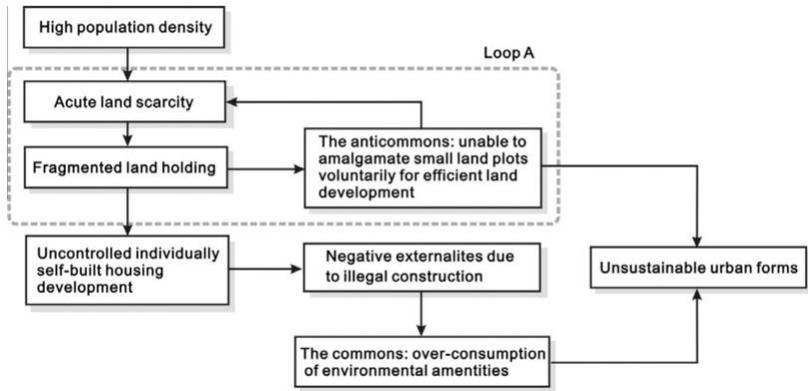
Research Question

The research question guiding this paper is as follows: how can we, and our innovations, be sustainable while also adhering to the needs of the people and cities around the world?

Conceptual Framework

Figure 1

How the cycle of the housing market leads to unsustainable forms



Note. From J. Zhu, 2012, *Cities*, 29(2) p. 86 (<https://doi.org/10.1016/j.cities.2011.08.005>). Copyright 2011 by Elsevier Ltd.

Figure 2
Assessing the sustainability of urban forms

Sustainable urban form matrix: Assessing the sustainability of urban form.

<i>Design Concepts (Criteria)</i>	<i>Neotraditional Development</i>	<i>Compact City</i>	<i>Urban Containment</i>	<i>Eco-City</i>
Density	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Diversity	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Mixed land use	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Compactness	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Sustainable transportation	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Passive solar design	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Greening—Ecological design	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High	1. Low 2. Moderate 3. High
Total score	15 points	17 points	12 points	16 points

Note: Scores of the urban forms are highlighted in bold.

Note. From Yosef Rafeq Jabareen, 2006, *Sustainable Urban Forms*, p. 47 (<https://doi.org/10.1177/0739456X05285119>). Copyright 2006 by Association of Collegiate Schools of Planning.

The framework I am using for this paper combines Zhu’s framework on housing and development as related to social sustainability in urban settings (Figure 1) with Jabareen’s sustainable urban form matrix (Figure 2).

Overall, Figure 1 can be seen as a cycle in the housing development market, which leads to unsustainable forms of housing development (Zhu, 2012). Zhu explains how due to developing areas with high densities, the state will often fail in securing public housing and economic efficiency relating to housing. “A vicious cycle of poor economic performance and incompetent state management traps the developing countries in an unsustainable process of urbanization” (Zhu, 2012, p. 86). Here she states how a cycle will keep leading developing areas

to unsustainable urbanization due to poor economic performance from the government and inadequate management on housing.

In Figure 2, we see that seven different design concepts (density, diversity, mixed land use, compactness, sustainable transportation, passive solar design, and greening) are compared across four different urban forms (neo-traditional, compact city, urban containment, and eco-city). The “low”, “moderate”, and “high” represent the scores of how sustainable and effective urban forms are. Neo-traditional development supports mixing housing types for a greater density and range of human incomes. Urban containment promotes low-density housing and extensive automobile use. Compact cities are a much more sustainable development that help to cut down gas emissions and expand the possibility to reuse land. An Eco-city emphasizes environmental management through greening and passive solar design. Out of the seven design concepts included in Figure 2, we can see that density, greening (ecological design), and sustainable transportation in a compact city all contributed to that particular design being the most sustainable out of the four design concepts. This entices the viewers to ask the question: why is density a key aspect of confronting climate change?

Another point that is brought up in Figure 2 is that cities are particularly intricate systems, reliant on all of them functioning. When one fails, the others are affected which interrupts the flow of the whole urban area. This puts an emphasis on the importance of all of the table’s factors, such as sustainable transportation, greening, and density. Without all of these systems operating smoothly, the city’s design could be dismantled.

Lastly, governance relating to social sustainability is a crucial element to urban design. Current literature on urban design in developing countries discusses the importance of having better governance to make the changes necessary for social sustainability in developing countries. Governance now shows their lack of support through weak planning and insufficient participation which translates into an absence of public awareness. By strengthening governance there will be more public knowledge and support, as well as much needed participation from citizens. For example, without more public knowledge given to the public, organizations such as “Citizens’ Climate Lobby” would not exist. This non-profit organization works to solve climate change with congress members and advocates for ideas such as pricing carbon, and delivers news that citizens would not have known otherwise. Strengthening governance will support reformed policies in struggling areas by having better interventions (Leitmann & Bernstein, 1992).

Literature Review

I will be organizing the literature review into three sections with density, urban forms, and public transportation. This review will focus on the effectiveness of compact cities, green infrastructure, and sustainable forms of transport.

Density

Numerous studies have shown the effectiveness of compact cities, which is a city with high density and compactness of people and buildings (Jabareen, 2006). If designed well, they can reduce travel distance while also saving natural and agricultural land for future generations (Zhu, 2012). Zhu talks about how compact cities have the potential to support public transportation use and promote efficient use of public and social facilities, showing some of the many positive results of dense, compact city areas. Zhu explains how developing cities in the areas they are already in will prove more sustainable and achievable in developing countries and can protect environments. The compactness of the urban areas presents the need for new design-based strategies which will help “arrest suburban sprawl and inner-city decline” (Jabareen, 2006, p. 43) meaning the spread of urbanization into rural areas will decrease through new policies. Suburban sprawl has had a large environmental consequence by steering the way to more Co2 emissions and increasing the cost of providing critical public services, causing local public finances to rise. By implementing policies to steer us away from suburbanism, we can support the environment by cutting down greenhouse gas emissions (less car-dependent cities) and making housing more affordable to the public, more specifically for those in poverty-stricken areas (OECD, 2018).

Figure 3
Compact City



Note. From Lina Poon, 2021, 10 Ways Cities Came Back in 2021, (<https://www.bloomberg.com/news/features/2021-12-27/10-urban-innovations-in-year-two-of-a-global-pandemic>). Copyright 2021 by BloomBerg.

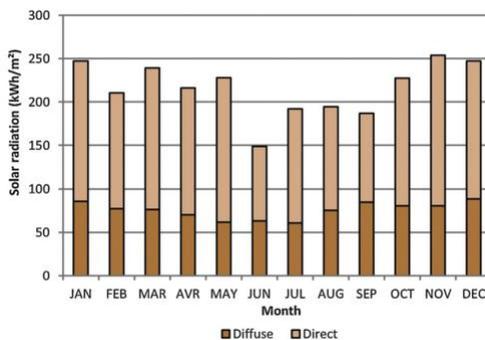
This meaning of density introduces us to another topic: compact cities. With strategic design, the compactness will minimize energy use for transporting water, materials, and people (Jabareen, 2006). As portrayed in Figure 3, a compact city is one with close buildings and a tight community, with pedestrians cycling and walking being more common than driving. The expansive development of land being consumed for driving has caused Co2 emissions to rise with forests unable to absorb the increased amounts of carbon. Therefore, vehicle miles must be significantly reduced, yet this cannot be achieved unless driving miles are not cut down. The solution to this is compact development which furthermore encourages the practice of compact

cities (Ewing et al., 2005). Once there are shortened distances between destinations, this will help citizens to use sustainable transportation in place of Co2 emitting vehicles. It was found that shifting 60% of new growth to compact patterns would save 85 million metric tons of Co2 annually by 2030 (Ewing, et al., 2005, p. 9). Further research shows that there are solutions we can implement to get the best out of compactness and density. Newman and Kenworthy (1989, 33) conclude that some policies can save significant amounts of energy, mainly by “increasing the urban density; strengthening the city center; extending the proportion of a city that has inner-area land use; providing a good transit option; and restraining the provision of automobile infrastructure.” By implementing and maintaining new policies by a strengthened government, we are able to control urbanization and the effects of this increase in population in one area.

However, when looking at other literature, we can see the adverse side effects of density. Despite the positive effects of a rising population, uncontrolled urbanization is increasing, where there is a faster growth in populated cities without development control and a burst of energy demand (Martins, Adolphe, Bastos, 2014). Martins et al. bring up how urban buildings are a large reason for the upscale of energy demand of urban areas. He presents Brazil as an example of this where buildings account for 47% of this energy demand. A case study was performed regarding the city of Maceió, Brazil. As many of the cities in Brazil experienced, rapid urbanization occurred without any effective control. This affected thermal conditions indoors and outdoors.

Figure 4

Monthly average solar irradiation for Maceió



Note. From Martins et al., 2014, *Energy and Buildings*, p. 47 (<https://www.sciencedirect.com/journal/energy-and-buildings>). Copyright 2014 by Elsevier B.V.

As seen in Figure 3, Maceió has very slight annual and seasonal variations in solar radiation therefore it holds potential to apply new strategies. By redesigning urban buildings and predicting new developments, we can address the problem of ineffective control. Through looking at five classes (individual sparsely habitat, the open-set mid-rise buildings, the colonial compact type, modern high-rise towers, and the densely low-rise buildings), class 4 (modern high-rise) was chosen to be developed into a building that optimized the objective function of minimizing the irradiation of facades and maximize it instead on building rooftops. This would

reduce solar heat on the facades and redirect solar energy production on the roof. The results showed a 12% gain on the roofs and a reduction of 44% was achieved on the facades. This study emphasized the importance of optimizing the key structural factors of designs where energy efficient choices are determined.

Uncontrolled urbanization and a burst of energy demand is an undeniable consequence of economic development which has been caused by slums, environmental degradation, poverty and inequality, social instability, and lack of security (Tannerfeldt, Ljung_2006). The problems that are caused by rapid urbanization include some of the following: pollution from urban wastes, transportation, resource management issues, and environmental hazards (Leitmann, Bernstein_1992). Especially in low-income cities, the lack of basic environmental services such as water supply, drainage, sanitation, and poor land development all cause damage and hazards to the body and environment. With about 40% of urbanization taking place in the slums, this can exacerbate socio-economic disparities and the issue of unsanitary conditions (Zurich, 2015). In order to control this issue we must advance urban design and promote sustainability in the midst of it (Watson, Zetter_2006) while also considering the effects it has on the environment and residents. Despite density's stigma as being an unfavorable repercussion of rapid urbanization, if we are strategic and manage the high population we can turn it into a positive component.

Urban Forms

Current literature on urban forms focuses on environmental problems and the practices we can implement in order to stop urban areas from further damaging the environment. Urban forms have a significant effect on the environment and other physical components, such as air quality, land, open space, and the global climate (Cervero 1998, p. 43-48; Jabareen, 2006). Jabareen focuses on sustainable urban forms. His design concepts include compactness such as compact cities as an urban design concept, sustainable transport (examples include cycling, walking, free buses and trains, passive solar designing) optimizing solar use to minimize need for heat or cooling, greening (i.e., adding in nature and open landscape diversity), density, mixed land uses, and diversity. Some of the most important urban forms from that list were mixed land uses and diversity, explaining the significance of having diverse functional land uses. This includes residential, commercial, industrial, etc. Mixed land use is a big step in ensuring public transportation for everyone and renews life while enhancing security for disadvantaged groups. Diversity also calls for different architectural designs and residential spaces, meaning a greater variety in those buildings. This helps with the appeal for housing, attractive architecture, and less segregation. Another design concept Jabareen promotes is greening which contributes positively to urban areas. Through improved design, residents are more inclined to travel in other means than cars, all the while strengthening a sense of community (Jabareen, 2006). This is shown when looking at the data for exercising in green areas versus less green areas. Data were found exhibiting the blood pressure reduction and improved mood for adults who exercised surrounded by greenness versus without (Lu, 2018). By reviewing the planning, designing, and literature that relates to sustainable development, we can find recurring themes and design concepts relating to

urban forms such as adding in green infrastructure and building materials (Jabareen, 2006). We must identify urban forms and then find relationships between the concepts to understand what will work and what does not.

Public Transportation

Public transportation is supported by the idea of compact cities as it would help reduce greenhouse gas emissions and energy consumption (Zhu_2012). However because of the high pricing for houses in cities and costly transportation services, “slum dwellers” are forced to stay and live on the outskirts of the town. In some countries authorities even go so far as to discourage migration and purposely limit access to new land and housing (Tannerfeldt & Ljung, 2006). That is why countries must use urban planning to design and establish effective transport that is available to residents in poorer living conditions. Tannerfeldt and Ljung explain in their book how public transportation also plays a role in compact cities, as more concentrated settlement patterns and incorporating public transport systems will decrease the use of private cars. It is brought up that in Curitiba, a public transport system was organized which mainly focused on bus networks as a railroad system was too expensive. This system moves at the same rate as New York subways, but it is significantly cheaper. Curitiba shows a great example of how public transportation can be installed despite financial concerns (Tannerfeldt & Ljung, 2006). Research also shows that urban transport policies must shift to making room for vehicles with reliable, accessible and affordable transportation (such as public buses) for people living in urban areas.

Cities such as Hanoi, Ho Chi Minh, and Phnom Penh experience critical problems related to transportation. Due to vehicle transportation and related air pollution issues, their small and narrow streets have been affected by unsustainable transport (Marcotullio, 2003). Jabareen argues in his paper how transport is one of the most brought up environmental topics. He brings up the importance of walking, cycling, and efficient public transport, each needing a compactness that provides consistent social interactions.

Innovations

In this section, we will look at innovations related to urban design in the face of climate change, and it is divided into three sections as aligned with the framework: innovations related to density, urban forms, and public transportation. The focus is to share the innovations that I found which will prove useful in designing urban areas.

Density

1. St. Louis-increasing density
2. New York-transport & density
3. South Korea-water & density

Density will play a big role in decreasing Co2 emissions due to the effectiveness of compact cities. When everything is close to one another, this minimizes the transportation of energy, water, materials, products, and people. With less area to cover when traveling from one place to another, you are given more sustainable transportation options.

That is why small cities such as St. Louis are trying to increase their density. Some strategies they have encouraged others to practice are zoning, strategically locating community services and institutions, offering different types of housing, ensuring accessibility to populated centers, and creating public spaces for people to use. Planning which targets specific areas for growth in residential areas, commercial areas, housing, etc. will help urban populations to increase. By strategically locating new or existing community services and institutions, as well as creating public spaces and public amenities for people to use will encourage less carbon dioxide emissions and more sustainable means of transportation and services. Offering different types of housing will appeal to a variety of people, causing population numbers to go up and increasing urban density with an infrastructure ready to incorporate the increased population in sustainable ways. Finally, ensuring accessibility to populated centers through public, sustainable transportation aids in fighting climate change through building socially sustainable infrastructure (Pack, 2021).

When thinking of New York, most visitors automatically think of the high number of people. Many view the urban layout as an unattractive factor to living there. Yet New York's high population has been the reason for a higher life expectancy, saving hundreds of thousands of lives. New York's life expectancy has increased to 80.4 years, leading over the US life expectancy at 78.8 years. The main reason for this? The transit system. In 2020 New York's fatality rate was 4.8 per 100,000, while Florida's was 14.7 per 100,000. The biggest factor for this is mass transit, 6 million people a day could travel without getting in an automobile (Gelinas, 2020), therefore less automobile accidents are bound to happen. Additionally, because of the compactness, there is greater access to easily getting around the city, providing a safer way of living. Despite numbers going up in the past two years, this shows the ability density has to turn high population areas into safer places.

However, density does not always work in our favor. South Korea is facing a high density and water scarcity issue. Being more vulnerable to floods than ever, with USD 4.3 billion flood damages and 200,00 people affected due to floods, they partnered with OECD to find a solution to this. They came up with four priorities: long-term planning against water risks, promoting water use efficiency and decreasing pollution, water regulations and environmental compliance, and updated government policies. Through these steps the Korean government and OECD was able to raise awareness to the public and manage future water-related issues. This comes to show that even if a high population has its cons, through hard work and effort you can turn it around and make a difference (OECD).

Urban Forms

1. Adding green infrastructure
2. Singapore's Garden City
3. Biodiesel Plant and Solar Panel
4. Biochar cladding
5. Carbon fiber yarn
6. Building ventilation
7. Stormwater runoff
8. Green Roofs

When learning about compact cities we need to apply the necessary urban forms and emphasize environmental management. Incorporating green infrastructure will add more diversity to the environment and regulate temperatures. Adding mini forests and/or pocket parks around the city will aid in the absorption of heat when temperatures rise (Sanchez & Hodson, 2019). Adding in urban gardens will build more resistance against heatwaves, and green roofs and vertical gardens will give more options when adding in more functional greenery. There have been many examples of the government helping the fight against climate change.

For example, Singapore's prime minister introduced the "garden city" vision which would transform their land into a city with lush greenery and a cleaner area. One of the bonuses of that idea is that it would greatly help tourism while improving resident's daily lives (one of their many goals was to increase happiness). They first took the initiative to plant over 55,000 trees. Parks were then created, with nature reserves and campaigns revolving around saving the planet appeared all over the country. This increase of trees as well as stricter laws that were set in order to make a cleaner country, encouraged cleanliness among the residents (The Straits Times, 1967). This is just one of the many examples of green infrastructure helping the environment as well as the people living in it.

Another one of Singapore's great feats against climate change was introducing the first biodiesel plant and largest solar panel installation located on Asia Square, two towers used for mixed development purposes. Through these new installations, the Marina Bay district (where Asia Square is located) was able to produce clean, renewable energy and sustainable fuel for Singapore (AECOM, 2022). Just as this benefited the country environmentally, implementing greening and new infrastructure would help urban areas greatly with cleaner air and scenery which attracts more people to potentially live there.

Building materials are immensely important in helping against climate change, as certain materials and design structures can determine whether or not a building will be sustainable. For example, Biochar cladding produces bioplast from forest and farm waste that holds carbon and is used to make objects with cladding, proving a much more eco-friendly choice.

Figure 5

Biochar grains

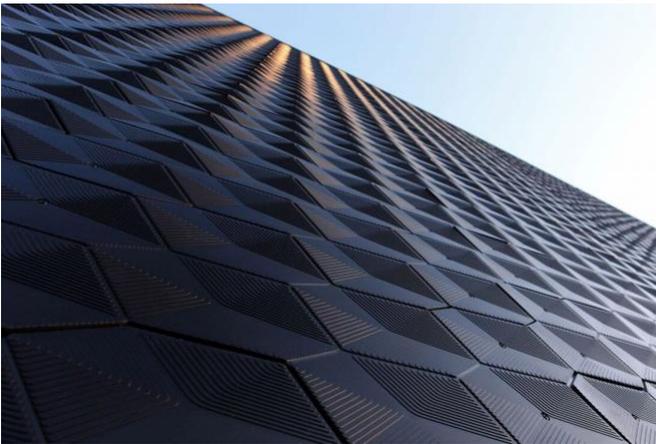


Note. From Jennifer Hahn, 2021, Atmospheric CO₂ is "our biggest resource" says carbon-negative plastic brand Made of Air, (<https://www.dezeen.com/2021/06/24/carbon-negative-plastic-biochar-made-of-air-interview/>) Copyright 2021 by dezeen.

These are biochar grains that are then melted and molded to look like this:

Figure 6

Air Hexchar's panel installed on Audi Dealership in Munich

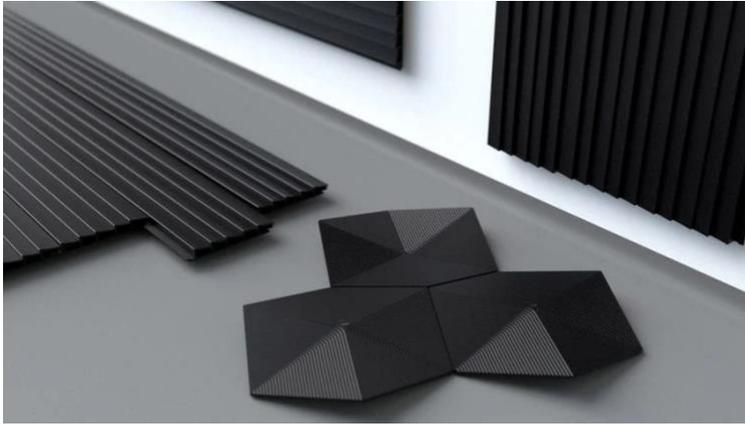


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Carbon fiber reinforced concrete is another example of this, strengthened with carbon fiber yarn. It uses less concrete helping in less use of material that is harmful to the environment. A tight weave helps with strength and stiffness

Figure 7

Carbon fiber reinforced concrete



Note. From Jennifer Hahn, 2021, Atmospheric CO₂ is "our biggest resource" says carbon-negative plastic brand Made of Air, (<https://www.dezeen.com/2021/06/24/carbon-negative-plastic-biochar-made-of-air-interview/>) Copyright 2021 by dezeen.

Reversible design is a great choice where buildings can be completely deconstructed and reused when its use is over. Building ventilation is another big factor in resilience against climate change. Large glass panes that open and close eliminate the usage of air conditioning and heat, bringing in a natural air flow and regulating temperatures.

Figure 8

Building ventilation

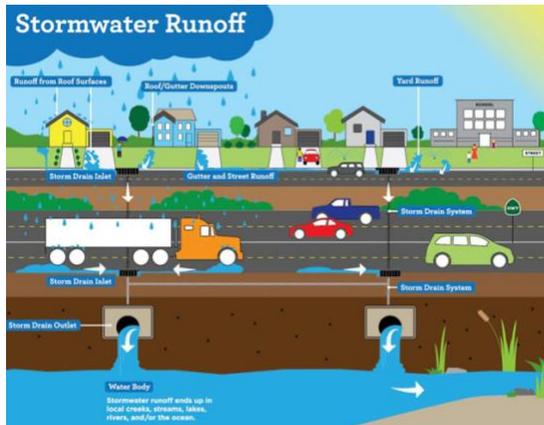


Note. From Lina Poon, 2021, 10 Ways Cities Came Back in 2021, (<https://www.bloomberg.com/news/features/2021-12-27/10-urban-innovations-in-year-two-of-a-global-pandemic>). Copyright 2021 by BloomBerg.

A great design that can be used in areas that are affected by storms is building roofs with water runoff and storm drainage. Functional design like the ones mentioned here will prove to be key to the climate crisis we are having right now.

Figure 9

Stormwater Runoff



From California High Speed Rail Authority, 2022, Stormwater management, (<https://hsr.ca.gov/programs/environmental-planning/stormwater-management/>). Copyright 2022 by State of California.

Instead of storm water creating floods and disrupting roads, the water flows back into the ocean and without affecting the citizens. The ability of controlling stormwater is crucial in architectural designs, as it has immense impacts financially, environmentally, and water cleanliness and availability. Recently, in St. Louis, historic flash floods caused chaos in the city and surrounding areas. Severe flooding is just another one of the consequences of climate change therefore we must plan in advance to be prepared for cases such as that on June 26 in St. Louis. It was a 1 out of 1000 chance of happening (7.68 inches of rain falling in just one hour), and the city and citizens were not prepared for this catastrophic event (Samono & Lati, 2022). If stormwater was managed and designs such as stormwater runoff were applied, there was a chance that this climate-caused event would not have been as destructive.

Figure 10
Green Roofs



From Urbanscape, 2016, Do You Really Know All the Benefits of Green Roofs?, (<https://www.urbanscape-architecture.com/do-you-really-know-all-the-benefits-of-green-roofs/>). Copyright 2020 by Knauf Insulation.

Along with stormwater drainage systems, another great example of cities using every factor they have including greenery is by “turning themselves into sponges” (Urbanscape, 2016). As climate change is causing unpredictable flooding and heavy rain, sewage systems might not be enough in the future. Therefore, especially in developing countries that receive heavy rainfall, by constructing “vegetated swales” and “bioretention cells” (Goldman et al., 2017, para. 5) which are designed to naturally absorb the water, as plants do, and provide a slow and therefore essential way of catching stormwater. Fayetteville, North Carolina has created a green street and took out three road lanes. Philadelphia announced their plans to turn 10,000 acres into green spaces. Toronto was North America’s first green roof law placer, and by the end of 2016 about 400 green roofs had been built (the equivalent of around 60 NFL football fields) (Goldman, 2017). Incorporating greenery into aiding against water hazards is an amazing option a few cities have opted for, and hopefully many more in the future.

Public Transportation

1. Accessible transportation
2. Luxembourg’s free transport

Public transportation is the largest factor in portions that contribute to greenhouse emissions, making up about 27%. This is why easily accessible transportation that is available for the public such as scooters, bicycles, and buses are crucial in fighting against climate change. Simple policies such as restrictions on vehicles and larger bike lanes will prove to be helpful. Restrictions on vehicles including “car-free Sundays” and larger bike lanes will encourage more bikers, pedestrians to walk, scootering, etc., further eliminating the usage of cars will provide many ways to travel that do not emit Co2. As there has been more knowledge spread about the importance of sustainable transportation, the government has implemented methods to encourage use of sustainable transportation to cut down gas emissions.

For example, Luxembourg became the first country in the world to announce in 2020 their decision to make all public transport free throughout the entire country. As this network is adapting to the people’s needs, this mode of transport has become increasingly popular among residents and visitors. This transportation includes buses, trains, and trams – all of which do not need a ticket to ride. This change has been successful with statistics showing the number of passengers for inner-city travel on buses rising from 22.5 million to 25 million passengers in a span of four years (Transition Minett, 2022).

Discussion

Based on the framework of social sustainability we looked over density, sustainable urban forms, and public transportation that is accessible for everyone. We did this by thinking about the particular needs of developing urban areas such as Maceió, Brazil and thought about existing innovations such as Singapore’s “Garden City” and eco-friendly building materials like biochar cladding. Some ways we can move forward are by implementing more green

infrastructure into developing areas to aid with climate change effects like stormwater and flooding, as well as heat waves that are more apparent in urban areas. Another potential way is to create free and easily accessible transportation in areas that are less developed than others, to encourage more sustainable ways of transport. Some things that we still need to figure out through research and learning is how to manage density in a way that will benefit everyone and provide the resources needed for certain countries to establish certain innovations.

Through public knowledge, governing policies, and international investment that benefit our environment, we can apply these innovations to places that do not have the financial resources needed in order to implement them themselves. If we are able to gain enough traction on this topic and urge one another to educate ourselves and others while actively participating in organizations and communities that fight for this cause, we will be able to change the course of climate change on our Earth.

Conclusion

This paper uses a conceptual framework focused on social sustainability that highlights the way climate change can be addressed through urban design in terms of density, urban forms, and public transportation. The paper first explored current literature related to the topic of urban design in the face of climate change and then discussed current related innovations. In terms of density, we see a large focus in the literature on the effectiveness of compact cities and the positive and negative sides of a high population area. We discussed the different design concepts such as mixed land use, greening, and diversity. On the topic of public transportation, we looked at the options of transport that are more sustainable and cleaner for the environment, while exploring the reasons for developing countries not having access to public, sustainable transportation. For the innovations, there was a focus on increasing density due to efficiency, yet also the disadvantages of populated cities. Moreover, innovations focus on the different urban forms such as greenery, building materials, and stormwater management designs. Finally, innovations around public transport is often designed to reduce gas emissions. Urban areas are a large contributor to climate change, but with the correct strategies and innovations we can transform them into an important solution.

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