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Urban forests and their contribution to sustainable urban development in a global context: a case study of Multan, Pakistan

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Currently, cities and towns are home to over half of the global population, and this percentage will rise over the coming decades. Cities can be wonderful homes to live in if planned and maintained properly, but most urban developments have noticeably caused environmental destruction, which in turn results in issues like urban heat islands, flooding, and air pollution. Cities require forests as their breathing organs. The study refers to the case of Multan City, where the climate is deteriorating at an alarming rate due to rapid urbanization and the lack of vegetation. The study aims to provide an urban green infrastructure (UGI), which abides by the key proactive resilience principles of effectiveness, diversity, dependence, durability, versatility, autonomy, planning, and adaptability. A strategic literature review has been done to study the effects of urban forests, and various studies were reviewed as per the methodology adopted worldwide. The policy frameworks of the Sustainable Development Goals (SDGs) and the New Urban Agenda (NUA) were considered while selecting sites for implementing urban forests. A five-point Likert scale questionnaire was developed for the participation of the community nearby. Ten different sites were selected in the city based on ownership and feasibility, irrespective of SDG, NUA, and community opinions. The study concludes with the design suggestion of one site as a prototype in the given context.

KEYWORDS

urban forests, SDG's, NUA, UGI, climate change

Introduction

The notion of an "urban forest" refers to all trees that grow within urban areas, and these trees play a significant role in providing towns and cities with ecological services (McPherson et al., 1997; Nowak et al., 2001). Significant built-up areas and dense populations in metropolitan areas currently make up only a small portion of the world's surface—up to 3% (Levan Alpaidze, 2022). Meanwhile, they share a major portion of the responsibility for human impacts on the environment (Elmqvist et al., 2013). Compared to the constantly rising demand from urbanized regions, where over half of the world's population already resides and around 60% of people will do so by 2030, cities only generate a small portion of

all goods and ecosystem services (Alpaidze and Salukvadze, 2023). The infrastructure of urban green spaces, or UGS, is currently receiving increased attention due to its importance for cities, whether they are developed, developing, or in the future. Sustainable development nevertheless requires sustained urbanization, and green planning for cities is seen as a successful defense against impending environmental and climate change concerns (Muhammad Rayan, 2022). According to David and McKane (2021), city planning is still a crucial arena for conflict in the pursuit of social and environmental justice. Globally, green infrastructure (GI) has become a key tactic for urban sustainability transitions (Grabowski et al., 2023). In addition, the existing state of affairs is causing ecological imbalances, disturbances to greenspace structures and ecosystem functions (ESF), biodiversity loss, and deteriorated health and well-being at all spatial scales. As a result, creative, green, nature-based solutions based on urban green infrastructure (UGI) are beginning to emerge as a new avenue for rehabilitating disrupted socio-ecological systems (Monteiro and Ferreira, 2020). Urban expansion and intensive land usage in urban green infrastructure are the main causes of the increasing pressure on urban forests surrounding cities in many regions of the world (Ingo Kowarik, 2019). Consequently, urban forest patches are becoming increasingly important for the conservation of biodiversity and are treasured by urban residents for their ability to make cities livable and the abundance of ecosystem services they provide (Konijnendijk, 2018).

The origins of urban forest patches and the ways in which humans have influenced their growth vary greatly, and as a result, they may make varied contributions to the conservation of urban biodiversity (Jim, 2017). It is widely known in restoration ecology that urban tree planting can create new forests, as seen in the cases of Oldfield et al. (2013), Johnson and Handel (2016), and McPhearson et al. (2017) and near-natural locations on the edge of cities.

However, resilience is becoming a global policy objective as cities face increasing challenges in recovering from acute and chronic shocks. Urban forests and trees are essential parts of the ecosystem because they assist city dwellers in several ways and strengthen the resilience of the broader social-ecological system. Reducing stormwater runoff, providing shade and cooling, and improving cognitive function are just a few of the advantages that come with cultural ecosystem services for human well-being. Other advantages include place attachment—the bonding of people to their surroundings—identity, and recreational space (Roy et al., 2012). People and groups that benefit from urban forests may perceive those benefits differently depending on how they interact with the forest and their individual values, preferences, and experiences with nature. These disparities in benefiting from urban forests are caused by the complexity of managing urban forests combined with the social and ecological heterogeneity of urban landscapes (Vogt, 2020). The rising impact of greenhouse gas emissions, of which CO_2 is the most important and which consequently affects the greenhouse effect in the atmosphere, is currently one of society's most pressing environmental problems (Wang et al., 2022). Many refer to it as global warming or climate change because forests absorb carbon. The paradigm is expected to gradually move toward a socio-climate centered on national and international policies that put more and more strain on forests in many cases (Börner et al., 2020).

Urban forests are the primary source of ecosystem services that urban dwellers receive. They do this by offering a variety of advantages, such as ecosystem services and contributions to the environment, economy, society, and ecology. Additionally, they offer a range of ecosystem goods and services that can enhance urban dwellers' quality of life and have positive restorative impacts on human health, such as lowering stress and anxiety levels, reducing depression, and aiding in attention recovery (Emylia Shakira and Abas, 2023).

In order to ensure livable and sustainable urban development, urban forests are essential. If a city's urban forest management is not updated and enhanced, its ecosystem function will be lacking since urban forests are a key mitigator of problems pertaining to people's well-being and environmental problems that arise in the city.

Role of urban forest in NUA and SDGs

In 2015, the international community supported two major global development accords, the Paris Climate Change Agreement and the 2030 Agenda for Sustainable Development, both of which have urban sustainable development at their core.

The 2030 Agenda, which builds on the MDGs, asks nations to mobilize efforts to end all forms of poverty fight inequality, and tackle climate change, while ensuring that no one is left behind by the 2030 agenda, which expands on MDGS. 17 Sustainable development goals or SDG,s are included in 2030 agenda (Desa, 2014).

The Paris Agreement's sustainability targets are largely dependent on cities, as acknowledged at the 22nd United Nations Framework Convention on Climate Change, which conducted its Conference of the Parties in Marrakech, Morocco, in 2016. The adoption of the New Urban Agenda (NUA) was the conference's principal result, which lays forth a global plan to handle the challenges associated with urbanization in the ensuing decades. The NUA states that cities need to create people-centered urban plans that support their residents' thriving rather than just surviving. Three "interlinked" concepts form the foundation of the NUA: environmental sustainability, inclusive and sustainable urban economies, and leaving no one behind. The NUA is predicated on the idea that, in both wealthy and developing nations, carefully thought-out and controlled urbanization may be an effective tool for sustainable development. It also emphasizes how connected it is to the 2030 Agenda and how it will help carry it out.

According to the NUA and the SDGs, especially SDG 11, urban green spaces like urban forests are essential for enhancing urban living

Abbreviations: SDG, Sustainable development goals; NUA, New Urban agenda; MDGs, Millenium development goals; IGOs, Intergovernmental organizations; NGOs, Non-governmental organizations; FAO, Food and Agriculture organization; UV, Ultraviolet; UNEP, United Nations Environment Program; U4SSC, Unified for Smart Sustainable Cities; UGI, Urban Green Infrastructure; NC, Nature conservancy; WWF, World Wide Fund; IUCN, International Union for Conservation of Nature; KPIs, Key performance indicators; SCRM, Sustainable climate risk management; PBS, Pakistan Bureau of Statistics; PHA, Pakistan Horticultural Authority; ESF, Ecosystem functions; EPA, Environmental Protection Agency; MSEP, Multi-stakeholder engagement procedures; GOV, Governance; ACAD, Academician.

conditions, fostering community cohesiveness, and advancing environmental sustainability. As a result, countries commit to promoting the creation of safe, hospitable, accessible, and ecologically sustainable public spaces (SDG 11). The role of urban forests in achieving Sustainable Development Goals is illustrated in Table 1, adopted by Salbitano et al. (2016).

Pakistan framework for green policies

Pakistan lacks the frameworks and inclusive land-use planning policies necessary to safeguard its citizens and ecosystems from escalating climatic risks. The majority of Pakistan's largest cities, such as Islamabad, Peshawar, Lahore, and Karachi, have seen a decline in the number of green spaces during the past 20 years, according to records and evidence. Lack of awareness and insufficient landscape and greening policies (LGP) are to blame for the conversion of agricultural land into urban infrastructure development in Pakistan (Rayan et al., 2022). The well-being of individuals, natural resources, and urban ecosystems is now under threat due to an increasing number of flood disasters. It is so because, according to the German Watch long-term climate risk index, Pakistan is the eighth-most vulnerable nation in the world to natural disasters, behind Thailand and Nepal (Eckstein et al., 2019). The lack of resources and inadequate management and planning procedures are the main causes of this, resulting in a variety of risks that have caused extensive (direct and indirect) harm to the urban system. Ineffective planning frameworks and standards for creating and regulating activities inside green areas are also to blame. The country will see many more natural disaster occurrences of varied sizes and effects if the current planning scenario holds (Rayan et al., 2022).

A significant aspect of the government's 100-day goal is Clean & Green Punjab, which is also started by the local government and community development department of Punjab.[1] As the campaign incorporates all government agencies, especially those in the districts, deputy commissioners are crucial to its success. The three main initiatives are planting trees, preventing encroachment, and maintaining cleanliness. To combat environmental problems, including pollution and garbage disposal, the Punjab Climate Change Department and the Environmental Protection Agency (EPA)[2] are also working to reduce these highlighted issues. Planting trees continues to be an important duty for them, but tackling urban green infrastructure is consistently disregarded.

Even though th World green building council regulates the Pakistan green building council. According to the World GBC's mandate, the Pakistan Green Building Council addresses all environmental concerns, including subsoil water levels, water utilization and usage, global warming, deforestation, carbon emissions, air quality, transport, farming, and industry. It also addresses building layout, living habits, and a system for certifying green products and buildings, and environmental education in schools. However, Pakistani development authorities have not yet put the code into practice (Muhammad Afrasiab et al., 2021).

1 https://lgcd.punjab.gov.pk/Clean%20and%20Green%20Punjab

2 https://epd.punjab.gov.pk/

Social cohesiveness, urban forest areas, and wellness for people

peri-urban and urban forests, which are "systems and networks including all forests, collections of trees, and particular trees located within and around urban areas," can be effectively planned and managed (Salbitano et al., 2016) and can significantly improve the standard of urban green spaces. In Baltimore, Maryland, United States, for instance, a strong opposite association between criminal activity and tree cover was found (after controlling for numerous confounding variables); this association held true for private as well as public lands but was strongest for publicly accessible public lands (Troy et al., 2012). According to a study on the overall effectiveness of various urban elements, parks are regarded as valuable community resources. They invite residents of the neighborhood to public spaces where they can engage in recreational activities during times when individuals are more likely to be receptive to others and open to what is going on around them since they are having fun together in a public setting (Cohen et al., 2008). After taking into account demographic and socio-economic factors, a study done in the Netherlands found that having fewer green areas in people's homes was linked to feelings of loneliness and an overall absence of social support (Maas et al., 2009). Overall, information obtained from interviews showed that those who had more access to green areas in their homes felt healthier, had less complaints about their health in the 14 weeks prior to the questionnaires, and had a lower self-rated propensity for mental illness. The study also found that the strongest and most reliable correlation between health markers and green space was found to be found beyond a radius of 1 km of people's homes.

Advantages of peri-urban and urban forests

The significance of urban and peri-urban forests in delivering ecosystem services and influencing urban residents' well-being is outlined in Figure 1. Policymaking, decision-making, and the value placed on ecosystem services are all impacted by preferences for specific ecosystem services. This management decision eventually affects the shape and composition of the urban and peri-urban forest estates. A city's ability to withstand shocks and strains from the social and environmental spheres can be influenced by all of the framework's elements (Dobbs et al., 2017).

Environmental implications

Storms and flooding, which can be severe and frequent, are more likely to affect those who reside in urban areas. Stormwater management benefits from urban trees are numerous. The retention of contaminants in plants and soil may enhance stormwater quality, whereas the evaporation of precipitation collected by canopy trees and through evaporation can reduce stormwater flow (Stovin et al., 2008). The NUA calls for environmentally friendly handling of natural resources in towns and settlements that protects and enhances urban ecosystems and their ecological services, reduces greenhouse gas emissions and air pollution, and promotes disaster risk reduction in accordance with SDGs 13 (climate action) and 15 (life on land). Urban

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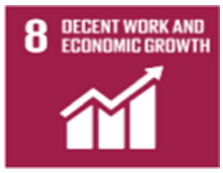
TABLE 1 The role of urban forests in achieving sustainable development goals.

Sustainable development goals	The role of urban forests
	Urban forests promote local green spaces by generating jobs, serving as a resource for business owners, lowering the cost of urban infrastructure, improving the living environment, and raising property prices.
	Urban forests serve as direct food sources for a variety of foods, including edible insects, wild meat, bark extracts, mushrooms, berries, seeds, leaves, and saps. By offering reasonably priced wood fuel, clean water, and better soil for productive farming, they indirectly promote healthy eating.
	Urban forests provide the perfect environments for a variety of outdoor leisure and relaxation activities, forests and other green areas in and around cities also help to prevent and treat non-communicable diseases and maintain mental health. Urban forests effectively filter and eliminate particles and contaminants, which also lowers the prevalence of non-communicable diseases.
	Urban hydrological cycles are well regulated by urban woods. By lowering biological and chemical impurities, they filter drinking water. They also minimize losses by evapotranspiration processes, which lessen meso-climatic extremes.
	Urban communities can use renewable energy produced by urban forests managed sustainably. For billions of people living in cities and peri-urban areas around the world, especially in low-income nations where wood fuel is frequently the most accessible and affordable energy source, this is an essential role.
	Urban forests and other green infrastructure investments contribute significantly to green economic growth by creating a welcoming atmosphere for business and tourism, raising property values and rental income, fostering job opportunities, supplying building materials, and lowering energy and healthcare expenses.
	Cities' ability to support a thriving economy, livability, and environmental sustainability are all greatly enhanced by well-planned and maintained urban woods. They offer ecological services and public benefits, lessen energy costs, poverty, and starvation, and assist prevent climate change and natural calamities.
	In addition to their direct role in mitigating climate change through carbon sequestration and greenhouse gas emissions reduction, trees and forests in and around cities also play an indirect role through energy conservation, lowering the urban heat island effect, and reducing flooding.
	Urban forests have a major role in soil quality improvement, habitat creation and enhancement, biodiversity pooling, and land restoration.

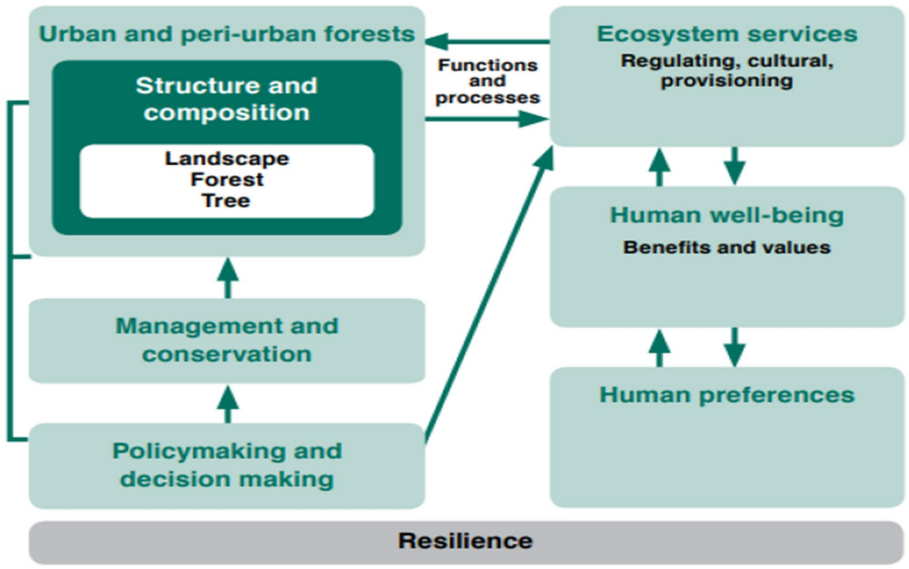


FIGURE 1
Urban and peri-urban forests' significance in delivering ecological services and impacting city dwellers' well-being. Source: Adapted from Dobbs et al. (2017).

and peri-urban forests and trees directly store and absorb environmental carbon dioxide, reducing the effects of climate change. Additionally, trees reduce wind speeds and provide shade, which indirectly reduces carbon emissions from power plants by lessening the need for air conditioning and heating (Nowak et al., 2013). Destructive combined sewer overflows are also less likely when there is less rainwater runoff (Fazio, 2010). Thus, trees are the source of shading and can extend the useful life of a roadway pavement by up to 10 years while reducing pollution from petroleum-intensive products and the operation of big machinery needed to resurface roads and take away waste (McPherson and Muchnick, 2005). By providing shade, lowering urban albedo, reducing the quantity of ultraviolet (UV) rays reflected back into the surroundings, and cooling through transpiration, urban and peri-urban trees can lessen the "heat island" effect (Lankao, 2008).

Urban and peri-urban forests can aid in reducing mortality caused, among others, by the consequences of climate change by increasing social cohesion. Long-term sustainable approaches to combating climate change must include measures to promote community stability (Williamson et al., 2010). For instance, in the catastrophic 1995 Chicago heatwave, the death rate varied significantly by neighborhood, partly because of variations in community cohesion (McMichael, 2003).

Socio-economic progress

According to the NUA, green spaces are increasingly seen as positive economic agents that can be used to raise economic status by, among other things, boosting property values, facilitating trade and public as well as private savings, and providing opportunities for everyone to earn a living (SDGs 8 and 10). Green areas are no longer just seen as beautiful landscape features. The effects of open spaces and woods in urban and peri-urban regions on property sale values are investigated using hedonic models. According to these calculations, a house's valuation rises by 7% if there are open areas within 80–100 yards of it (Wolf, 2003; Conway et al., 2010) investigated the relationships between modifications to urban forest features and customer behavior in various American municipalities using contingent valuation methodologies. He discovered that consumers were 9–12% more likely to make a purchase in retail districts with trees than they were in equivalent areas without trees.

Inclusive governance in urban forest

In order to ensure the long-term survival of urban and peri-urban forests, inclusive leadership is crucial. This is because there is mounting evidence that governmental organizations are no longer the sole major players in decision-making processes (Lawrence et al., 2013). Therefore, in this aspect, long-term inclusive governance is necessary. The concept of governance with government is displacing governance by government in UPF, as it is across various urban policy sectors. To optimize the benefits of urban trees and other greenery in improving standard of living for city dweller, there needs to be constant, reliable dialogue between the persons and the population they serve. There are several benefits for inclusive public participation in decision-making regarding the urban living environment, such as improving these choices themselves, boosting the credibility of options, and gaining the support of the public for them.

In order to achieve inclusive governance, it is necessary to evaluate

- the categories and functions of participants in an inclusive UPF leadership program; and
- the community's and its stakeholders' desire to participate in governance activities and their attitude toward achieving it consequently.

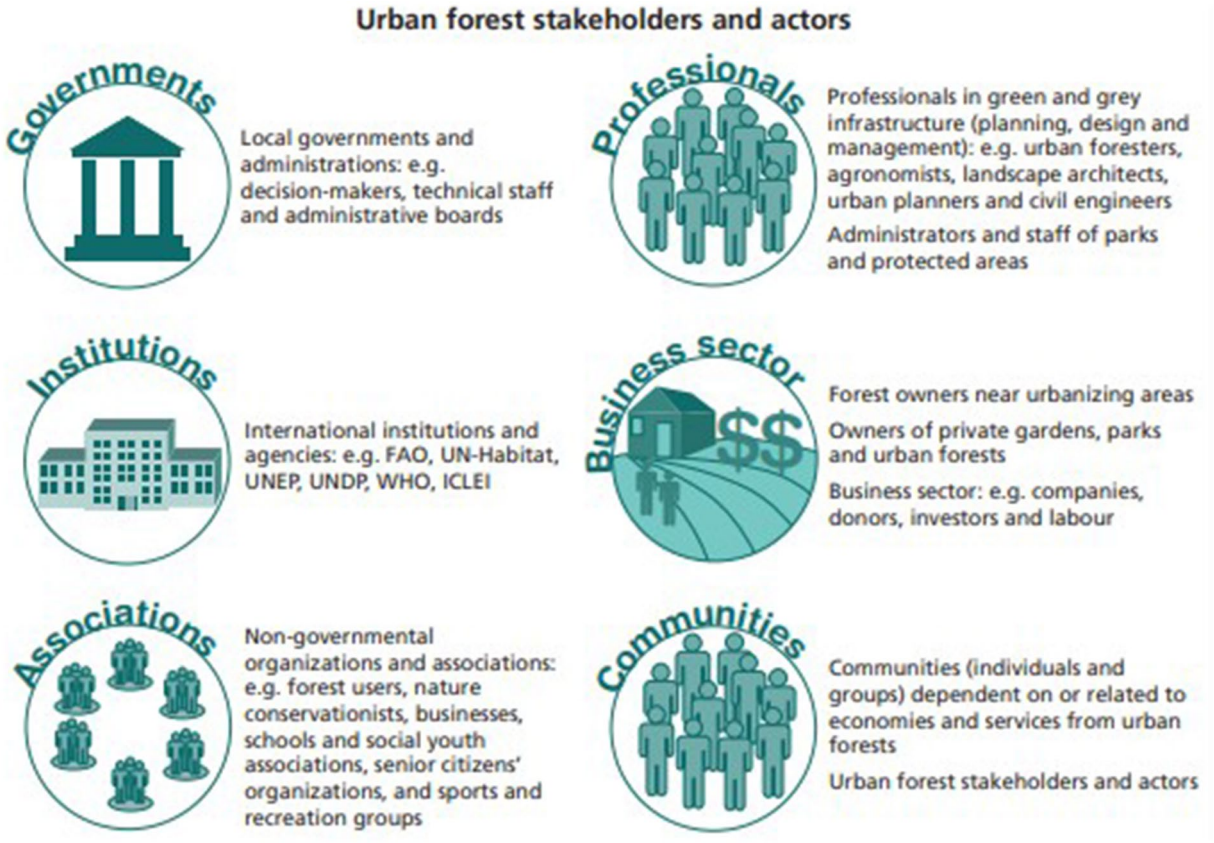


FIGURE 2
The inclusive governance of urban forest participants. Source: Salbitano et al. (2016).

Communities have complex socio-ecological systems (bio-geo-physically, socially, and inFstitutionally, for example), and there are a wide variety of stakeholders who could participate in urban forest governance. Figure 2 illustrates the phenomenon. Others may be more or less actively associated with urban forest governance procedures, while some may be directly involved in urban forest planning, design, and administration as professionals, technicians, users, and decision-makers (Salbitano et al., 2016).

Civil society actors are increasingly seen as having a role to play in encouraging the prospective advantages of forest areas in urban or peri-urban regions. By undertaking action research, giving policy advice, and developing institutional capacity, intergovernmental organizations (IGOs) and non-governmental organizations (NGOs) have played crucial roles in bridging knowledge gaps. These organizations also foster communication among nations, towns, and civil society to increase awareness of the need for living more sustainably among people worldwide (Ordóñez, 2021) and finally accomplish total integration of urban planning and administration with peri-urban and urban forests.

It is necessary to take into account the concept of "forest culture," which refers to the perspectives and practices of a community regarding urban and peri-urban forests in relation to their biodiversity and biogeographical characteristics. A variety of worldwide methods for urban and peri-urban forest design are compiled in Table 2 in order to accomplish different goals.

Statement of the problem and proposed intervention

Pakistan currently lacks green policies and sustainable land-use planning methods. In order to address the increasing climate hazards, UGI may serve as the central focus of Sustainable Climate Risk Management (SCRM; Khayyam and Noureen, 2020; Rayan et al., 2021). According to the Pakistan Bureau of Statistics (PBS), due to Pakistan's huge terrain and numerous homes (220 million people), a sizeable fraction of the population (39.22%) lives in urban areas, and by 2030, this number will have increased to 50% (Rayan et al., 2022). There is a need for creative UGI design, putting urban areas and their residents at risk of catastrophic climate change. Increasing frequency of natural disasters. Due to persistent flooding, Pakistan's susceptibility to natural catastrophes has increased to the ninth ranked (Eckstein et al., 2019; Khayyam and Noureen, 2020). The main area for this study is the urban center of District Multan, i.e., Multan City. We chose this area primarily for two reasons: (1) Multan is one of the fastest-expanding cities in Pakistan (Manzoor et al., 2019). Multan, also known as the city of Sufis and Saints, is one of the oldest towns on the Asiatic subcontinent, with a rich history and culture. It was established in the period of the Indus Valley Civilization, *circa* 5,000 BC. Latitude 30.18 N and longitude 71.48 E are the coordinates for Multan City (Fatima et al., 2021). Nonetheless, there has been no past research on the spatiotemporal changes in the urban green infrastructure, accept the authors own conference paper

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TABLE 2 List of a variety of international strategies for urban and peri-urban forest design to meet different goals.

Country	Name	City	Goal	Description
Germany	Berlin	Biotope Area Factor (1984)	To regulate new urban development with an ecological approach.	Part of the area to be developed is to be used for green spaces in which the original vegetation is to be kept or new plant cover planted. Guidelines are provided for landscape planning and design, species protection, and conservation. One of the main advantages of the Biotope Area Factor is that it is flexible in the design of the urban forest and enables stakeholder participation. Since the Biotope Area Factor was introduced in the design and planning of green areas, the provision of vegetation in heavily populated areas has significantly reduced the impacts of climate change, such as heatwaves, flooding, and storms.
Sweden	Mälmo	Green Space Factor (2001)	To regulate urban development for new urbanization areas using an ecological approach.	The approach is similar to the Biotope Area Factor, with various versions and biotopes.
United States	Seattle	Urban Forest Stewardship Plan Seattle Green Factor	To create an ethical model of urban forest management for all stakeholders.	The management plan is framed within the Trees for Seattle Strategy, which brings together all efforts on forests in the city. A section of the strategy focuses on the design and safety of street trees and their role as elements for reducing driving speeds, crime, and domestic violence without reducing the important esthetic values they provide. The Seattle Green Factor is an adaptation of the Mälmo Green Space Factor, which is being incorporated into other cities in the United States.
			To make specific improvements with a view to achieving a net increase in the functions of urban forests and the associated economic, social, and environmental benefits.	
			To increase forest cover by 30%.	
			To strengthen the health and longevity of urban forests, improve the quality of species and eliminate invasive species.	
Australia	Sydney	Greening Sydney Plan, 2012	To protect and maintain existing urban forests.	Strategy aimed at developing and protecting urban and peri-urban forests.
			To increase canopy cover.	
			To improve biodiversity.	
			To increase knowledge and commitment in the community.	
Sweden	Umeå	Youngurban forests	To develop new urban forests.	Young urban forests have been created by regenerating previous forests or by planting trees, the latter seeking to perform predetermined functions entailing specific forest treatments that need to be permanently maintained. An experimental study was carried out in Umeå on a 2.1-ha plot that had been reforested 20 years before. In this forest, 12 small forest compartments were created using various thinning methods, with different functions and traditions, creating areas for relaxing and meditating in isolation; children's play areas; natural-looking spaces; areas subject to heavy management for esthetic purposes; and various samples of local forest types.
Norway	Akerselva (Oslo)		To create multisensory environments.	A corridor was created along the Akerselva River to enable downtown residents to travel to nearby parks hosting 14 "quiet areas" for contemplation.
United States	New York	Program PlaNYC: 2030	To ensure accessibility.	The aim is for every inhabitant to have a green area within a 10-min walking distance.
Singapore			To provide opportunities to be outdoors and enjoy nature.	The integration of 200 km of pathways through elevated runways to enable inhabitants in different parts of the city to access parks.
Japan	Nagoya		To promote actions to actively support nature conservation.	Conserve 10% of land next to the city boundaries as an unmanaged area and protect it as a nature reserve.

(Continued)

TABLE 2 (Continued)

Country	Name	City	Goal	Description
United States	Phoenix		To encourage actions to actively support nature conservation.	17.000 ha of desert were purchased to avoid the negative effects of urban expansion, and this area was designated as a nature conservation site.
United States	Portland		To invest in social infrastructure that helps urban dwellers understand nature.	Investment of more than 5% of the annual city budget in biodiversity. The aim is to attain one of the highest tree canopy covers among the nation's cities (29.9%).

(Anum et al., 2021) in the Multan region's environment, and (2) Multan is situated in the southern portions of Punjab province, which is said to be one of Pakistan's most climate change-vulnerable regions. The damage varies due to the Multan future developmental Master Plan illustrated in Figure 3, where huge ignorance about urban green infrastructure is observed, which is leading the city toward disastrous climate change. As a result of unprecedented urban growth, pressure on green places is growing. Numerous climate-related issues are already developing, such as urban heat islands, droughts, and flooding (Desa, 2014). The previous studies of the author reveal that the spontaneous growth of housing societies is cutting off huge amounts of agricultural land (Anum et al., 2021). Furthermore, the current state also contributes to ecological imbalances, disturbances of ecosystem functions (ESF), loss of biodiversity, and deteriorated health and well-being at all spatial scales. Therefore, planning for urban green infrastructure (UGI) is becoming a new technique to improve disrupted socio-ecological systems through creative green, nature-based solutions (Monteiro and Ferreira, 2020).

The objective of the study and research questions

The objective of the study is to provide a framework for an urban green infrastructure model in the form of urban forests to enhance the resilience of targeted areas against climate hazards. This model will be created with a collaborative approach, involving professionals and community members.

The research questions are as follows:

Q1. What sustainable UGI indicator-based approach is necessary to build a climate-resilient city?

Q2. Does the community know about the SDGs and the NUA to build a climate-resilient city?

Materials and methods

This article explores the role of urban and peri-urban forests (UPF) as part of an all-encompassing strategy to develop urban green infrastructure by presenting several international perspectives on the necessity of proper design in UPF. The study refers to the case of Multan City, where the climate is deteriorating at an alarming rate due to rapid urbanization and the lack of vegetation.

The methodology of the study addresses the following areas, illustrated in Figure 4, through a flow chart:

- The strategic literature review identifies the role of urban forests on a global scale and how SDGs and NUA will play a vital role in making cities resilient to cater to climate change.
- To review the proposed Multan city Master Plan by the local development authority for the identification of urban infrastructure in a development plan.
- Questionnaire from multi-stakeholders and the community at the regional level.
- To identify 10 different neglected open spaces and native species of plants by the Environmental Protection Agency (EPA) and Pakistan Horticultural Authority (PHA) in the city, irrespective of ownership of land.
- To conclude prototype design suggestions for future implications.

Examining a potential framework model based on UGI indicators

The UGI model is created by combining two approaches: (a) creating a conceptual framework on which to construct the framework, which is then extended to combining anthropogenic behaviors and UGI for strong cities; and (b) creating climate resilience methods that depend on ecosystem functions, well-being for humans, and UGI elements. The framework/model that is being offered, as well as the resilience strategies, as a result, address or incorporate various theoretical concepts (such as green space networks, energy and the management of water, the sustainable economy, biodiversity and wildlife, organic food, adaptation and mitigation, ecosystems, social cohesion, and adaptability) that were spawned from the informal discussions that were carried out through a field survey. As a result of these innovative concepts, the UGS infrastructure may assist in addressing sustainable climate risk management (SCRM). The determination of UGI criteria for green urban design, such as managing stormwater, a decrease in noise pollution, an improvement in air quality, etc., results from the thorough integration of all three aspects—the ecological, social and cultural, and economic dimensions.

Processes for engaging multiple stakeholders (MSEP)

As a participative planning strategy, multi-stakeholder engagement procedures (MSEP) continue to be beneficial in involving the stakeholders. The Environmental Protection Agency, Pakistan Horticulture Authority, and the respondents from the GOV (governance), ACAD (academicians), PRACT (professionals), and INGO (international non-state/government actors/organizations) experts to whom the local survey was extended are among the study's stakeholders, as illustrated in Figure 5. Therefore, in this instance, MSEP offered a thorough pathway to ensure the effective participation of the population/native participants in the process of decision-making, including the experts acting as

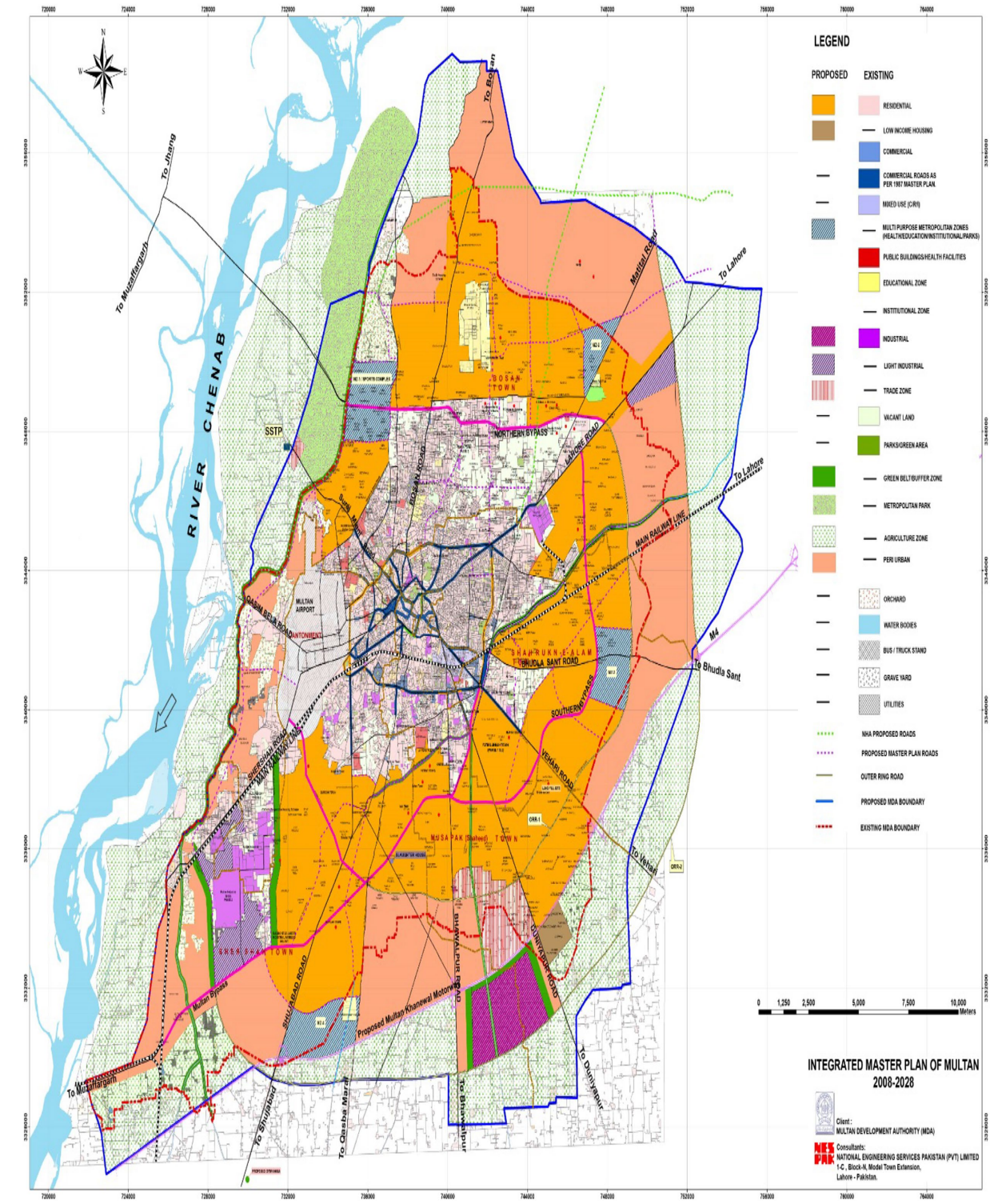

FIGURE 3
The Multan Master Plan, 2008–2028. Source: Multan Development Authority (MDA).

policymakers, professionals, scholars, and the local community. This study uses MSEP to develop an environmentally friendly UGI indicator-based structure, which is valuable but underutilized when formulating strategies and frameworks for putting land-use planning into practice (Ashfaque, 2015). However, MSEP continues to be useful for developing and putting into action programs for nature-based green infrastructure (NBGI).

To find and hypothesize similarities between the community and the experts' perspectives on UGI indicators, a paired MSEP analysis is used here. This leads to the classification of UGS components, which is based on the sociocultural and environmental context of the area. A number of fundamental sustainable UGI indicators and UGS components have also been confirmed and validated by the MSEP implementation. This resulted in the creation of a framework

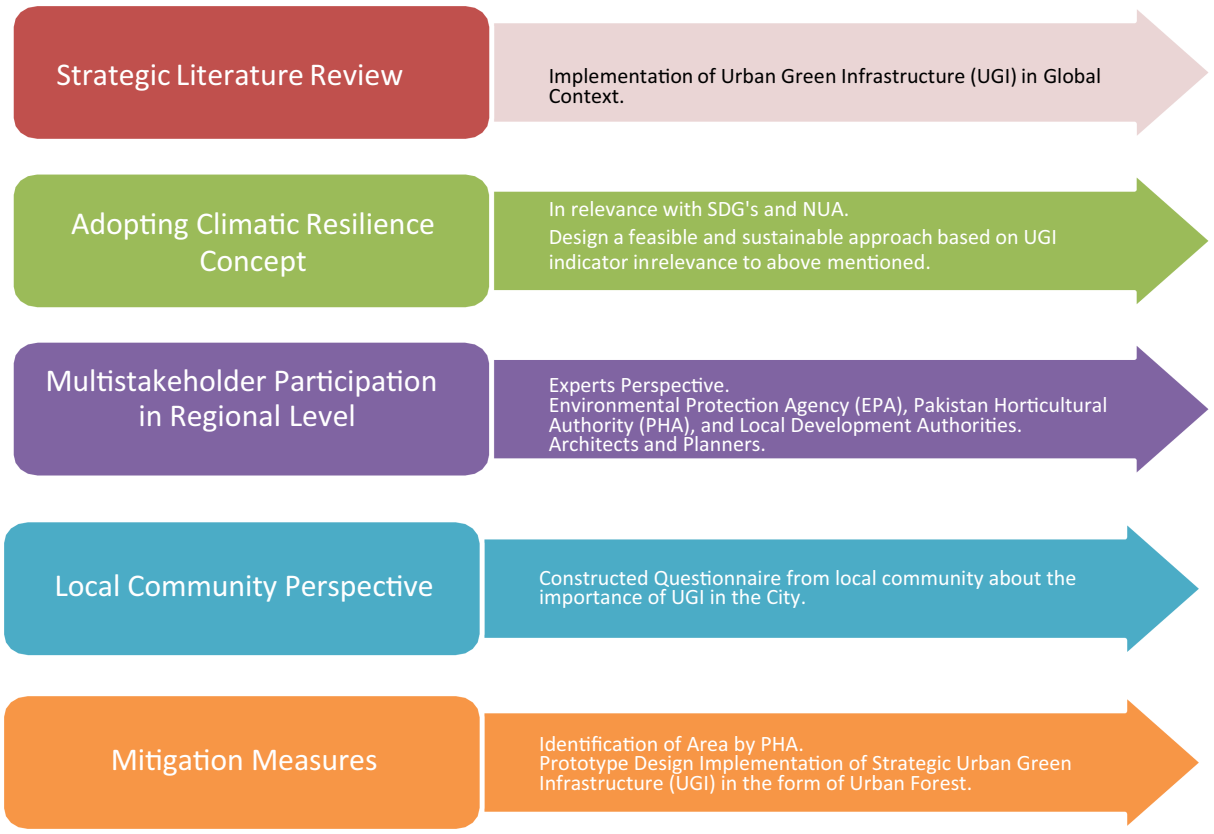

FIGURE 4
Conceptual framework. Source: Authors' elaboration.

FIGURE 5
Expert strata. Source: Authors' elaboration.

or model based on UGI indicators that is inclusive, sustainable, and richly multifunctional and can be applied to the local built environment. A paradigm like this enables community members to participate in the creation of cutting-edge, multipurpose urban green areas, reducing the high risk of disasters like urban flooding, droughts, urban heat island (UHI) effects, etc. Overall, MSEP has contributed to the creation of an environmentally friendly and climate-resilient model.

TABLE 3 Participants in the eight different expert strata/groups' demographic information.

Sex	Percentage
Male	55.10
Female	44.90
Education	
Primary education and below	0
Secondary education	0
Higher secondary education	0
Tertiary/higher education	83
Other	17
Experts	
Building architecture	40.1
Infrastructure	9.3
Landscape planning	11
Urban planning	19.9
Horticulture	1.7
Environmentalist	9.1
Economy	2.9
Sociology	3.1
Other	2.1
Professional expertise	
<5 years	37.2
5–10 years	30.8
11–15 years	11
<15 years	20.9

Source: Authors' elaboration.

Survey design

Two survey approaches were used in this study to operationalize a thorough empirical analysis. First, 200 people participated in an expert-based perception survey, of which 162 were used to create the final findings. Since the required questions were not answered, the rest of the surveys were excluded. The expert-based perception survey's demographic data showed that 44.9% of respondents were female. The specific participants were divided into eight different expert strata using a purposive sampling technique (Table 3).

The second main approach for gathering data was based on empirical research conducted in the study districts of Multan. A snowball approach was used to label every fourth house away from a reference point on specific houses. A systematic questionnaire that was divided into sections labeled A–C mentioned in Figure 6 was used to collect data to obtain community perspective and the importance of urban green infrastructure in the context of Multan. Verifying participants' backgrounds, qualifications, and knowledge is the primary objective of Section A. The four questions in Section B, which are included in Appendix A, were designed to confirm and validate the viewpoints of the local community and experts on the UGI, the impact of climate change, climate change adaptation, and urban resilience. Ecological, sociocultural, and economic subsections make up Section C, with marking appropriate on the five-point Likert scale questionnaire attached in Appendix B. Each area comprises a number of questions with the goal of rating them on a Likert scale and determining the level of importance of each unique sustainable UGI indicator and its connections to various green components. These indicators and components for potential UGI were generated by earlier studies. Through this method,

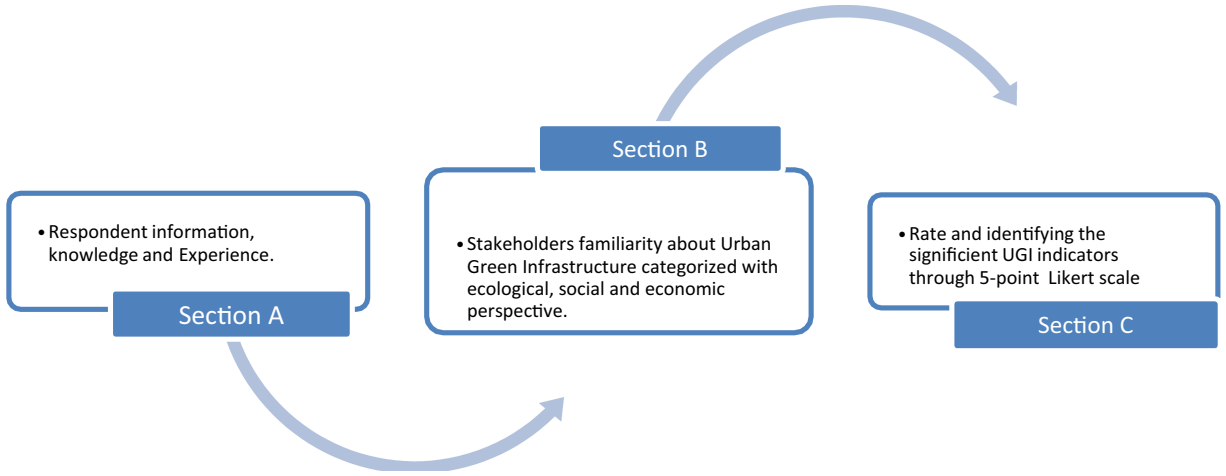

FIGURE 6
Detailed (expert and community) questionnaire sections organized in a hierarchy (Rayan et al., 2021).

we were able to identify the most important green components that would improve a specific UGI indicator's standard and quality and build urban areas that are resistant to natural disasters like flooding (Rayan et al., 2021). The focus of community-based questionnaires, with respondents ranging from a variety of socio-economic strata, is illustrated in Table 4.

TABLE 4 Information about the community members' demographics.

Sex	Percentage
Masculine	66.6
Feminine	22.4
Diverse	–
Prefer not to say	12
Literacy	
No education in elementary	0
Secondary education (SSC)	7.3
Intermediate	19.3
Higher education	73.4
Other (informal)	2.6
Age	
15–20 years old	0
20–30 years old	34.4
30–40 years old	43.8
40–50 years old	21.9
More than 50 years old	7.3

Source: Authors' elaboration.

Identification of open spaces in the Multan City

In order to cover regions where there is a shortage of vegetation, 10 sites are chosen throughout the city, as illustrated in Figure 7. There is diversity in the locations; two are in public universities, two are in industrial areas, five are in parks managed by the Parks and Horticulture Authority (PHA), and one is in the parking lot of a mall. It is clearly evident in the satellite image that a fertile plain is being deprived of its vegetation, resulting from unjustified urban growth and austere neglect of climate change. This research, therefore, aims at rejuvenating urban land through the creation of urban forests. The identified stakeholders will then take care of these forests until they are mature enough to survive on their own. The location of sites and their potential use in correlation with SDGs and NUA were discussed in Table 5.

Results

Perspectives from experts and the community on several cross-cutting themes

In answer to the questions provided, this part defines the understanding of the definitions of climate change (CC), adaptations to CC, urban resilience, and UGI ideas held by the planning professionals and community in the study area discussed in Figure 8. The findings demonstrate that, in comparison to community preferences, planning professionals believe alternatives 1, 2, 5, and 6 are more effective than options 3 and 4, with options 1, 2, 6, and 7

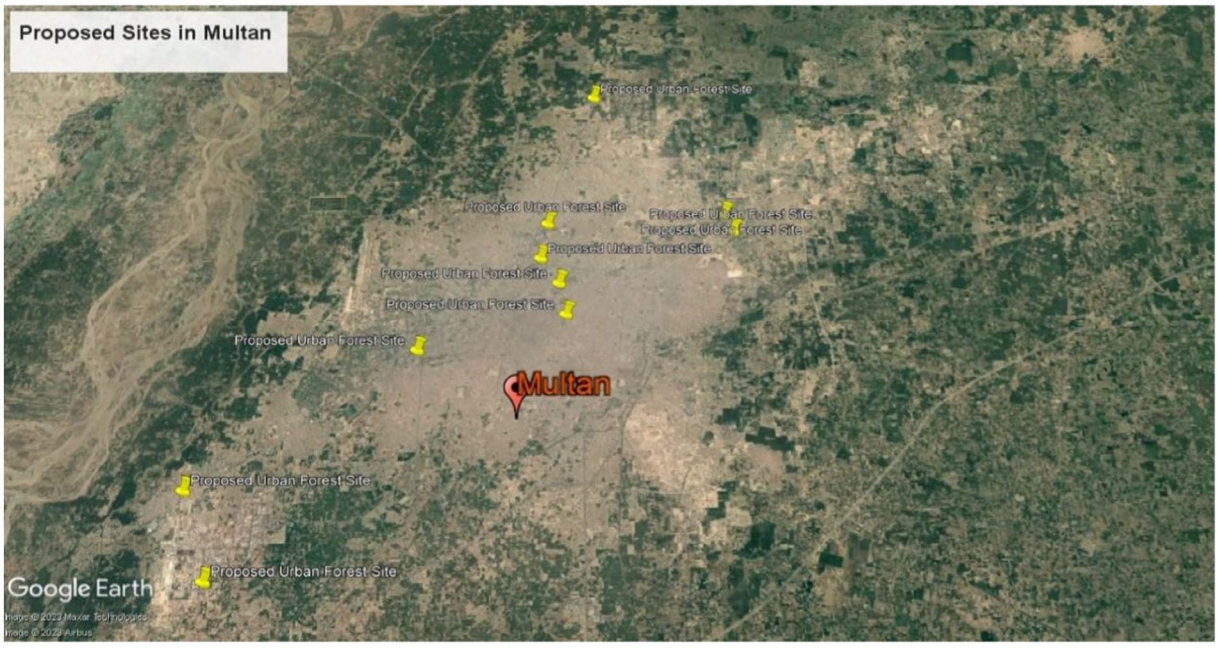

FIGURE 7
Proposed 10 sites with their potential uses and native plants.

TABLE 5 Proposed 10 sites with their potential use and native plants.

S. No.	Proposed site	Size (m^2)	Potential uses	Proposed native plants	
1.		1,000	Ecological Diversity Micro-Climate Control Air Filtration Edible Fruits Students Sitting Space Jogging/Walking Track		
2.		1,900	Ecological Diversity Micro-Climate Control Air Filtration Edible Fruits Residents Sitting Space Jogging/Walking Track Children's Activity/ Awareness Areas	Acacia modesta (Phulai) 	*Sapindus mukorossi* (Reetha, Soap-nut) 
3.		2,600	Ecological Diversity Micro-climate Control	*Acacia catechu* (Catechu)	*Nerium oleander* (Kanir, Oleander)
			Edible Fruits Sitting Spaces Jogging/Walking Track Animal Shelters	 *Prosopis cineraria* (Jand, Kandi)	

(Continued)

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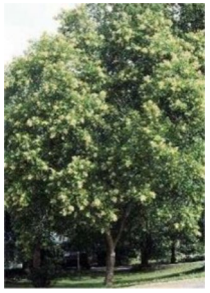
TABLE 5 (Continued)

S. No.	Proposed site	Size (m^2)	Potential uses	Proposed native plants	
4.		3,300	Ecological Diversity Micro-Climate Control Air Filtration Edible Fruits Residents Sitting Space Jogging/Walking Track Children's Activity/ Awareness Areas Women Empowerment Animal Shelter Participatory Activities		
				Salvadora oleoides (Vann)	*Murraya exotica* (Marwa)
5.		2,000	Ecological Diversity Micro-Climate Control Air Filtration Edible Fruits Students Sitting Space Jogging/Walking Track		
				Tamarix aphylla (Frash)	*Punica granatum* (Anar)
6.		1,000	Ecological Diversity Micro-Climate Control Air Filtration Sitting Space Children's Activity/ Awareness Areas Animal Shelter		
				Crateva religiosa (Barna)	*Phyllanthus emblica* (Amla)
7.		850	Ecological Diversity Micro-Climate Control Edible Fruits Air Filtration Sitting Spaces Jogging/ Walking Track Children's Activity/Awareness Areas Animal Shelter		
				Bauhinia variegata (Kachnar)	*Platanus orientalis* (Chenar)

(Continued)

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TABLE 5 (Continued)

S. No.	Proposed site	Size (m^2)	Potential uses	Proposed native plants	
8.		6,000	Ecological Diversity Micro-Climate Control Edible Fruits Air Filtration Sitting Spaces Jogging/ Walking/Cycling Track Children's Activity/ Awareness Areas Animal Shelter	 *Tamarindus indica* (Imbli)	
9.		1,000	Ecological Diversity Micro-Climate Control Edible Fruits Air Filtration Sitting Spaces Jogging/ Walking Track Children's Activity/Awareness Areas Animal Shelter	 *Cordia myxa* (Lasura)	
10		850	Ecological Diversity Micro-Climate Control Air Filtration Edible Fruits Residents Sitting Space Jogging/Walking Track Children Activity/ Awareness Areas Women Empowerment Animal Shelter Participatory Activities		

Source: Authors' elaboration.

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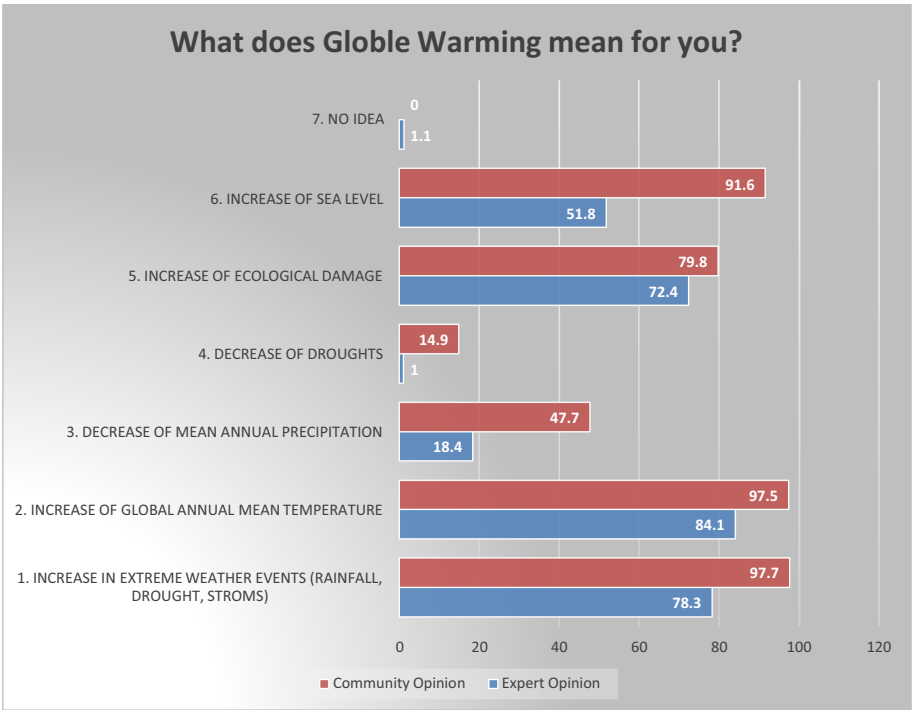

FIGURE 8
Climate change (CC) information. Authors' estimates use survey results as a source.

having more satisfaction acceptance votes (SAV) than option 4. This demonstrates the relative weight that the community and professionals place on various issues (not their disparities). Most of the time, the importance levels overlapped since both groups of stakeholders emphasized the significance of related variables. As a result, the overall result represents possibilities that are equivalent, such as options one and two, "increased extreme weather events," and option five, "increased ecological damage," with a vote of confidence (VoC) rating of >75%. Nevertheless, both groups did not give the same weight to option six.

"An increasing sea level" (experts: 51.8% and community: 91.6% VOC), despite the fact that a greater VoC viewed it as a crucial factor. All four of these scenarios can be thought of as a threshold level by which to define the concept of climate change in its natural spatial setting.

The results that follow similarly look at climate change adaptation. Options 1 and 3, which received 74.8 and 65.7% VOC, respectively, were thought to be more advantageous by the experts. While the neighborhood rated choices one, two, three, four, and six as being of the utmost importance, giving a score of >75% SAV in Figure 9. Therefore, in order to implement the "adaptation to the effects of climate change" notion in the local urban context, all five of these variables are crucial to enhancing adaptive ability as well as building durability against ever-rising hazards to the environment, such as urban flooding, flooding, etc., across metropolitan areas. These five overlapping variables emphasize the significance of encouraging an environmentally friendly and climate-resilient environment.

A deeper investigation reveals the core of urban resilience, which is produced through comprehending local knowledge, traits, and perspectives on prospective opportunities. The specialists supported choice one, but the general public agreed that the primary potential variables are one, two, three, four, five, and seven (all with strong positive scores). The pattern in Figure 10 shows that one's ability to learn when dealing with climate change challenges determines how well one adapts to CC. In order to promote nature-based infrastructure (NBGI) solutions, it is still crucial to fund regional mitigation/adaptation activities, even though adaptation to CC is still essentially subjective.

Additional findings help to clarify UG and demonstrate that option 2 was recognized as a high-priority attribute by three-quarters (75.9%) of the experts, in contrast to other choices (such as one, three, and 10), which received >50% VoC. However, the neighborhood also acknowledged choice 2 as having a highly substantial quality (80.7% SAV). With a confidence level ranging from 60 to 75%, the community also supported alternatives 1, 3, 6, 4, 5, 8, and 9 in Figure 11. Therefore, all conceivable variables that could have an impact on planning must be taken into account while closing any gaps. This was done by the planning professionals. This will afterward help the government. Institutes in the development of nature-based green infrastructure (NGBI) methods for long-term human settlements in the city of Multan and beyond. Additionally, in order to promote a comprehensive strategy, all nine viable options are listed below (as agreed upon by both planning professionals and the community), ranked according to importance, and can be used as a yardstick to determine UGI.

In conclusion, the results above support: (a) endorsing multiple optimal options for urban green indicators; (b) understanding cross-cutting themes from a multi-stakeholder perspective (e.g., climate change adaptation, urban resilience, and UGI); and (c) recognizing and promoting community stewardship in the planning/decision-making

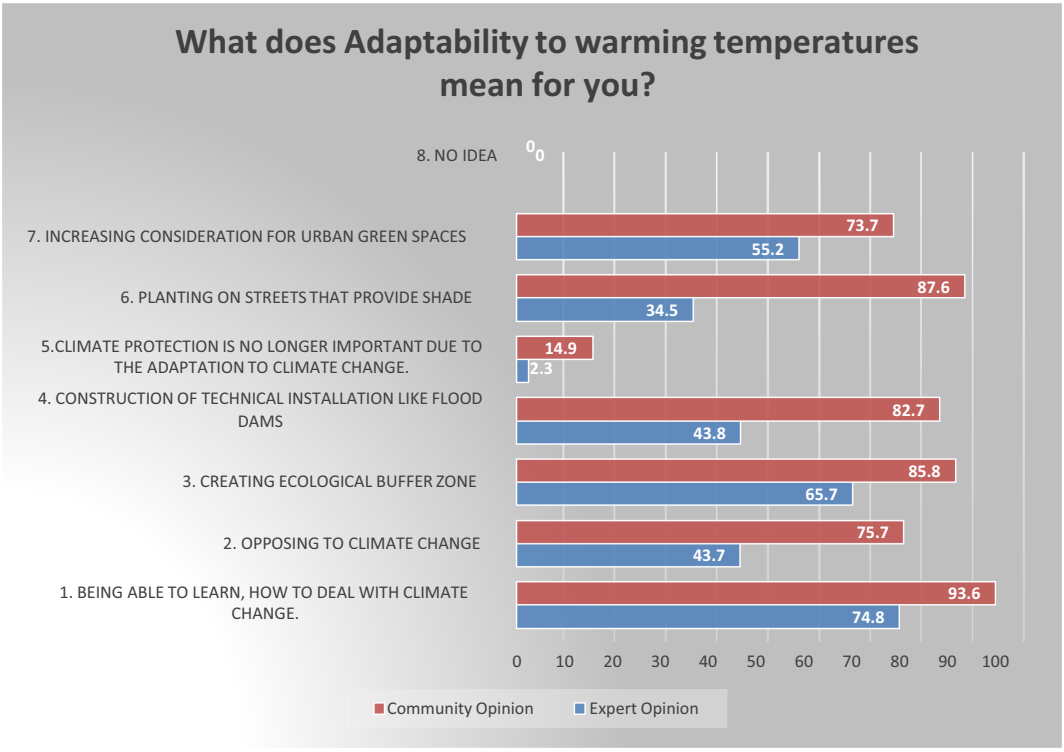

FIGURE 9
Understanding climate change (CC) adaptations. Authors' calculations are based on survey results.

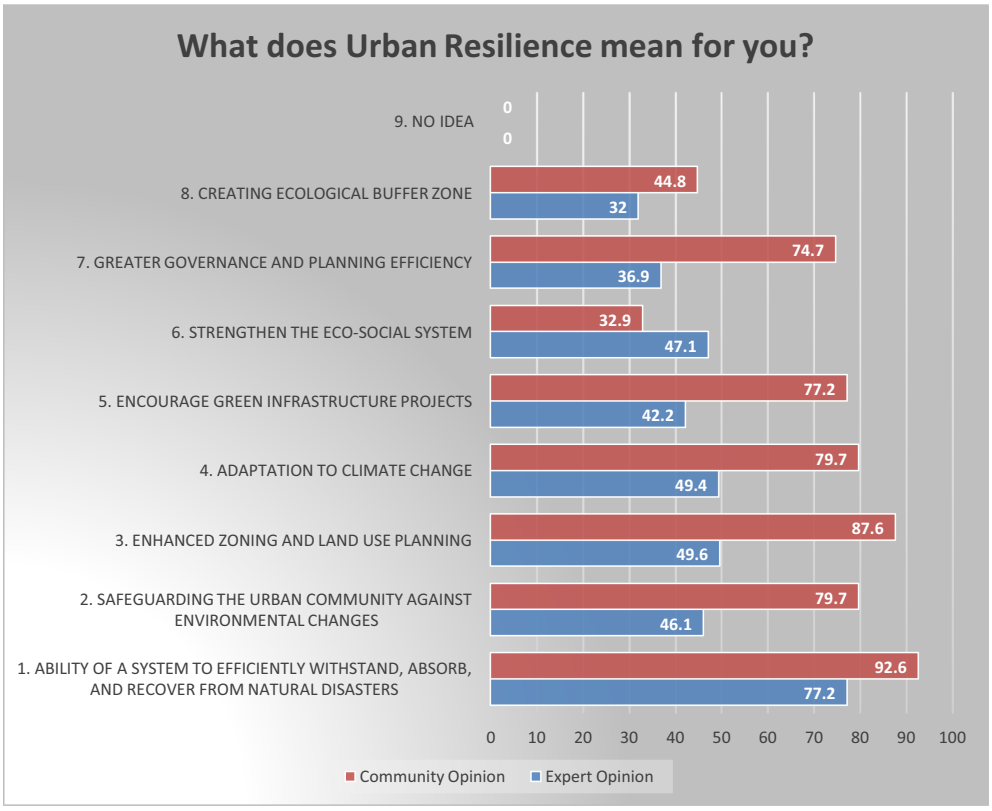

FIGURE 10
Urban resilience definition. Authors' calculations are based on survey results.

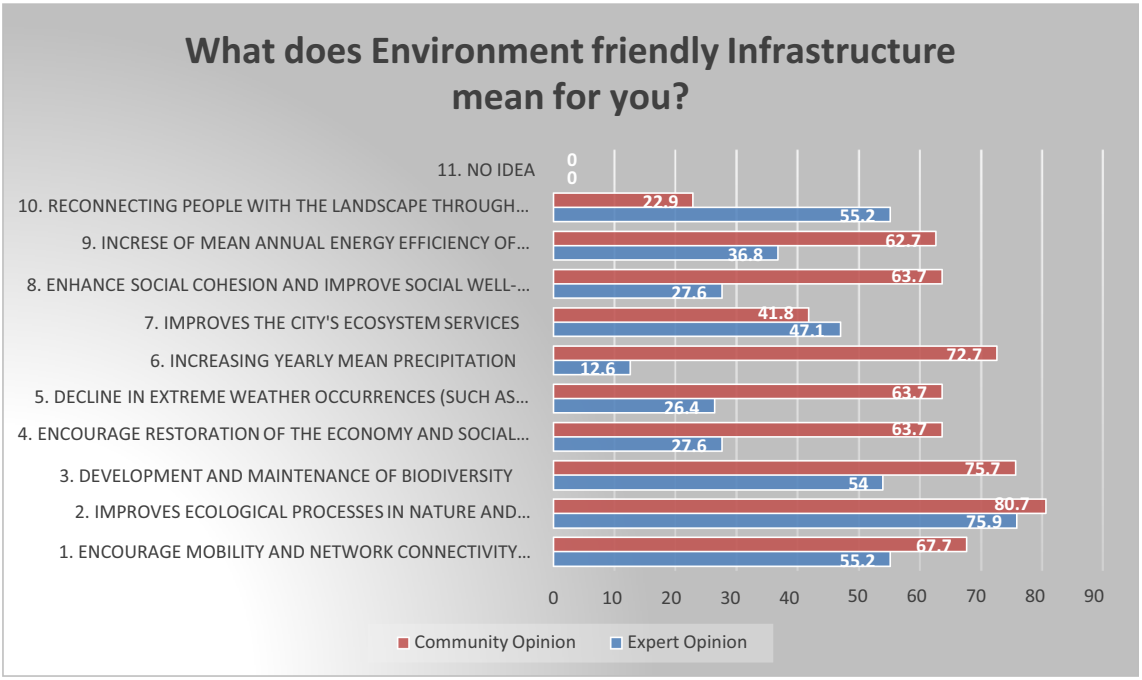

FIGURE 11
Urban green infrastructure (UGI) definition. Authors' calculations are based on survey results.

process for NBGI initiatives. These actions can aid in the effective tackling of socio-environmental issues brought on by climate change. Such initiatives could help create a framework based on UGI indicators that is richly multifunctional. This concept is adaptable to a natural spatial setting. As a result, the delicate reciprocity between CC, UGI, and UGS and human health and well-being is strengthened even further. All of this aids in the building of climate-resilient, green cities.

Design suggestion

Figure 12 shows the proposed urban forest design with native plant species on one of the 10 sites identified in the research. Regional trees are used to create the requirements for the prototype design idea for an urban forest. The involvement of multiple stakeholders provides a comprehensive approach to suggestions made during participatory design in all areas of study. The design recommendation of the total number of trees and shrubs in a city makes up its urban forest, which is a component of the forest ecosystem and offers the city numerous quantifiable ecological service benefits. The assessment of ecological benefits such as carbon sequestration and oxygen release, air quality improvement, cooling and humidification, noise reduction, energy savings, and precipitation retention is also beneficial to the ecological service value of urban woods. Additionally, the proposed design will preserve the richness of local bird species.

Conclusion and decision-making implications

According to the research study, creating an eco-friendly, green, and climate-resilient city-state may be possible with the help of urban green infrastructure. Including Urban forests which aim to bring people back into peace with the natural world and raise awareness of the multi-functional green infrastructure in an effort to establish a new sustainable cultural paradigm that will support green urban development in the Multan region of Pakistan. This includes a two-way sustainable development path that includes expert opinion and native inhabitants, presenting a more participative and innovative approach—this green and resilient urban development is projected. The local setting has been shown to affect people's values and views in context.

In addition, a nature-based green infrastructure (NBGI) holds a stronger way of addressing the attitudes and preferences of those same local stakeholders, both specialists and people in the community, once it builds on the local realities. As a result, using such a comprehensive participatory approach to create a taxonomy of UGS features is still productive and practical. It is special because it establishes a connection with the relevant sustainable UGI indicators in the neighborhood's built environment, whereby the creation of a framework or model based on inclusive sustainability of UGI indicators embeds the neighborhood context. In Multan and worldwide, it might have the potential to able to meet the requirements for a green, climate-resillient city state. Further evidence suggests that a local, context-based model linked to the SDGs and NUA may alter the sustainable UGI indicators used to build the model and comprehensively link that model with a variety of green components to reshape urban land-use planning and ensure a resilient city-state.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

FIGURE 12
Proposed design suggestions for urban forests.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

AA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Writing – original draft. SZ: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. SQ: Conceptualization, Writing – original draft, Writing – review & editing. SS: Conceptualization, Data curation, Writing – original draft. SM: Investigation, Writing – original draft, Writing – review & editing. MK: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2024.1275102/full#supplementary-material

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Appendix

Appendix A

Verifying and confirming the viewpoints, knowledge, attitudes, and choices of the regional multi-stakeholder community (planning experts and community members) with relation to the potential consequences and definitions associated with the UGI, urban resilience, environmental change, and adaptation. The following four questions were added to Section B of both the expert-based assessment survey and the neighborhood-based empirical survey in order to define the notions of the aforementioned themes in light of the native geographical setting.

- "What does global warming mean for you?"
- "What does adaptability to warming temperatures mean for you?"
- "What does urban resilience mean for you?"
- "What does environment-friendly infrastructure mean for you?"