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What are the Principles of Sustainability that Contribute to the Development of a Green City? Arguments, Approaches and Solutions of Current Research

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Abstract. *As the population in cities continues to escalate, and environmental problems worsen, it is clear that green cities need to be produced, and we must produce them sustainably. The green city is a city with sustainable application of ecological practice and community prosperity, where green systems, renewable energy systems and efficient transportation, and proper waste control are all implemented to green the city. This paper explores the concept of green cities from essential elements, economic implications, implementation challenges as well as future prospects. Besides that, it highlights the importance of smart technologies, green buildings ideas, circular economy principles and social inclusivity in urban spaces design through an environmentally and socially sustainable way. Illustrated are green city models which can be adapted from cities like Copenhagen, Singapore, and Curitiba to green cities and to learn from each other. The paper further discusses the huge hurdles against green city projects including political resistance, financial constraints and infrastructure constraints as well as how to solve them. However, the future of green cities shall hinge upon the capacity of adaptation of these cities to the effects of climate change together with other effects and issues, the degree of resilience these cities could foster to counteract these impacts and eventual changes in the populace and urban management, and at the same time, how these cities would make use of newly developed technologies in building a setting that embodies sustainability, inclusivity, thriving and well beyond the objective to simply be sustainable. Ultimately however, the cities will become green spaces and ultimately become a major intervention in the development of a more environmentally and comfortable settlement of cities for the urban population of the world. For the bibliometric analysis, in this study VOSviewer was used to obtain the visualization of the keyword co-occurrence to identify key research trends, which provides a new insight into the study area.*

Keywords: Green cities, Renewable energies, Circular economy, Climate change, Sustainability.

Introduction

Urban challenges to sustainability, environmental degradation and resource use are growing everywhere due to urbanization.

Green city is a term used to denote an attempt to implement a cross section of sustainability in all urban aspects ranging from the ways in which electricity is generated (such as production of non-renewable electricity) to transportation system, the way waste is managed and green space. A green city also is conducting its quest to cut environmental footprint but also aspires to promote social justice, promote the quality of life of inhabitants, and prepare them for future climate impacts. Some of the topics in green cities are renewable energy, alternative modes of transport,

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energy efficient technologies, as well as urban spaces that are linked with nature, biodiversity and the like (Artmann, Kohler, et al., 2019).

However, the process of a city transition to a green city is complicated and multi-dimensional. This transformation necessitates a long-term vision and strategic planning, as well as significant investments in green infrastructure and technologies (Mingaleva et al., 2019). They will also have to do without financial support, entrenched political interests and, of course, most importantly, the forms of resistance that would oppose any change in the traditional natural configuration of residents and businesses dependent on the existing urban systems.

To achieve a green city, it is never an end game, it is always forward and there is never standing still. Today, towns of all sizes throughout the world are experiencing rising levels of pressure from climate change, population growth, environmental degradation and increasing exposure to disasters and are realizing that we need to raise the level of sustainability. Green urban areas give us a chance not only to save the city from deleterious of city urbanization, but also to make cities healthy, vibrant and resilient (Borck & Pflüger, 2019). This research reviews the concept of a green city using a number of selected concepts, strategies, technological innovations, policy frameworks and challenges to greenways.

This paper aims at synthesizing various former studies of the principles of green cities and developing a holistic description of which processes make towns to be made greener, more sustainable, and more liveable. It discusses theoretical foundation of green urbanism, elements of a green city, policies of transition, technological innovation that helps the transformation, and the social effect of implementing the measures of sustainability. It also provides further information on the obstacles in which cities have tried very hard to reach the level of sustainability and some of the successful cases.

Methodology

An example of the application of bibliometric coupling is based on Bibliometrics, a field of quantitative studies of science. At the other end of it, bibliometric coupling is the relation between two documents (namely scientific papers or articles) and between them based on the pattern of their citation. This entry considers an assumption that if two documents have the same references, they are also most likely to be relevant in regard to content.

The network presented in Figure 1 illustrates the theme of sustainability, energy, climate change and urban development, which are connected. They appear in the largest, most central nodes of the discussion on the environmental policies, the energy management or the urban planning ("sustainable development", "sustainability") which mark their role as being the key points of the debate.

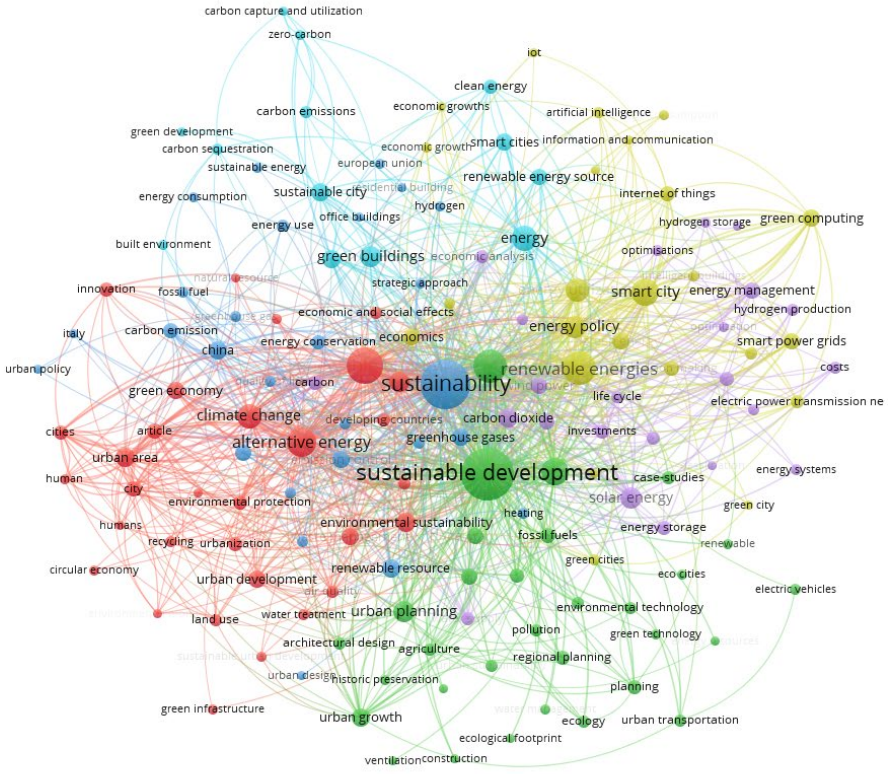

Figure 1. Bibliometric coupling of renewable energy and sustainability in green cities
Source: Authors' own research.

For this bibliometric analysis we used 284 research papers. Renewable energy, sustainability and green cities were the keywords analyzed. Keyword selection accuracy directly influences how effective citation analysis as well as network visualization in VOSviewer will be.

There are distinct nature color coded clusters focusing on different thematic areas:

1. Carbon Clean (Climate Change & Carbon Emissions): Assesses the Earth's decreasing carbon levels and aims to provide effective carbon solutions.
2. Urban and Environmental Studies: Explains sustainable growth, eco cities, pollution control and architectural designing while connecting this to city planning.
3. Green Buildings (Blue Cluster): Illustrates the use of sustainable architecture in carbon emissions, energy use and green development.
4. Yellow Cluster (Smart Cities & Technology): Addresses finding the energy uses that work best with IoT, AI and smart grids in optimizing cities and infrastructure.
5. By showcasing solar energy, hydrogen storage, and the electric power networks that will form part of the clean energy transition, Purple Cluster (Rethinking Energy & Energy Storage) offers both a survey of the development of a renewable energy system and a forecast of this process.

The relation between these topics suggests where there needs to be a highly coordinated approach to sustainability, urban planning, technology and policy need to work together to fight climate change and encourage green development.

To begin data analysis through VOSviewer, we first extracted bibliometric data from Scopus or Web of Science platforms and then saved the data in CSV format files. Once processed,

the data was imported into VOSviewer before analysis, with irrelevant records removed, and duplicate terms merged. After selecting the visualization types, in this case keyword co-occurrence, network structures were adjusted by clustering parameters. The findings are derived from network maps and density visualizations and overlays, and the results were exported for reporting purposes or any other needs of further analysis.

Theoretical Foundations of Green Cities

Based on the theoretical models of sustainability and ecological urbanism, the idea of green city is embedded in models of sustainability and ecological urbanism that understand the conditions for making sustainable cities with environmental, economic, and social goals (Ostárek, 2021). Therefore, the purpose of the chapter is to understand the initial concepts of green cities based on the theory of resiliency, ecological urbanism, ecology of city, and the science of sustainability. Green city planning frameworks are applied for environmental protection, resource efficient, and fair to social equity.

Sustainability and Sustainable Development

The essence of the movement is to ensure our current needs do not compromise future generations' ability to fulfil the same or even similar level of living. The contemporary sustainability paradigm is closely linked to the definition of sustainable development given by the Brundtland Report (1987) in which the term sustainable development cuts first with the definition of development that satisfies the needs of the present without compromising the future generations' ability to meet their needs (Hajian & Jangchi Kashani, 2021). These three core pillars, when put together, are the 'triple bottom line' and the broadly defined concept of that concept includes environmental sustainability, economic sustainability and social sustainability such as put together.

Sustainability related to urban development is the way we have to develop the cities in order to minimize the environmental effect, to optimize the use of resources, and to promote social inclusion. A green city represents the characteristics of sustainable urbanism by defining its design criteria so as to minimize energy use, reducing waste, and promoting biodiversity, as well as providing clean air, water and green spaces for every resident (Michalina et al., 2021). Sustainability integration in urban planning develops systems more efficiently and effective and homeostatic to environmental and future stresses.

Ecological Urbanism

Green cities are based on ecological urbanism theory and assume that urban spaces can be recreated (or conceived) as part of a blending between nature and itself (Colding et al., 2022) They remind us of the isolation of urban areas, their civilizations, their humanism, and how they distance space from nature; the arrival of a model that disowns tradition. In fact, the formal design philosophy of ecologically urbanism is a quite integrative model of ecological urbanism as a linear model of ecology, the cities as a continuous system, which takes over human needs and organizes organic procedures.

Scholars of Waldheim (2006) argue that the urban landscape should be perceived in terms of procedures towards nature and ecological principles like natural processes and systems, namely water filtration, habitat restoration and climate regulation. Ecological urbanism treats urban areas as 'green' infrastructures built with the inspiration from nature's resilience and adaptability (Ostárek, 2021). Urban forests, wetlands, and green roofs are included with implementation to service in that ecological way, but also to improve vibrant and exciting public spaces.

Another integral part of ecological urbanism is the idea of 'biophilic design,' which calls for human relationship to nature as well as includes natural characters in constructed environment (Thomson & Newman, 2021). Not only does ecological urbanism encourage ecological health of the city, but it also takes the responsibility of taking care of the mental and physical wellbeing of its inhabitants. It completes the thought that a more natural, livable, resilient city could potentially be built on inserting nature in the urban landscape.

Urban Ecology

Urban Ecology is one of the multidisciplinary fields, specifically, the study of human population and human environment. Thus, it is a cross of ecology, geography and sociology and urban studies to think of cities as an ecosystem. Green spaces, biodiversity and ecosystem services are necessary for city and resident health, and urban ecology (Rivkin et al., 2019).

The natural world encompasses cities as they are an expression of the natural world and urban ecology is a basic concept just as the existence of cities must be. Thus, the ultimate goal of releasing these green urban settlements is to create fostered towns mimicking the natural process for extracting carbon from the atmosphere, filtering and clean air, and upgrading daily life in cities. It is said that urban areas can support biodiversity when they allow wildlife to live, just as other scholars and (Grimm et al., 2008) concluded.

Natural systems are used in the design of green cities, and this is regarded as ecological understanding. This may include the activities in the degraded ecosystems or work in urban parks and green corridors (Artmann, Kohler, et al., 2019). On the other hand, urban ecology plays an important role in urban biodiversity since its capacity to sustain and enhance helps to keep up ecosystem functions necessary for the city health: soil fertility, water regulation, as well as pollination.

Resilience Theory and Green Cities

Resilience theory (ecology) bases its strength in being able to withstand shocks and operate as systems extend from natural, social and urban environments, continuing to remain functional and adjusting to change. This concept serves to understand what 'resilience' means in cities, in the sustaining of the environmental shocks such as floods, extreme weather, heat waves while maintaining core functions (Zuniga-Teran et al., 2020).

Urbanization across the world is increasing, and in vulnerable towns, climate change is making green cities areas more important to urban resilience. This is the basis of the resilience theory that cities must adjust to the unforeseen challenges and build infrastructure which can respond to change (Zuniga-Teran et al., 2020). We define towns as more resilient when they are green urban settlements aimed at avoiding environmental risks and supporting long term welfare policies.

Regarding the green urban areas, green City is an idea that can be applied to both ecological and social systems (Alyami, 2019). From the ecological point of view, resilience is the quality of city that makes it reactive to the change in the environment: such as the one generated by high sea level, more frequent storms.

The Role of Green Infrastructure in Urban Sustainability

The green infrastructure concept is basically the basis for green city theory where the natural and half natural features form a group connected together which gives ecological, social and economic

value to urban areas (Chatzimentor et al., 2020). Parks, green roofs, tree canopies, wetlands, urban forests, permeable surfaces are elements of green infrastructure that assist green and resilient cities.

As such, it is important that green infrastructure integration is critical to mitigate negative urbanization impacts, including pollution, heat island and stormwater runoff. For instance, green spaces are crucial as they are a carbon sink as they absorb the carbon dioxide from the atmosphere and forms a mitigation to avoid the possible consequences of climate change. "What green infrastructure does is still provide such services as water filtration, temperature maintenance, habitat for wildlife," as stated in (U.S. Environmental Protection Agency, 2015).

Green infrastructure provides support towards social equity as well as well-being through vital functions. The benefits of green spaces made public also include those concerning aspects of one's physical and mental health, as well as social interaction and the aesthetic quality of the urban environment. Green spaces are becoming increasingly crowded and polluted, and as a result, the need for safe and easy access to green spaces for citizens' quality of life becomes more important (Giannico et al., 2021).

Sustainable Urbanism and the Green City Framework

Along with the other key theoretical foundation for green cities, sustainable urbanism has augmented the importance of the transformation of urban design and planning to promote environmental, social, and economic sustainability. The green city paradigm accepts the sustainable pattern into the theoretical substance of the universes from power system to transportation system, waste administration, and so on.

Sustainable Urbanism teaches cities how to make themselves independent through their sustainable efforts in a multi-dimensional way by diminishing their consumption of natural resources and producing harm to their environment (Byrne et al., 2020). It entails planning cities that are self-sufficient in terms of energy generation from renewable sources, the treating of waste in the form of recycling and composting, and the provision of choices for low carbon living in terms of sustainable mobility choices. Reduced social inequality stems from this along with sustainability and equality of resources for all citizens and connections in the community that embrace social cohesion.

In practice, the sustainable urbanism and the green city framework requires a systemic approach to urban development in addressing the interrelation of environmental, economic and social systems. As such, urban designs have to be integrated with policies to push up the life span sustainability of the whole urban system, in the hope that the city can endure across generations.

Components of a Green City

The notion of green city is multi-faceted and comprises of components which together produce a green sustainable, liveable and resilient urban environment. Energy systems and transportation networks, green infrastructure and sustainable waste management have to be implemented in a competent way for a green city (Artmann, Inostroza, et al., 2019). The chapter will discuss the important elements that make a green city, emphasizing the integration of ecological principles, new technology and sustainable urban design, a city which exploit the impact of the environment to produce a high quality of life for the residents.

Renewable Energy Integration

A green city creates its power infrastructure relying on renewable resources to power its buildings as well as its transportation networks. An environment considered to be in contact with a green

one, sometimes or regularly, aims to reduce the use of fossil fuels because this engagement produces greenhouse gases and pollutes the air, and this further degrades the environment. A sustainable alternative to this is renewable energy like solar, wind, geothermal, and hydropower that can help a city cut down its carbon footprint and keep the city environment green.

Of the several widely used and readily available green energy sources, the use of solar power in the urban environment is one of the most widespread and popular. One of the central priorities of green cities is implementing solar panels on rooftops, as with public buildings and infrastructure, transforming their urban environment into source of localized power (Brown et al., 2021). By using photovoltaic (PV) systems at their buildings, cities produce electricity at their location and reduce the grid power and the transmission waste(Choudhary & Srivastava, 2019).

Few arrangements and occurrences in densely populated urban zones still let wind power function effectively in green cities with sufficient wind potential (Khan et al., 2018). The urban wind farm facilities on rooftops or in public places supplement the city power system with energy, which diversifies the municipal power source.

Geothermal systems are the main component of green cities which produce electricity by earth heat for heating and cooling and power generation (Rahman et al., 2022). This reduces urban heating fossil fuel use and decreases energy costs of heating in general using geothermal energy systems.

Green cities tend to implement smart grids in order to ensure integration of renewable energy into urban areas (Judge et al., 2022). Electrical communication and real-time digital data are used in smart grids to control how electricity is distributed, provide more efficient use of energy and plug renewable energy sources into the grid in a more efficient manner. Such a system permits better storage of energy and at the same time reduces losses and maximizes the use of renewable electricity (Worku, 2022).

Sustainable Transportation Systems

Developing green urban areas is an essential part of any sustainable transportation activity. Because of conventional fossil fuel powered vehicles, urban areas see their largest source of carbon emitted into the atmosphere from transportation. By doing this, green cities are helpful to promote alternative modes of transportation that will decrease greenhouse gas emissions, reduce traffic congestion and improve air quality (Faulin et al., 2019).

A green city relies on: High quality, efficient, and accessible public transportation system. Panasonic promotes bus trains trams ferries to reduce private car use in order to lower congestion and pollution levels. For example, electric buses and trains help to produce a cleaner and quieter public transport chain as well as make a reduction in emissions.

Sustainable urban mobility is made up by cycling and walking. Green cities construct dedicated biking facilities, gather walkable streets and combine living areas to build simple accessible safe walking and biking paths to many locations (Kiba-Janiak & Witkowski, 2019). These initiatives aim to substitute cars for other means of traveling, to avoid pollution in the air and to promote public health, through encouraging physical activity.

Key strategy to reduce transportation related emissions in green cities is widespread adoption of electric vehicles (EVs). Furthermore, they do not emit exhaust while in use, which means they are powered through utilizing electricity, usually from renewable sources. It is putting investments into building EV charging stations in green city administrators to make people adopt electric vehicles and this is done across public places and residential areas. Combinations of

programs of electric carsharing system and EV ownership promotion reduce the total number of operational vehicles (Manousakis et al., 2023).

Specifically, green cities allow residents to drive in their cars only in car free zones close to the center that are provided with a combination of Car Free Zones and Mobility as a Service (MaaS); a car has no privileges in the city (*Papers HUSO2019* , n.d.). Mobility Platform service (MaaS), which integrated various forms of transport such as bus, train, bike sharing, and ride hailing into a single accessible and easy to use service, reduces the need to own a car with less sustainable and more flexible urban mobility system (Butler et al., 2021).

Green Infrastructure and Urban Green Spaces

Green cities were established by the role of urban green spaces. These public areas comprising urban parks and gardens, as well as roofs with vegetation and community woodlands, are the essential benefits of ecology and social connections and improved health. Green Infrastructure is the integration of natural processes into urban landscape for the management of stormwater, for reducing the urban heat island effect, and for increasing the biodiversity (Lombardía, 2023).

Green roofs and walls that bring natural habitats to the urban landscape have the capacity to bring an urban space into the realm of nature. These herbaceous structures on the roof serve as water absorbers and also help in improving air quality and bring down heating and cooling requirements of the buildings. This vertical gardens or green walls have many advantages with visual fixing of urban buildings (Manso et al., 2021).

Public Parks and Green Corridors are needed to maintain biodiversity of Cities. These spaces provide habitat locations for local wildlife species and recreational areas for inhabitants to recline in urban areas with such spaces (İnançoğlu et al., 2020). Drawing on agglomerations' existing green spaces, green corridors serve as connecting spaces between these different green spaces and are also helping animals to freely roam across urban areas and increase biodiversity.

Techniques that help manage stormwater in cities are becoming more widely used in order to avoid flooded streets and water pollution. Together, rain gardens and permeable pavements, along with bioswales, allow ground infiltration of water in place of drainage systems run off that endangers urban sewage network capacity. The solutions maintain urban natural water cycles and minimize the environmental impact of the growth of urban development (Lombardía, 2023).

Sustainable Waste Management

Green city has an essential factor that we must pay attention to such as management of waste. Websites that have reliable waste management systems include methods of incinerating trash with the leftovers dumped in landfills are proving to be harmful to nature's resources while causing pollution. Incorporating strategies towards wasting reduction, recycling, composting, and waste to energy systems, green cities adopt approaches that help towards a circular economy.

Waste reduction, and therefore environmental degeneration, penetrates most deeply through the reduction of waste. Three things in green cities are the reduction of waste, public environmental campaigns and waste administration policies alongside within the sustainable consumption advocacy (Minelgaitė & Liobikienė, 2019). Residential and commercial areas are implemented for the implementation of reusable products as well as reusable packages and materials.

Recycling and composting have become practiced to create green urban settlements that have efficient systems of recycling landfill waste and reduced dependency on new raw resources. Towns achieve these objectives by means of the provision of recycling containers, as well as

organic waste composting arrangements, and the practice of waste segregation at initial points of origin (Li et al., 2020).

It is technologies of Waste-to-Energy (WTE) that help cities to generate energy from streams of non-recyclable waste material into a valuable resource (Hsu et al., 2024). However, such systems can help reduce landfill use, reduce the emission of methane and generate renewable energy. Waste derived energy is integrated into Green cities sustainability networks in order to operate waste derived energy operations in its waste circulation system across different industries and buildings in the local district.

Water Conservation and Management

Given that many urban settlements have ever growing pressure on their water resources stemming from climate change, population growth and pollution water management is critical in the development of a sustainable urban environment. In green cities, a lot of water conservation measures and technologies are applied to save water, minimize waste and ensure a water resource.

Water recycling programs are instituted in green cities, which direct treated waste into the two sectors namely, industrial machinery use and irrigation and cleaning operations for non-drinking water purposes (Radcliffe & Page, 2020). It relieves the stress on the potable water supplies and promotes better use of water.

Typically, in green cities the rainwater is harvested and used later. By reducing water supply demands from public utilities parsed out from the systems are able to effectively provide users with rainwater for their yards and reduce flooding risk through good stormwater management systems meet two purposes (de Sá Silva et al., 2022).

Green Cities use advanced water efficient irrigation technologies that help avoid water waste in the parks, gardens and agricultural lands. Near to its key reference in the body text, the systems should mention their key point that can prevent both evaporation and runoff to direct water to plants directly at root zones.

Social and Cultural Implications of Green Cities

Green cities development has major effects on technological progress along with environmental sustainability and the social structure, as well as cultural elements in urban areas (Artmann, Kohler, et al., 2019). Green is cities plan to achieve ecological and economic sustainability and social sustainability, towns with environments where residents physically and mentally live well. This chapter deals with the impact of green cities on the social and cultural implications, how green cities affect community well being, social equity, cultural engagement.

Social Equity and Inclusion in Green Cities

Social equity is one of the major principles upon which the green cities are built; it ensures that all residents whether they belong from the upper segment or lower segment of the society have equal access to sustainable resources, services and opportunities (Malek et al., 2021). Typically, urban development has been traditional in which from an individual, people of wealth will tend to have access to clean air, green spaces, good infrastructure while the marginalized or the poor in the society haven't access to these basic needs. The mission of green cities is facilitated by this initiative of offering equal opportunities of sustainability to every section of the people.

Public parks and gardens, as well as recreational areas, are available in all the neighborhoods of green cities, which allow the residents of the disadvantaged communities to safely enjoy green spaces. Allowing people to have access to green spaces has been pointed out to

help people enhance their physical and mental health, manage stress, and interact socially. Green cities make green spaces available for everyone and promote healthier and more socially integration in green cities gives green spaces common to people of multiple community (Giannico et al., 2021).

Sustainable Urban Planning in Green Cities: Affordable housing, in green cities, is an energy efficient, environmentally friendly and close to public transport, schools and health care (Jeddi Yeganeh et al., 2019). This method improves the shortage of urban housing and residents use less energy, spend less money, and as a result gain improved health and obtain reduced transportation expense. Affordable housing in green cities uses strategies such as green building certification and energy efficient design to ensure that housing in green cities embodies high standard in environmental and social levels.

Social equity in green cities includes decisions made by all the residents and hence, community members must play a part in such decisions through the inclusion in various processes of inclusive decision making (Malek et al., 2021). Participating key members of diverse communities in urban planning and sustainability projects make the processes of policies and projects inclusive, considering the needs of all residents. Public participation in decision-making processes, such as community consultations, urban planning workshops, and local sustainability programs, fosters a sense of ownership and engagement in the transformation of the city. This is an image where communities engaged in the physical environment of the community reduce social exclusion risks while providing sustainability benefits are available for every social rank.

Public Health and Well-Being

Social and cultural effects of green cities, having direct impact on outcomes of public health, are created. This is because of heavily industrialized urban areas with highly populated places, having problems in health due to their combination of environmental contaminations with restricted access to open areas as well as foods, further past the noise pollution. Green cities create a better environment by reducing health hazards and lessen the suffering of people from chronic diseases and improve mental health as well as increase physical activity.

Green cities are a provider of the best Air Quality and Pollution reduction. Urban plant use to filter pollutants is practiced in green cities where the trees and plants along shrub plants removes PM, NO2 and SO2 emissions from the environment (Hui et al., 2023). The segment of green spaces combined with the introduction of green roof and wall gives better air quality results through absorption of pollution. Decreases in standards of clean air reduce the number of respiratory illnesses and maintain the community health as a whole.

Green cities: Walking, biking, and using transit make up active Transportation and Physical Health because walks, cycles and use of transit get people up and moving, away from never leaving the house sedentary lifestyles (Faulin et al., 2019). Ensuring the development of pedestrian friendly streets, cycling lanes and green corridors encourages residents opt for sustainable mode of transport which reduces obesity, heart related diseases, etc.

Influence of green spaces: Mental Health and Social Cohesion: Access green spaces also plays an important role in maintaining the mental health of an individual as well as maintaining social cohesion (Kruize et al., 2019). Numerous scientific research shows that nature experiences or using green spaces lower stress and anxiety and improve depression symptoms. Recreational spaces and parks enhance the bouncy feeling of a residential community that provides people with a place to relax and bond with people to support social connections among citizens which helps in keeping community unity. In a green city, public spaces are created not only for the pleasure of the

eye, but also as socially positive, where social integration, mental relaxation and strong feeling of belonging is fostered (Kruize et al., 2019).

Cultural Engagement and Community Identity

In terms of the cultural implications, green cities bring mutual benefits, including the experience of cultural expression, creativity and sharing community identity. The sustainable urban structure refers to the integration of both cultural heritage and local customs, as well as psychological approaches in designing the urban environment. Cultural space strives to enhance the urban diversity and enrich city life, and at green cities, changes occur within the environment and the cultural space become one.

Green cities: Green urban areas can provide protection of Cultural Heritage by tending to historical and cultural landmarks integrating it within sustainable urban planning. Green areas near to the historical site can protect cultural history of these sites at the same time they can support the preservation of the environment through sustainable development. The outcome of this approach includes pride, connection to the past, and it fosters such a strong cultural identity that binds people together and also moves towards a sustainable future for their identity (Lidelöw et al., 2019).

Community Gardens and Urban Agriculture: Community gardens and urban agriculture are another instance of a green city supporting cultural engagement. As such, urban farming gives a local source of food as well as strengthens community ties by bringing people together to perform shared activities (Ilieva et al., 2022). Community gardens are a means for cultural dialogue between people because different community members do exchange understanding over food cultivation methods in exchange of their traditional practices and sustainable food production methods. This will contribute to increase the local food security, practicing sustainable manner while reinforcing social cohesion through teamwork.

The green areas of Urbanscapes are used as settings for cultural activities and meetings of the community through concerts outside, festivals and public showing of art and performing arts activities. The fact that these celebrations bring people together helps to ignite artistic expression and provides useful social areas for cultural participation among the residents. In green cities, parks and squares are places that are far beyond recreational space: they are centers of interaction, exchange of cultures and identity of a community.

Education and Environmental Awareness

In addition, green cities play a very important part in education and environmental awareness, while shaping how people live, perceive and interact with the environment. These green spaces, along with other useful components of sustainable urban initiatives, offer the opportunity for environmental education and, in turn, the development of a culture of sustainability for all age groupings.

Green cities tend to have programmes for Sustainability Education for residents to learn how best they can go green by using energy conservations, waste reduction and optimal use and management of water and foods. In education programs and public awareness campaigns and community workshops that are carried out to citizens via school programs, they will learn how to live more sustainably. Through environmental education in green cities, ecological accountability is practiced in the community on the solution to environmental problems affecting one and all.

So, green cities facilitate early exposure to sustainable practices for children and young adults because they make such practice available (Samuelsson et al., 2019). Engaging in school curricula, outdoor learning experiences and in the community, will allow young people to gain a

strong understanding of environmental issues. Outdoor education and actual learning of nature, biodiversity, and the value of sustainability are accessible in green spaces. Experiencing the environment is used to raise future leaders who would seek to protect the environment.

Case Studies of Green Cities

Towns all over the world are facing the difficulties of rapid urbanization, climate change and environmental devastation, and this is where, a number of urban centers are beginning to implement green city initiatives in order to make urban spaces sustainable, livable, and more resilient. The selected urban centres are research examples of other methods of urban transformation with acquired knowledge of them during their development. This chapter focuses on three individual sustainable urban strategies applied on three of distinctive green urban areas – Denmark's Copenhagen, Singapore, and Brazil's Curitiba.

Copenhagen, Denmark: A Global Leader in Sustainability

As the first capital city to reach carbon neutrality by 2025, Copenhagen is recognized as one of the most environmentally sustainable towns in the world where officials are aware of (Hansen & Agger, 2023). In its long term vision, the city has allocated itself to placing sustainable goals of reducing emissions as well as promoting renewable energy and improving urban environment quality.

Copenhagen's push towards carbon neutrality is in the expansion of renewable energy; it supersedes petroleum in lead over natural gas. Because Denmark has suitable winds for power generation, it receives substantial investments from Copenhagen in wind power. Copenhagen gets about 40 percent of its electricity from wind turbines and wants to increase it while building energy efficient buildings and district heating schemes (Johansen, 2021). Copenhagen supplies energy heat to 98 percent of their residential buildings through its district heating network that utilizes waste heat from power plants.

The city's stance of sustainable transportation spells out its dedication to maintain a clean environment from its actions. There is a broad system of cycling paths in Copenhagen which is used as a preferred method of travel for the city (Nilsson, 2019). Cycling is the transport mode of preference for over 40% of Copenhagen's residents (James Thoem, n.d.) and of course the city has not ignored to give a push to cycling as well, implementing bike sharing programs, safe and efficient cycling infrastructure as well as integrating cycling with public transport systems. The entire bus and metro network and its public transit mode of transport that serves to decrease car dependency is powered by renewable energy.

Copenhagen also pays special attention to its green infrastructure and to the improvement of mapping and planning of green spaces (Krähmer, 2021) in the city for the purpose of adaptation to climate change. Investments from the municipality were dedicated towards building green roofs additionally, parks and urban forests and creating waterfront green areas. Since they realize that climate change enhances the risks of flooding and heavy weather states, the Copenhagen city officials included climate adaptation in their urban planning (Sørensen & Torfing, 2022). For managing stormwater and mitigating heavy rainfall, green roofs and permeable surfaces are employed. Coastal defenses are also formed to help protect the city from increasing sea levels.

Singapore: Urban Greening and Smart Technologies

Being a small island country with limited land allocation, Singapore has used nature integration to become an exemplar of urban sustainability as a global financial hub (Diehl et al., 2020). Compared

to any other city in the world, Singapore is known for its 'City in a Garden' vision (Yeo, 2019), which has combined well with how much it has embraced innovative technology while retaining extensive green landscaping to generate an exciting, green, environmentally conscious urban neighborhood.

Very stringent green building regulations were implemented in Singapore in order for new developments to meet high environmental standards. Singapore's Green Mark certification system is the certification system that promotes sustainable building practices such as energy conservation, water conservation, among other practices. The system catalyzes environmentally friendly development of building because more than forty percent of Singapore structures were certified (Han, 2019).

Through the provision of comprehensive biodiversity management activities across the city, Singapore has come to be known for it. Over 5 million trees had been established by the municipal authority, as well as links to urban areas through connecting green corridors between nature stands and parks. Gardens by the Bay constitutes just one prime manifestation of (urban) green integration in Singapore, exhibited through the Supertree structures as well as the biodomes that it contains on its expanse of 101 hectares (Montefrio et al., 2021). In its environmental approach, the city dedicates efforts of biodiversity conservation with the species protection programs and nature ecosystem restoration initiative. The example of biodiversity importance isn't just happening on real urban areas, but the urban areas like Singapore Zoo and also Night Safari.

Singapore is a leading nation in the use of smart technologies in order to enhance the efficiency and sustainability of urban systems. The city has a Smart Nation initiative to introduce digital technologies in the provision of services such as energy, waste, and transportation. Smart sensors are used in Singapore for efficient traffic and management through monitoring systems to minimize congestion and smart waste system used in Singapore to develop smart waste monitoring systems that improve waste bin monitoring and collection routes. The technologies are used by Singapore to reach its zero waste community target.

Curitiba, Brazil: A Sustainable Urban Model in the Global South

Curitiba is a model for how to plan a sustainable city in the Global South for its 1.9 million inhabitants as the spirit of the Global South champions the Brazilian city as how to plan successfully. The basis of the urban sustainability efforts in the city is to establish an efficient public transportation framework as well as green spaces' development and emotional involvements of community in decision (Larbi et al., 2022).

Oriented towards Public Transportation and the Bus Rapid Transit (BRT) System: Curitiba's most remembered accomplishment when it comes to sustainable urbanism is its Bus Rapid Transit (BRT) system, which has been the blueprint for cities all around the world (Negri Pagani et al., 2021). In the 1970s, the BRT system was introduced as a fast, affordable and reliable public transportation by dedicated bus lanes and smart routes. All users get used to the system because its automated buses with high capacity and as good a car are a good substitute for transportation based on schedule. Air pollution problems and traffic jams were cut down alongside affordability for Sao Paulo citizens on the BRT system.

Curitiba devoted extensive priority to ecological planning together with the green spaces. As for air quality conditions, Curitiba has an extensive parks together with ecological corridors operating that also contribute to reduce heat island effects and making recreational parks to be enjoyed by its citizens. The Parks System of the city is anti flood system that combines flood management system with its parks through artificial lakes and wetlands that are natural stormwater

management elements. Curitiba's environmental sustainability and commitment in waste management are also displayed in recycling system, promotion of composting and waste diversion.

The most important aspect of Curitiba's success in sustainability has been the fact that the concept of community involvement and social equity was the center of its plans. It is well known that local residents have always been involved in the planning process of the city, of urban policies and projects. If a city wishes to achieve sustainability it has to cater for all its residents' needs. It has kicked off Curitiba's progressive approach to sustainability (Larbi et al., 2022; Marius et al., 2016; Pâslaru et al., 2008). For example, the city's public housing initiatives — for example — intend to address the issue of affordable housing in better connected and accessible areas with access to good connecting transport and green spaces.

Challenges in Implementing Green Cities

Solutions of green city are compatible with the requirements for urban sustainability, yet they come up with problems for environmentally and energy efficient, socially equitable urban space (Artmann, Kohler, et al., 2019; Pislaru et al., 2011). However, they are complex in all of the political, economic, social and technical domains. Finally, this chapter also examines in the context of green city initiatives the most pressing problems a city seems to have when trying to instill such measures in order for the city to reach a sustainable urban future.

Financial Constraints and Economic Barriers

Indeed, green cities are one of the most challenging ones to implement due to their high upfront costs of sustainable infrastructure and technologies (Artmann, Inostroza, et al., 2019). Despite the fact that they provide substantial comparative value to the overall effort for such investments, very large initial capital costs remain in many developing region or low income urban areas cities for investments in renewable energy systems, green buildings, renewables transportation networks and smart technologies.

Many governments from developing countries in particular are faced with the constraints of poor finances when it comes to financing large scale green projects. Often the things that cities must do are short term, and the things that they cannot do are long term, and budget limitations don't allow for enough of one or for the other. The main concern with any form of green initiative in any municipality is the availability of funds when the municipality has to compete with other important needs, particularly, public health, education, or even infrastructure maintenance.

Renewable Energy Technologies have fallen in price in recent years but are still far too expensive for many cities where finances are limited (Al-Shetwi, 2022). At the same time, large scale implementation of green technologies such as electric buses, green roofs or energy efficient buildings necessitate huge investment in infrastructure and training in local governments and the industries.

In cities with an experienced significant difference in economics, lower income communities may experience transitioning to a green city at greater costs. However, in many cases, the urban poor may find it unaffordable to live in sustainable housing, make use of energy efficient appliances or to easily afford green transportation systems (Alyami, 2019). These disparities must be addressed and ways to reap benefits of green city for everyone must be found by policymakers.

Political and Institutional Challenges

Green city initiatives rely on the political landscape to determine success. For implementing sustainable urban solutions, effective governance, long term policy commitments, as well as

coordinated actions over several governments' levels are inevitable (Artmann, Kohler, et al., 2019). But several political and institutional barriers tend to get in the way.

Lack of Political Will: There needs to be a strong political will and long term planning to accomplish the goals of a green city. In other cases, city leaders help out on environmental sustainability for the sake of economic growth or immediate political gain. Also political cycles can mean that there can be sometimes inconsistent policies: new administrations tend to play right into it, abruptly oppressing or dismantling the green city initiative and going instead to more pressing matters.

Urban governance largely has been shaped by complex networks composed of various local and regional and national authorities with varying interests and priorities, leading to fragmentation of governance. This is in the case of governance, it could result into misalignment of policies, delay in decision making and inadequate coordination between different stakeholders. For instance, transportation, energy and waste management departments operate autonomously from each other and hence, there would be problems with the implementation of integrated green solutions.

The barrier: another is resistance to change, especially from those industries that gain from the present state of things. For example, fossil fuel, construction and automotive industries might not be willing to go through the financial costs to move from using dirty energy sources to green infrastructure. Often progress also comes along with an attempt to change something in urban planning, such as introducing congestion pricing, or zoning laws for green spaces, where public opposition may slow progress down.

Urban Density and Infrastructure Constraints

More than half of the world's population is now urban. The population in these towns is growing, and has the benefit of opportunities and the challenge of creating green cities. With continued urbanization, urban spaces experience increased need for resources, space, and infrastructure to integrate into cities in a more sustainable way (Gu et al., n.d.).

Most of the urban areas all over the world are urban areas with various natural as well as artificial limitations. It is too often subjected to pressure to convert green spaces into commercial or residential areas in order to accommodate a growing population. The solutions for promoting the preservation of green space in the context of the high demand for housing and infrastructure, while balancing economic and environmental priorities, typically involve complex trade offs regarding environmental and economic priorities.

Aging infrastructure is an issue that cities, in developed countries in particular, have to face. Often retrofitting the old buildings and public utilities with sustainable technologies such as energy efficient systems, waste management systems or stormwater management systems can be very costly and difficult logistically. Sometimes, green technologies might require the total redo of the existing infrastructure to be able to achieve its sustainability goals.

The effect that the urban heat island can have on high density urban areas is such that the temperatures in the city are higher than those in the areas surrounding the city. It worsens the air conditioning demand and is an environmental burden. Green roofs, tree canopy coverage and reflective shiny materials that absorb less heat can be a good implementation, but in among skyscrapers it is difficult to get the space to implement (İnançoğlu et al., 2020).

Social and Cultural Barriers

The implementation of green initiatives may also be affected by social and cultural conditions in the city (Colding et al., 2022). Green city concepts might be foreign to many residents and some

may be wary of change, even when the change involves things that are counterintuitive, such as breaking new ground with terminated or neglected norms or habit set by the old city.

A major hurdle to the green city issue is a low level of public awareness and involvement in this issue. Although large numbers of people can be supporters of environmental sustainability in principle, they may not really understand what green technologies' longer-term wonders are or lack motivation to shift their behavior unless it entails giving up and making an upfront investment. The awareness of the importance of green spaces, energy saving and efficient transit is vital to create the culture of sustainability and it is crucially important to educate the public about it.

Many residents of urban areas interpret cultural norms and tend to the adoption of green practices. In many cities, car culture is very grounded, unless you want to turn public transportation, cycle or walk, this may be viewed as inconvenient, or undesirable. Similarly, waste disposal and resource recycling in these cases may not be prioritized as 'waste management' is regarded as an afterthought. Given these cultural barriers to make sustainable choices, education, incentives and supportive infrastructure are combined to achieve these goals.

Future Directions for Green Cities

Against the backdrop of growing towns and the effects of climate change, population growth, and resource depletion, green cities have become at the core of the sustainable development of the city concept. Although tremendous progress has already been made to establish green cities, the green cities future is still in the early stages. If this continues, green cities will evolve as long as innovation, technology, policy update and community interaction continues (Almalki et al., 2023). This chapter takes us through different aspects of the future directions of green urban settlements and indeed looks into some of the trends and strategies that will drive the towns of tomorrow.

Integration of Smart Cities and Green Technologies

The integration of the smart city technologies with the sustainable practices is one of the most promising further development directions of green cities' future. The digital technologies and Internet of Things (IoT) bring great possibility to improve the urban sustainability (Almalki et al., 2023). Depending on the data available, sensors, data analytics and artificial intelligence can be used to improve urban systems from energy consumption to water management, transportation to waste disposal.

As more and more cities have become green, real time management and monitoring of resources has become increasingly implemented through smart technologies (Ahad et al., 2020). In one instance, smart grids can better handle electricity distribution, and Intelligent Transportation Systems can reduce the congestion and maximum possible traffic, thus lowering emissions. Besides that, data driven decisions will facilitate urban planners target policies to tackle environmental degradation, waste reduction and sustain living.

Circular Economy and Waste Management Innovation

In the future of green cities, a circular economy model will be essential not only for the global population's growth and resource consumption. Whereas the traditional linear model of 'take, make, dispose' focuses on getting resources through raw extraction and converting them into a waste ready to be dumped, the circular economy seeks to get the best use of resources by promoting recycling, re-using and re-purposing of materials. In the process, cities will create closed loop systems of waste being minimized and materials being continuously cycled into the economy (Hidalgo et al., 2019).

Ideally, future green cities of will more widely implement technologies like waste-to-energy systems and composting program and higher use of biodegradable and recyclable materials. In addition, urban agriculture efforts like vertical farming or community gardens will be helpful in lowering the environmental effects of food's production and waste disposal.

Enhancing Green Spaces and Biodiversity

Green spaces will remain as a critical part in the planned future green cities by their integration into urban environments. Yet, the future holds a change in the green infrastructure solution, which moves away from the more creative and diverse solutions that also meet urban ecological needs.

Future green urban areas are going to be the cities that put more focus on the conservation of biodiversity through incorporation of various ecosystems in the ambient design. Cities will come to include green roofs, living walls, urban forests, among other biodiverse parks. In addition to improving the looks and recreation enjoyment of the urban waterscape, these green spaces will assist with air quality, degrading urban heat islands and slop water management (Knobel et al., 2019).

Resilient Urban Design and Climate Adaptation

Since climate change continues to affect cityscapes across the world, future green cities will need to concentrate on resilience and climate adaptation. In future, cities will be designed in a way that can reduce their vulnerability to climate related risks like flood, heat wave and rising sea levels.

Security of the urban populations will depend on the existence of such things as resilient infrastructure, including permeable pavements, flood resistant buildings and elevated transport systems. Cities will also increasingly depend on nature based solutions for the adaption of climate impacts (Peng et al., 2021). The possibility of such things as wetland restoration, forest conservation, and the strategic use of vegetation to soak up excess rain and lower the urban heat island effect are among them.

Social and Cultural Innovations

Such green cities will also put huge emphasis on the social sustainability, that these benefits of green development should reach each and every segment of the population with equity. Fostering social cohesion, cultural engagement and inclusivity, the design and implementation of green spaces as well as community-oriented projects, affordable housing, among others, will be the responsibility of this (Afshari et al., 2022).

Community driven solutions will be a key in forming the urban environment in the future. Residents will become more engaged with counties in the participatory planning process, contributing to the planning of their towns and cities. Using this approach also allows local communities to be empowered and green city initiatives to be a response to the diverse needs and values of urban communities.

Using VOSviewer, we conducted the bibliometric analysis based on a large literature review of 284 research papers in the scope of keywords 'renewable energy', 'sustainability', 'green cities' in order to observe, trace and map the trends over trends, patterns, connections in the research literature in relation to theses keywords. The results of this analysis offer some insights as to how these areas have evolved and showcase features that ought to be studied for possible approaches in the development of sustainable urban development and energy programs.

Conclusion

The prospect of green cities is a bright one in which the very future holds the possibility of creating towns that are as ecologically sustainable as they are socially equitable, economically vibrant. Drawing upon smart technologies in combination with circular economy, biodiversity and building of resilient urban infrastructures, cities can deal with the challenges of rapid urbanization, rapid urbanization and climate change. If green urban areas are to continuously evolve they will be hubs of innovation and sustainability, leading the way as an example of a more harmonious way humans relate with the environment. Consequently, future sustain urban life requires moving forward with continuous cooperation between governments, businesses and communities, alongside individuals, toward creating a future of a sustainable urban life for generations.

This study aims at looking into the present state of knowledge of renewable energy, sustainability and green cities to obtain key trends and influential studies together with gapping in the literature. The research questions attempted to understand how these concepts connect and play a role in sustainable urban development.

Bibliometric analysis showed that for effective green cities aimed at urban resilience, it was necessary to integrate renewable energy and sustainability in their systems. Also, this result is consistent with previous literature suggesting that urban areas with high values of renewable energy, environmental resilience efforts as well as inclusive urban infrastructure components are more ecologically resilient, as shown by (Greene, 2024; Mutani & Todeschi, 2020; Yang et al., 2024). This is consistent with climate change induced push for building sustainable towns.

These results show a notable alignment to smart cities, sustainable mobility, and green technologies in the urban planning as is indicated from the results gathered by previous studies (Kumar, 2024; Spiridonov & Shabiev, 2020). This implies that we regard green cities to be ecosystems important to helping achieve environmental sustainability.

However, the study is limited because bibliometric data depends mostly on the last trends and research published in the English language.

This study is useful to urban planners, policymakers, researchers, since they can gain a better understanding of how to integrate reasonable energy and sustainability in the green cities. The existing literature gaps identified in this research raises further areas of research that will help to improve sustainable urban development strategies.

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