Green Infrastructure Planning Framework: An Exploratory Study Towards Resilient Cities In Khyber Pakhtunkhwa Province, Pakistan.

[Source: Author owns]

By

Muhammad Rayan
Master of Science in Infrastructure Planning (Stuttgart)
Bachelor of Science in Architecture (Pakistan)

Dissertation submitted to the Department of Spatial Planning, TU-Dortmund University, in response to the requirements for obtaining a Doctorate in Engineering (Dr.-Ing) degree.

Department of Spatial Planning
Technische Universität Dortmund, Germany

Page left intentionally blank.

Green Infrastructure Planning Framework: An Exploratory Study Towards Resilient Cities In Khyber Pakhtunkhwa (KP.) Province, Pakistan.

by

Muhammad Rayan

Dissertation submitted to the Department of Spatial Planning, TU Dortmund University, as a requirement for the Doctor of Engineering (Dr. -Ing.) degree.

Examination Board:

Chairman:

Prof. Dr. Stefan Siedentop, TU Dortmund University, Germany

Supervisors:

Prof. Dr. Dietwald Gruehn, TU Dortmund University, Germany

Associate Professor. Dr. Umer Khayyam, NUST University, Islamabad, Pakistan.

Technische Universität Dortmund
Dortmund, Germany
(Jan) 2024

Declaration

I hereby declare, that the submitted cumulative doctoral dissertation entitled "Green Infrastructure Planning Framework: An Exploratory Study Toward Resilient Cities in Khyber Pakhtunkhwa (KP) province, Pakistan" is the result of my independent study conducted at the Chair of Landscape Ecology and Landscape Planning (LLP), Department of Spatial Planning, TU-Dortmund University between February 2019 and December 2023 (see the timeline in Annex E) under the supervision of **Prof. Dr. Dietwald Gruehn**, and **Associate Professor. Dr. Umer Khayyam**. The scientific research study was funded by the German Academic Exchange Services (DAAD) under "Research Grant: Doctoral Programme in Germany, 2018/19 (57381412)".

I also confirm that all the sources within this dissertation have been appropriately acknowledged. In lieu of an oath, I affirm that this dissertation either submitted nor published elsewhere. My contribution (as a principal author) to this work and the contributions of my supervisors (co-authors) are clearly outlined below. The work presented in this study is structured into three main parts: The Introduction, and the theoretical and conceptual perspective on green infrastructure planning, urban resilience and multi-stakeholder participation and their framing, the Contributions, and the Conclusion. The contribution section (Chapter 3) primarily constitutes three academic articles published in double-blind peer-reviewed (WoS/Impact Factor) academic journals.

All three key publications are principally written by (Muhammad Rayan) in the capacity of the lead and corresponding author, and each publication contains more than 40,000 characters. **Prof. Dr. Dietwald Gruehn**, and **Associate Professor. Dr. Umer Khayyam** provided invaluable supervision and guidance to achieve the research goals. Their expertise and support were crucial in ensuring the quality and accuracy of these publications.

1. The first step was the evaluation of the native top-down (planning experts) perspective, published in an **Elsevier Urban Climate journal with the title: "Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective"** by Muhammad Rayan (author of the declaration), Dietwald Gruehn (supervisor) and Umer Khayyam (supervisor). MR: Conceptualised and led the investigation, developed the algorithms, conducted the analysis and wrote the original draft; MR, DG, and UK: conceived and developed the methodology and supervised the project; DG and UK: provided methodological

feedback and supported the development of the algorithms; all authors reviewed the manuscript **(DOI: https://doi.org/10.1016/j.uclim.2021.100899).**

2. The second step was the examination of bottom-up (community-Led) perspective, published in an **International Journal of Environmental Research and Public Health as "Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan"** by Muhammad Rayan (author of the declaration), Dietwald Gruehn (supervisor) and Umer Khayyam (supervisor). MR: Conceptualised and led the investigation, developed the algorithms, conducted the analysis and wrote the original draft; MR, DG, and UK: conceived and developed the methodology and supervised the project; DG and UK: provided methodological feedback and supported the development of the algorithms; all authors reviewed the manuscript **(DOI: https://doi.org/10.3390/ijerph191911844).**

3. The third and last step was merging and localisation; integrating the two-way sustainable development path that is top-down and bottom-up, published in a **Sustainability Journal as "Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan"** by Muhammad Rayan (author of the declaration), Dietwald Gruehn (supervisor) and Umer Khayyam (supervisor). MR: Conceptualised and led the investigation, developed the algorithms, conducted the analysis, and wrote the original draft; MR, DG, and UK: conceived and developed the methodology and supervised the project; DG and UK: provided methodological feedback and supported the development of the algorithms; all authors reviewed the manuscript **(DOI: https://doi.org/10.3390/su14137966).**

Other Research Accomplishments

Beyond the prerequisite of the dissertation (publication of three scientific articles), partial fulfilment of the requirements for obtaining a doctorate in engineering (Doctor Ing.) at the TU Dortmund University, Germany. I have also published book chapters and presented and discussed my empirical research findings at several international conferences. as mentioned below.

Book Chapters:

1. Rayan M., Khayyam U., Gruehn D. (2022). "Local Perspectives on Green Resilient Settlements in Pakistan". In: Ha-Minh C., Tang A.M., Bui T.Q., Vu X.H., Huynh D.V.K. (eds) CIGOS 2021, Emerging Technologies and Applications for Green Infrastructure. Lecture Notes in Civil Engineering, vol 203. Springer, Singapore (https://doi.org/10.1007/978-981-16-7160-9_138).
2. Rayan, M., Gruehn, D. & Khayyam, U. (2021): "Green Infrastructure Planning. A Strategy to Safeguard Urban Settlements in Pakistan". In: Jafari, M., Gruehn, D., Sinemillioglu, H. & Kaiser, M. [Eds.]: Planning in Germany and Iran. Responding Challenges of Climate Change through Intercultural Dialogue. Mensch und Buch Verlag. Berlin, pp. 197-221. (https://books.google.com.pk/books/about/Planning_in_Germany_and_Iran.html?id=OQ2HzgEACAAJ&redir_esc=y)

Conferences:

1. Rayan M., Khayyam U., Gruehn D. (2023). "A strategy for green urban resilient future in the northwest region, Pakistan". 6th (DOKORP) Dortmund International Conference on "If possible, please turn around! Researching and Planning for the Sustainability Turn", Dortmund, Germany, February 13. (https://raumplanung.tu-dortmund.de/storages/raumplanung/r/Downloads/Dortmunder_Konferenz/2022_23/230125_Book_of_Abstracts_01.pdf)
2. Rayan M., Khayyam U., Gruehn D. (2022). "Experts and Community's Perspective to Build Sustainable Urban Cities in Pakistan". 10th (ICSD) International Conference on Sustainable Development "Creating a unified foundation for the Sustainable Development: research, practice and education" - Organised by the European Center of Sustainable Development (ECSDEV), Rome, Italy, September

7-8 (https://ecsdev.org/images/conference/10thICSD2022/abstracts_10ICSD_2022.pdf)

3. Rayan M., Khayyam U., Gruehn D. (2021). “Green Infrastructure Indicators to Plan Resilient Urban Settlements in Pakistan: Local Stakeholder's Perspective”. 6th CIGOS conference on: Emerging Technologies and Applications for Green Infrastructure. Ha Long, Vietnam. October 28-29. (https://cigos2021.sciencesconf.org/data/CIGOS_2021_ABSTRAT_BOOK_v2.pdf)

4. Rayan M., Khayyam U., Gruehn D. (2020). “Green Infrastructure Planning: A Strategy to Safeguard Urban Settlements in Pakistan”. 5th International Dortmund Conference 2020: Rethinking Spaces Planning in a Changing World. Technical University of Dortmund, Germany. February 17-18. (https://raumplanung.tu-dortmund.de/storages/raumplanung/r/Downloads/Dortmunder_Konferenz/2020/Book_of_Abstracts_2020.pdf)

Dissertation Advisors: Prof Dr. Dietwald Gruehn
Associate Professor Dr. Umer Khayyam

Green Infrastructure Planning Framework: An Exploratory Study Toward Resilient Cities in Khyber Pakhtunkhwa province (KP), Pakistan.

Abstract

Strengthening the resilience of urban regions to climate threats through Green Infrastructure (GI) is an emerging and important subject that seeks new ways to adapt disruptive social and ecological systems through innovative Nature-Based Green Infrastructure (NBGI) solutions. This is because, urban regions are vulnerable to the growing in-daunting global Climate Change (CC) trends, which is detrimental to countries' socio-culture, ecology, and economy. CC is one of the main contributing factors that has caused multifaceted natural catastrophes (such as urban flooding, droughts etc.) and poses severe threats to the region's urban ecosystems. Thus, the concepts of GI, multi-stakeholder participation and resilient cities have emerged as a new dimension and theme for sustainable green-growth urban development – leading to strengthening resilience of the Eco-System Functions (ESF), preserving biodiversity, and enhancing human health/well-being, and ameliorating pressures on the natural environment through planned networks of multifunctional Green Spaces (GS) at the urban interface of any area.

Multiple facets are one of the primary characteristics of urban green infrastructure (UGI), along with the other two (connectivity and conversation) central principles (Ahern, 2007b; Benedict & McMahon, 2012; DG-ENVI, 2012; Hehn et al., 2015; Horwood, 2011; Llausàs & Roe, 2012; Roe & Mell, 2013; Wright, 2011). UGI is emerging as a new way forward widely recognised as a natural, green, landscape-based planning approach to climate change adaptation and mitigation. Such green adaptations can play an instrumental role in relieving pressure on land-use change, improving poor air quality and rainwater management, reducing the urban heat island (UHI) effect, revamping access to and connectivity to green spaces etc. (Chiesura, 2004; EC, 2013; James et al., 2009). It is also widely recognised as a planning tool that can help reconnect people with nature and increase their knowledge of nature-based solutions, which, in turn, can help to strengthen urban resilience in the face of the ever-increasing impacts of climate change.

Pakistan is undoubtedly at high risk to climate change (CC) and its impacts. It has also faced frequent flooding since 1950. The floods over the past few decades have been

constant, like 1977, 1992, 2003, 2010, 2013 and 2022; whereas 2010 and (very recent) 2022 floods were the most devastating in the country's history. This frequency of floods in the country are now once every year. The floods of 2022 made more than half of the nation vulnerable (NDMA, 2022). The northwestern areas of KP Province were no exception. According to the World Bank, in the 2010 floods, around 2000 people died, 20 million were affected, and 1.6 million houses were destroyed (Arshad & Shafi, 2010; NDMA 2011). Following floods of 2022, 20 million people were affected and more than 1,700 people lost their lives, including one-third children (NDMA, 2022). The country is faced with the most recent episodes of floods of 2023 – the damage estimates are yet to be confirmed.

It would be simplistic to claim that there is no single systematic cause for the calamities and disruptions in the cities. The devastation in the country, particularly in the KP areas, is linked to a weak governance system, a lack of scientific knowledge, a lack of social awareness, and a short-term and reactive planning approach that fails to manage risks in the course of development effectively (Ahsan 2018; Alvi & Khayyam, 2020; Naeem et al., 2018). Also, outdated, and unbalanced land-use planning policies/practices (Rayan et al., 2022a) show the need to formulate and implement a framework of synergies between both theoretical and practical implementation of NBGI planning practices at (national, regional, and local) levels. Such efforts would not only contribute to the natural mitigation of high-risk disasters (e.g. urban flooding, but would also perform an effective role in strengthening community stewardship of bottom-up green initiatives, improving the environmental resilience of cities, and benefiting residents in times of climate uncertainty.

This cumulative research focuses on evaluating the significance of the sustainable UGI indicator and its relationship with the vital taxonomies of Green Spaces (GS) at the neighbourhood level, which has hitherto been overlooked by native policymakers and researchers. The primary goal of this work is to develop a rich, multifunctional/inclusive UGI framework/model that is based on triple bottom line (TBL) sustainability and can be tailored to each specific local built environment. Hence, this model remains rich and flexible; at the same time, it also facilitates reconnecting the community members with innovative, multifunctional GS. The human-nature relationships explore the knowledge of using nature-based initiatives to address human-ecological challenges and establish an eco-regional approach to ensure a climate-resilient urban environment in the environmentally challenged province of Khyber Pakhtunkhwa (KP), Pakistan. This research empirically emphasises the views of native stakeholders, top-down planning experts and bottom-up household community members in the planning process, in order to identify and analyse similarities and differences among multi-stakeholder perspectives on key indicators of UGI and elements of sustainable green growth planning. This research empirically emphasises the views of native stakeholders, top-down planning experts and bottom-up household community members in the planning process, in order to identify and analyse similarities and differences among multi-stakeholder perspectives on key indicators of UGI and elements of sustainable green growth planning. The empirical (bidirectional sustainable development pathway), which involves both top-down and bottom-up participatory approaches, studies the NBGI values in the KP region to identify each sustainable UGI indicator's significance level. It also determines the pivotal green space elements for respective UGI indicators according to the region's socio-cultural and ecological context. This strengthens the built environment's potential resilience and effectively enhance the urban neighbourhoods against the anticipated environmental challenges.

This study employed a mixed research approach to achieve the dissertation objectives. Two survey techniques were operationalised. The first was a top-down, expert-based perception survey; local planning experts provided their perspectives on potential "sustainable UGI indicators and green space elements". Also, they were interviewed in order to understand their knowledge of multiple "cross-cutting" notions like climate change (CC), CC adaptation, urban resilience (UR), and urban green infrastructure (UGI) within the real-life context. The second was the bottom-up community-based empirical survey, which helped better understand the linkages between "UGI indicators and UGS" from the perspective of the local inhabitants. Integrating both (bottom-up and top-down) approaches results in a unified framework that enables the development of a "sustainable UGI indicator-based (framework) model" (Rayan et al., 2021b). Such a model enables an opportunity to support and promote the holistic representativeness of the "multi-stakeholder participatory planning (MSPP)" approach in planning NBGI for climate change adaptation and mitigation. Moreover, it enhances the decision-making process for developing resilient land-use planning through policymaking and implementing urban landscape and urban greening strategies (ULUGs).

The experts-based perception survey results utilised data from 172 [1] questionnaires (out of 212), collected during an in-depth online survey. A relative importance index (RII) was operationalised in the empirical study to rank and assess the importance of potential "twenty-two" primary and secondary sustainable UGI indicators and "ten key UGS" taxonomies. In addition, the study employed purposive sampling to identify a group of local planning experts with knowledge and experience of sustainable, innovative, natural green landscape-led, and participatory (citizen-led) approaches for climate change adaptation and mitigation. This diverse group consisted of policymakers, practitioners, and academics, with nine distinct strata of expertise, as detailed in Rayan et al. (2021a).

[1] The rest fifty questionnaires were not considered in generation of results/findings, due to their unclear responses, double tick and/or non-responded questions.

The findings of the (top-down) perception survey exhibited that all the potential sustainable UGI indicators were grouped into three main classifications based on their level of importance. The categories were extremely important (E-imp), important (Imp), and moderately important (M-imp). The survey used a nine-point scale criterion to determine the importance of each indicator, as proposed by (Rayan et al., 2021a). This was done to accomplish variance in the level of importance. Subsequently, patterns of variation were also noted in the final list of approved key UGS elements. This underlines the fact that each potential UGS is characterised by a specific quality, and not every green space plays a fundamental role in strengthening the functional linkage and resilience of the respective UGI indicators to climate variabilities in the urban context. Overall, the study's first phase shows that planning experts generally give more weight to ecological indicators than to the other two categories. This portrays the significance of potential "sustainable UGI indicators" in the local built-in environment.

The (bottom-up) community-based empirical survey dataset was collected through a field study of 192 HHs in three central counties of KP Province, Pakistan: "Peshawar, Mardan, and Charsadda". The research employed a "two-point scale" criteria to select Tehsils and Union Councils (UCs), especially in the study area (Rayan et al., 2022b). Since no official list of dwellings affected by climatic uncertainties exists at the UC level, a snowball sampling technique was employed to identify such households. The first affected household served as a benchmark. From the reference point, every fourth household was selected as a sample to collect info on the potential UGS infrastructure and its relationship with the respective "sustainable UGI indicators" based on the local built-in environment.

Unfortunately, planning authorities in Pakistan (at a three-tier level) lack a centralised and established data bank where such detailed local information is accessible or can be acquired even at a fee. In contrast, some institutions, such as the KP-Urban Policy Unit (UPU), may possess some information. However, they do not have all the variables to establish a "sustainable UGI indicator-based framework" for building an eco-friendlier and climate-resilient urban environment in the study region. Based on empirical evidence, it is important to acknowledge that bottom-up (community-led) and top-down (expert-led) research studies generate different outcomes with varying patterns of variation, thus providing an opportunity to adopt a holistic approach to MSPP.

In order to ensure rational results/conclusions, the study suggests pairwise and cross-examination of (both) native multi-stakeholder perspectives. This approach helps in validating and verifying the feasibility of potential UGI indicators based on the "triple bottom line" of sustainability and its interlinkage with multiple vital taxonomies of "UGS elements". This led to the developing of a comprehensive "sustainable UGI model" that can be implemented in the native built-in environment. Such a model is intended as an aid, giving an idea about UGI's environmental performance and its relationship with CC, ESF, and local inhabitant's health and well-being. Moreover, the research also presents the holistic multi-stakeholder perspective regarding the significance of UGS infrastructure as a natural-based climate adaptation and mitigation strategy to address “sustainable climate-risk management (SCRM)” in catchment areas. Such innovative NBGI approaches can effectively address socio-environmental issues (EC 2013; Foster et al., 2011; Rouse & Bunster-Ossa, 2013) and bolster a green, climate-resilient urban environment.

The cumulative dissertation offers practical and policy implications for bolstering/optimising stakeholders' participation in NBGI planning and management; the methods employed in this study can be applied to 'other' er similar context regions where reliable data are hard to come by. Furthermore, these findings provide valuable insights to multi-stakeholder groups, including policymakers, experts, and the community, enabling them to comprehend the potential of nature-based green adaptation planning techniques in addressing “SCRM” and promoting the harmonious coexistence between human-centric and eco-friendly activities in any urban interface. Adopting such green adaptation strategies can enhance the resilience of the city-state and assist in remodelling and restructuring land-use planning for a sustainable and resilient future.

Based on our findings, this study paves the way to enhance & stimulate the holistic representativeness of the multi-stakeholder participatory planning (MSPP) approach when planning nature-based green landscape (NBGL) techniques for resilient landscape planning, which are not being institutionalised and practised in the country in general (Ashfaque & Awan, 2015; Nizamani & Shah, 2004; Rayan et al., 2022a). This work is one of the first empirical attempts to identify and validate the importance levels of sustainable UGI indicators and determine how UGS structural attributes relate to the native built-in context of “The Peshawar, Mardan and Charsadda Districts” in KP Province. Since no such empirical study has been conducted on such a subject, integrating a bidirectional sustainable development pathway from the top-down/bottom-up serves as a participatory and innovative approach (Rayan et al., 2022b) in the context of a non-collaborative planning environment, as prevails in countries like Pakistan (Ashfaque & Awan, 2015; Hussnain et al., 2014; Rayan et al., 2021b; Wakil et al., 2016). This remains true even for the northwestern parts of the KP region. Such a holistic MSPP approach to developing a framework model based on “sustainable UGI indicators and green space elements”, embedded in the indigenous built-in context, makes it a unique and novel study.

Contents

List of Abbreviations

CC	Climate Change
CP	Community participation
CRI	Climate risk index
ESS	Ecosystem services
ESF	Ecosystem function
GAP	Green Action Plans
GI	Green infrastructure
GS	Green Spaces
IPCC	Intergovernmental Panel on Climate Change
KPK	Khyber Pakhtunkhwa
KP-UPU	Khyber Pakhtunkhwa-urban policy unit
KPBOS	Khyber Pakhtunkhwa bureau of Statistics
LGP	Landscape and greening policies
MOCC	Ministry of Climate Change
MSEP	Multi-stakeholder Engagement Processes
MSPP	Multi-stakeholder Participatory Planning
NBGL	Nature-Based Green Landscape
NBGI	Nature-Based Green Infrastructure
NDMA	National Disaster Management Authority
NGO	Non-State Actors
PBS	Pakistan Bureau of Statistics
PDA	Peshawar Development authority
PDMA	Provincial Disaster Management Authority
SD	Sustainable Development
SFRM	Sustainable flood risk management
SCRM	Sustainable climate-risk management
UC.	Union Council
UGI	Urban Green Infrastructure
UGS	Urban Green Space
UGP	Urban Greening Policies
ULGP	Urban landscape and greening policies
UL-UG	Urban landscape and Urban greening
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ULGI	Urban landscape and greening infrastructure

List of Figures

List of Tables

Acknowledgements

I am grateful to Allah (SWT) for giving me the strength and perseverance for the completion of this research study.

I would like to express my deepest gratitude and admiration to my supervisor, Professor Dietwald Gruehn, from TU Dortmund University in Germany. His guidance and unwavering support have been invaluable in improving my work, and his dedication, encouragement, and appreciation throughout my PhD journey have been exceptional. I am grateful to him for believing in me and allowing me the freedom to pursue my ideas and interests. I also sincerely thank my second supervisor, Associate Professor Dr. Umer Khayyam from NUST University in Islamabad, Pakistan, for his commitment and constructive feedback that helped me improve my research. Thank you for being my motivator and mentor throughout my PhD journey.

I am filled with immense gratitude towards the entire LLP team for their support and help in all matters, unconditionally, to strive towards my goal. I am particularly grateful to Anne-Marie Geudens, Dr. Lawrence Bryce, and Dr. Emmanuel Kofi Gavu, whose unique contributions were instrumental in achieving my goal. Additionally, I would like to express my gratitude to DAAD (Deutscher Akademischer Austauschdienst) for trusting in my abilities and providing me with a scholarship (Grant No.91684435) throughout my PhD studies in Germany.

I also express my gratitude to the experts and officials of various international and local institutions in Pakistan for their invaluable assistance in conducting the expert interviews. I would particularly like to acknowledge the contributions of esteemed individuals from academia, including Dr. Faisal, Shahid Mansoor, Dr. Shaker Mahmood, Dr. Abdul Waheed, and Dr. Ijaz Ahmad, as well as the dedicated members of PCATP, such as Ar. Shama Usman, Ar. Muhammad Tahir Khattak, Ar. Aazar Raza, Plnr Khurram Farid Bargatt, and Plnr Zulfiqar Kumbher. The team at MOCC, led by Dr. Mazhar Hayat and Ar. Fayaz Ahmed, provided invaluable insights that greatly enhanced our work. I am also deeply grateful to Project Director Ar. Vasif Shinwari from UPU and Assistant Director Javad from PDA for their invaluable assistance. Lastly, I wish to thank the anonymous members of the KP district governments for their insightful comments.

I am deeply indebted to the urban residents of “Peshawar, Mardan and Charsadda” for their hospitality and help in gathering ground-level information. I am grateful to Muneeb Khan, Fawad Akthar, Faisal Khan, Imran Khan and Jawad for their help in collecting data for this research.

Finally, and most importantly, I owe my mother a great debt of gratitude for their motivation and encouragement. Thank you for your prayers and love, which have enabled me to pursue my research objectives.

Muhammad Rayan
Dortmund, (01.12.2023)

Dedicated to my mother: for being a motivation to accomplishing greater heights.

FIRST CHAPTER

[Source: Author Own]

"[...] all cities, whether old or new, can be made to be more sustainable"

(Pickett et al. 2013, p. S20)

Introduction

1. Introductory Note

This chapter delves into the impact of global climate change on the region's green space (GS) infrastructure. It explores how these infrastructures can be leveraged as a nature-based solution to foster community stewardship and create resilient, safe, and green urban areas amidst climate change (CC) in Pakistan, particularly in the KP province. Furthermore, this section provides insight into the origin of the problem, niche creation, research objectives and (correspondingly) the research questions for the study's relevance in the prevailing conceptual context. Finally, it outlines the structure of the dissertation.

1.1. Research background to climate change (CC) and urban green infrastructure (UGI): International, Local, and Academic discourse

Cities are exposed to multiple risks and challenges; from rapid urbanisation to climate change (Seto & Fragkias, 2011). Cities are the most pertinent global issue of our time that humans are facing (Dhakal & Chevalier, 2017; Wong & Brown, 2009). However, the impact of climate-induced stresses significantly depends upon society's living standards. It has been established that urbanisation is an essential driver of environmental concerns; confronted by urban areas. The United Nations Framework Convention on Climate Change (UNFCCC) defines Climate Change (CC) as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (UNFCCC, 2007; 2014).

As per expert analysis, unbalanced anthropogenic activity is a major cause of persistent climate change, which is projected to persist in the future (IPCC, 2012). Failing to mitigate the effects of global climate change could have dire consequences for both our environment and society. These consequences may manifest as a rise in the global annual mean temperature (GMT), a surge in sea levels, and alterations in precipitation patterns leading to more frequent and severe droughts and floods (IPCC, 2014). Research by the Intergovernmental Panel on Climate Change (IPCC) suggests that Asia could experience an average annual temperature increase of 3 degrees Celsius by 2050 and 5 degrees Celsius by 2080. Moreover, the average mean precipitation in Asia will increase by 7% by 2050 and 11% by 2080 (Waseem & Khayyam, 2019). This exacerbates weather, and climate hazards, posing wide-ranging direct and indirect effects on natural and human systems (Gill et al., 2007), thus disrupting both the lives and livelihoods in the urban areas. Moreover, this situation is projected to become more severe owing to ascending temperatures and alterations in precipitation cycles (Barros et al., 2014; Elliott et al., 2014).

The research asserts the prevalence of climate-related hazards caused by the rapid expansion of urban areas, population growth and unregulated land use. This has led to the degradation of ecosystems and the loss of local biodiversity (Grimm et al., 2008; Seto et al., 2011; EEA, 2017b). It is widely recognised that more than half of the world's population lives in urban areas, and the trend towards urbanisation is expected to increase by 72% by 2050, bringing the global population to 9.3 billion (Desouza & Flanery, 2013; UN 2014). his growth is predicted to result in two-thirds of the worldwide population living in urban agglomerations by 2050, with over 90% of the new urban dwellers hailing from developing nations (UN 2011, 2019; UNFPA, 2008). For instance, the urban population in Pakistan is expected to rise to 50% by 2030 (Jan & Iqbal, 2008). This issue has already resulted in- and result into an ecological imbalance environment, affecting the city dwellers' health and well-being across regional and local scales.

Globally, urban areas are becoming more vulnerable to climate-related hazards and stress. This is because built-up areas are expanding at a faster rate than population growth. Research indicates that by 2030, there will be a 72% increase in urban population compared to 2000, while cities with 100,000 residents are projected to expand by 175 per cent (UNFPA, 2008). This growth, coupled with increased human activities, is leading to significant changes in land cover and the loss of natural landscapes. This poses a major concern for urban areas as the quantity and quality of green spaces are under threat. In addition, the decrease in permeable surfaces reduces the urban landscape's infiltration, evapotranspiration, and rainwater retention capacity. This results in an increase in the stormwater runoff coefficient, which makes urban areas more vulnerable to the impacts of urban flooding (Roggema, 2010; Wong et al., 2014).

It is a well-established fact that the effects of climate change are felt significantly more damaging in the developing countries of Asia, like Pakistan, compared to developed nations (IPCC, 2014). This is primarily due to a lack of resources, inadequate planning practices and infrastructure constraints (Ahsan, 2018; Ahmad and Anjum, 2012). To turn an adverse problem of climate variation, majorly urban flooding, into an eco-friendly environment requires the integration of green goals and objectives into the land use planning system (Rayan et al., 2021a; 2021c). This reinvigorates the discourse on the 'application of GI as an integrated, resilient land-use planning strategy for climate change adaptation' (Foster et al., 2011; Chapin et al., 2010).

Land use planning is an effective tool for mitigating the impacts of ever-rising environmental hazards (Berke & Stevens, 2016). Integrating urban green infrastructure (UGI) is an excellent complement to green and climate-resilient land use planning policies and strategies. UGI encourages nature solutions that can help minimise the vulnerability of urban areas to climatic hazards, such as urban flooding, drought, and the heat island (HI) effect, naturally (Beatley, 2000; Foster et al., 2011; Gill et al., 2007). Furthermore, UGI strongly contributes to enhancing the resilience of cities, improving the well-being of inhabitants, and bolstering ecosystem function (ESF) in the wake of climate-related challenges of varying severity (Tzoulas et al., 2007). Therefore, UGI is acknowledged as one of the key strategies for accomplishing sustainability, as it provides multiple benefits across different levels (James et al., 2009; Pauleit et al., 2019).

This concepts of GI is traced back to 1990s (the United States) when it emerged as a new approach to manage an uncontrolled urban sprawl (Benedict & McMahon, 2012; Pauleit et al., 2019). Since then, Urban GI is considered as a novel planning terminology in the landscape planning. Scientific experts believe that it is a "re-articulation of the present idea of urban green space (UGS) planning" (Davies et al., 2006; Rayan et al., 2021a). In the scientific literature, GI essentially narrates a "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and function's, sustain clean air and water and provides a wide array of benefits to people and wildlife" (Benedict & McMahon, 2012).

The European Union has integrated green infrastructure (GI) into its biodiversity policy through a programme known as "Green Infrastructure - Enhancing Europe's Natural Capital". This framework defines GI as a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services" (EC, 2013). Ecosystem (ES) services refer to "the benefits people obtain from the ecosystem" (MEA, 2005). That is to say; urban GI is a fundamental part of the ecological network that interconnects multiple ecological features, varying at regional, urban, and neighbourhood scales (Benedict & McMahon, 2006; EC-European Commission, 2015; EC, 2013). Based on the results of the literature, many scientific experts hypothesised a link between GI and ES functions (Pauleit et al., 2019; Lafortezza et al., 2013; Pataki et al., 2011; Tzoulas et al., 2007). However, the explicit interlinkage between green infrastructure (GI), resilience and multi-stakeholder participatory planning (MSPP) remains less prominent.

The concept of resilience and resilience thinking has emerged as a new dimension and theme for urban development underpinning a wide array of strategic interventions and policymaking in terms of land use planning. It refers to the system's capability to recover and return to its normal state following natural or man-made disruptions (Holling, 1973; Walker et al., 2004; Walker & Salt, 2012). Resilient action plans and strategies have been formulated to cope with various integrated challenges in the urban system, including socio-economic, functional, organisational, physical, behavioural, and spatial aspects. However, the resilience concept is often used in the climate change context (Leichenko, 2011).

So, to have a smooth-running resilience system, a research study was needed to analyse the sustainable pathways in the field of building infrastructure, that is being disturbed by the continuous pressure of in-daunting climatic challenges, resulting from anthropogenic activities. In this regard, green grass-root initiatives needs to be encouraged, besides fostering eco-friendly living practices on an urban, regional and neighbourhood scale (Fors et al., 2015; Rayan et al., 2021b , 2022b; Sturiale & Scuderi, 2019). So, to foster a sustainable environment in the upset urban regions (to cope with gradual climate-changing like flooding) the real question remains; "what should Pakistani cities do in their planning process and in implementing policies that treat urban green space (UGS) structure, ESF, inhabitants' health and well-being, and CC as an integral part of the built environment? In order to transform the vulnerable conditions of upset urban regions of Northwest areas of Khyber Pakhtunkhwa (KP) province into green cities and climate-resilient state?".

1.2. Genesis of the Problem

Pakistan cities are considered among those that need a framework for sustainable urban landscape and urban-greening (UL-UG) policies and strategies for planning environmentally resilient land use (Rayan et al., 2021a, 2021b). It is a vast country with over 241.49 million populations, out of which in (2023) 38.82% of inhabitants dwelled in urban areas [digital census results approved by the Council of Common Interests (CCIs)] (PBS, 2023; Khan, 2023). The empirical studies show that unprecedented urbanisation trends are expected to rise to 50% by 2030 (Haider & Badami, 2010; Jan & Iqbal, 2008; UNDP-Pakistan, 2019), pose urban regions, and the country's inhabitants are at the brink of multi-climatic catastrophes (UN-OCHA, 2010), especially the consistent flooding events observed during the last few years (Khayyam & Noureen, 2020; Khayyam 2020). Moreover, the growing incidence of natural calamities has threatened the safety of natural resources, urban (ESF), and human health. The "Global Climate Risk Index" (CRI) ranks Pakistan as the world's 5th most vulnerable country to natural catastrophes, followed by Vietnam and Bangladesh. (Eckstein et al., 2020; NDMA, 2012).

Overall, the country's vulnerability to climate-induced extreme events is very high. It is mainly the result of the weak institutional, the absence of a well-defined legislative planning framework, and the inability to implement necessary planning reforms effectively (Ahsan, 2018; Naeem et al., 2018) further to blame unbalanced and inadequate UL-UG policies at three tiers (Rayan et al., 2021b, 2022c; Bano and Khayyam, 2022; Ahmad & Anjum, 2012). This exerts dramatic pressure on land cover and biodiversity, transforming natural green spaces into built infrastructure, leading to the deterioration of the 'multifunctionality and connectivity' of urban GS. This has triggered severe natural catastrophes of varying magnitude and impact across the country, and Khyber Pakhtunkhwa (KP) province is no exception. For example, the flood of 2010 and 2022 flood, which have been described as the worst flood in history, struck the KP region hard, resulting in massive human and economic losses (Atta-ur-Rahman & Khan, 2013; Rayan et al., 2021b, 2022c; NDMA, 2022). A similar pattern was witnessed from 2011 to 2015 - albeit less intensely (EPA-KP 2022), making conditions even more challenging.

The KP province is highly vulnerable to climate variability like, rural and urban flooding (NDMA, 2012; 2022). It is because of its unique geophysical location and topographical features that it stands out. The region is situated in the basin of four rivers - "Swat, Kabul, Kunhar, and Panjkora" - originating from the high and rugged mountains of the "Hindukush, Himalayan, and Karakoram ranges"(Rayan et al., 2021b). This exacerbates flood risk and vulnerability in the built-up area. Unfortunately, the probability of catastrophic effects has increased over time due to poor management and outdated land-use policies. The KP region needs better enforcement and resources to address these issues effectively (Ahsan, 2018; Rayan et al., 2021a). In addition to these planning inadequacies, the lack of knowledge and awareness, combined with the absence of participatory planning (PP) practices, also exacerbates the problem (Alvi & Khayyam, 2020; Naeem et al., 2018; Rayan et al., 2021a; Ahmad & Anjum, 2012; Khayyam, 2016). This exerts negative pressure on urban green spaces (UGS), leading to their declining quality and quantity, which in turn degrades and depletes (Naeem et al., 2018) "natural green barriers" (Rayan et al., 2022b). The loss of natural green barriers leads to more devastating impacts of multi-climatic hazards such as floods, droughts and the heat island effect, posing significant risks to the environment, the health and well-being of urban residents and infrastructure (Desa, 2014, 2019 ; Rayan et al., 2022). It is, therefore, imperative to address these issues to ensure the safety and welfare of individuals and protect the environment.

Green Infrastructure (GI) has often been viewed as a non-essential urban activity mainly focusing on beautification in developing countries like Pakistan. However, it's essential to understand that GI is a vital amenity that significantly impacts urban climate resilience (Rayan et al., 2022a; Naeem et al., 2018; Waseem & Khayyam, 2019). Global studies affirm that urban GI planning (nature-based green solutions) is an innovative approach to improving disrupted socio-ecological systems in any region (Lafortezza et al., 2013; Mell et al., 2017; Monteiro & Ferreira, 2020). Moreover, GI helps reduce "surface runoff" and enhances the "infiltration rate", thereby enabling aquifers to be recharged more efficiently (15%-64%) than grey infrastructure (Mentens et al., 2006). Therefore, it's essential to strategically plan green spaces that complement the existing grey infrastructure and strengthen the urban resilience in the KPs region, especially in the face of the constantly rising climatic catastrophes (Gill et al., 2007; Mensah, 2014; Rayan et al., 2021a).

Over the past two decades, urban areas in KP's region have experienced a decline in green spaces, mainly due to imbalanced urban planning and ineffective urban greening policies. This decline is also attributed to an insufficient understanding of green spaces' value, leading to agricultural land's conversion into urban functions. Weak planning and law enforcement authorities with undue influence have further distorted the planning process and its outcomes (Naeem et al., 2018; Rayan et al., 2022b; UNDP-Pakistan, 2018; Waseem and Khayyam, 2019). Additionally, a lack of scientific knowledge and social participation obstruct the effective implementation and operation of "Green Action Plans (GAPs)" at city levels (Rayan, et al., 2022a) – ending in multi-climatic catastrophes and causing extensive damage to the urban system (CABE, 2010; Greiving et al., 2021; Greiving & Fleischhauer, 2022). Therefore, it is essential to have a comprehensive and holistic understanding of "urban green infrastructure (UGI), urban resilience (UR) and multi-stakeholder participatory planning (MSPP)" concepts in land-use planning policies and to develop a "sustainable UGI indicator-based framework model", tailored to the native built context. This framework encompasses a set of fundamental "sustainable UGI indicators and UGS taxonomies" based on inputs from local planning experts and community members under the PP approach. This ultimately paved the way for creating an inclusive, eco-friendly, and climate-resilient city-state in the KP region of (Pakistan) with further application to all other areas having similar characteristics.

1.3. Establishing a Niche

The constant proliferation of climate change, coupled with inadequate planning and structuring of institutions to deal with natural climate encounters, impedes effective land use planning policy and implementation in Pakistan (Ahsan 2018; Hussnain et al., 2014; Rayan et al., 2022; Wakil et al., 2016). This has led to uncontrolled urban expansion with no direction and destination, exacerbating manifold socio-ecological issues within Pakistani cities (Fahad et al., 2018; Fahad & Wang, 2020; Khayyam & Waseem, 2021). On various levels, research and efforts on natural disaster risk management phases are being conducted in Pakistan. However, the study on UGI planning for climate-resilient cities is limited. In addition, the idea of linking both UGI, climate resilience and MSPP concepts are still not clear in the planning context. Therefore, there is a need to examine the nexus between academic and planning practice. Such an approach required extensive examination of GI planning, perceived as NBS for mitigating and adapting to CC (Lafortezza et al., 2013; Mell et al., 2017; Monteiro & Ferreira, 2020). Such planning instruments contribute an imperative role in improving urban and regional resilience associated with climate-related disasters (Ahern, 2007b; EC-European Commission, 2015; EC, 2013; Mazza, Bennett, Nocker, et al., 2011; USEPA, 2010).

The study is unique from a research perspective that sofar no such examination has been done on such a topic in Pakistan, especially in the northwest regions of the 'Khyber-Pakhtunkhwa'. It has analysed the gaps and the potential for improvements of existing land use planning policy by exploring the linkage between 'GI, UR and PP' concepts in the planning process and "develop a rich body of multi-functional conceptual UGI indicator-based framework model, grounded upon triple bottom line (TBL) sustainability. Such a scientific framework encompasses core sustainable UGI indicators and UGS elements, according to the native local environment" (Rayan et al., 2021a). Furthermore, the inclusive UGI framework strengthens the interlinkages between "climate resilience strategies, the GS, the ESF and the health and well-being of the people" in the study region. Consequently, this enables us to assist in establishing pragmatic UL-UG policies and strategies for planning resilient land use that ultimately mitigates the adverse impacts of environmental catastrophes and fosters a sustainable environment in the KP province.

Moreover, in the discussion, a vital area of the empirical study is to encourage collaborations among "three-tier groups, namely decision-makers, experts, and the local community" (Rayan et al., 2021a, 2022a, 2022b) which is not prevalent in the policymaking of the (Ashfaque & Awan, 2015; Nizamani & Shah, 2004). To achieve a greater consensus among native actors regarding the "potential taxonomy of UGS elements for sustainable UGI indicators", we embedded all multi-stakeholder perspectives in the examination, including planning experts (Rayan et al., 2021b) and community members (Rayan, et al., 2022b). This (bidirectional) approach validated the findings from both exploratory research phases and led to the developing of a "sustainable UGI indicator-based framework model" tailored to the native environment. Moreover, the model promotes a sense of societal ownership and helps improve collaboration processes among relevant government institutions and communities. This, in turn, bridges the planning gaps and enhances scientific knowledge of natural green landscape-based initiatives to adapt to and mitigate climate change.

There have been theoretical and empirical evidence that indigenous knowledge on GS infrastructure contributes more positively to natural resource protection, conservation, and enhancement like, in water management, local temperature regulation, public green spaces networks, and disaster prevention in various world regions (Foster et al., 2011). However, in Pakistan, it has been observed that natives' inhabitant's knowledge of nature-based green landscape (NBGL) approaches has not been taken into account enough in current land-use planning work (Ahsan, 2018; Ashfaque & Awan, 2015; Nizamani & Shah, 2004). The limited representativeness of community knowledge in urban sustainability planning and implementation deteriorates the urban settlement system's resilience and functions. However, some small rural regions where the minority groups live acknowledge such green strategies (Rayan et al., 2022a). This research acknowledges the effective participation of all the local multi-stakeholders and sought a contrastive research study to testify the correctness of local inhabitants' knowledge regarding specific indicators of sustainable UGI and GS elements, which enables the building of an environment that is environmentally friendly and climate-resilient, in an ecologically fragile environment.

1.4. Aim and Hypothesis

The overarching goal of this dissertation is to improve the ways to capture and operationalise multifaceted urban (GI) concepts through new methods and data mining to improve the resilience of urban settlement systems against the climate-related disasters. The operationalisation of UGI, climate resilience and MSPP as a planning concept is a broad research field. Thus, the study aims to identify, develop, and experiment with a technique that interlinks sustainable indicators of UGI with GS elements—aimed to understand the environmental performance of the respective indicators and elements of green growth planning as well as their ability to withstand the impacts of climate change, especially in a local setting. This is important because not all elements of UGS may possess an effective functional linkage that enhances the resilience of UGI indicators when confronting environmental hazards, like flooding in urban areas (Ahern, 2007; Pauleit et al., 2019; Rayan et al., 2022a, 2022b).

Furthermore, the second aim of this dissertation takes its cues from the multi-stakeholder participatory planning (MSPP) approach – involving the knowledge and input of local stakeholders, such as planning experts and community members – to develop a "multi-functional UGI indicator-based framework" model that is grounded on the principles of "triple bottom line (TBL)" sustainability and is tailored to the local conditions. Such a model strengthens the interlinkages between "climate resilience strategies, the GS, the ESFs" and ensures the health and well-being of the community in the study region (Rayan et al., 2021a; Rayan et al., 2022b). Moreover, this dissertation intends to bolster the understanding of local stakeholders and relevant government authorities of the potential role of nature-based green infrastructure in addressing sustainable SCRM. This aids in developing proactive and pragmatic long-term UL-UG policies and strategies for planning resilient land use in the catchment areas of KP province, ultimately leading to an environment that ensures sustainable human settlements.

To conclude, the main objective of this empirical research is to achieve a harmonious equilibrium between human-centric and eco-centric activities with the aim of creating a new culture and eco-regional environment that encourages green growth development, both in the KP region and across the country.

This study hypotheses:

H_{0a}: Green infrastructure planning foster a sense of community stewardship and amplify urban resilience against climate-related disasters.

H_{0b}: Implementation of green infrastructure planning enhances interconnect networks of green spaces, ecosystem function (ESFs), biodiversity, and ensuring human wellness, both at the individual and community levels.

1.5. Research Objectives

The urban landscape and greening infrastructure (ULGI) hold the potential to counteract the environmental and spatial problems caused by climatic disasters in the urban interface. Therefore, this dissertation aims to strengthen the notion of GI as a nature-based spatial planning strategy that bolsters MSPP and enables the building of green (resilient to climate change) urban areas in the KP region.

The primary goal of this study is "to develop a sustainable UGI framework under MSPP" that recommends UGI indicators grounded upon the "TBL" of sustainability and their spatial functional linkages with the innovative multifunctional GS, which are to be implemented in the UL-UG design guidelines of Pakistan as a whole, and more specifically, the KP province. The objective is to enable climate-conscious green landscape development, according to the built environment and empirically based (native experts and community) facts and findings.

This main objective is met through specific sub-objectives of this study, which are:

- **RO1.** To investigate theoretical and conceptual evolution of GI planning–urban resilience–MSPP (nexus) for resilient land-use planning, and their synergies to develop a "potential sustainable UGI framework".
- **RO2**. To explore the understanding level of native multi-stakeholders (experts and community) for CC, UR and UGI concepts in the local built-in environment.
- **RO3.** Identification and empirical quantification of the level of importance of each "sustainable UGI indicator" with regards to their applicability and scale for building an environmentally friendly urban neighbourhood under MSPP.
- **RO4**. Identification of the key "UGS elements" that robust resilience and quality standards of specific UGI indicators for SCRM.
- **RO5.** To propose an "applicable sustainable UGI framework model" under native MSPP for green and climate-resilient city-states in the KP region?

1.6. Research Questions

The limited consideration of UGS infrastructure–climate change nexus to enhance participatory planning (PP) and urban resilience against flooding has been identified as the vital research gap. This research study aims to address this gap by answering the following research question:

"How to synthesise urban green infrastructure (UGI), climate resilience and MSPP concepts into the urban planning process to develop a sustainable UGI indicator-based (framework) model. This UGI model is structured according to the native built environment and based on the due inclusion of the concerned multi-stakeholder (experts and community) inputs under the PP approach. It is to enhance the adaptive capacity and building the KP region more resilient against climate change".

This dissertation is structured around five overarching sub-questions to find answer to the main research question (a reflection of study's ROs):

- **RQ1.** What is the theoretical and conceptual evolution of GI planning–urban resilience–MSPP (nexus) for resilient land-use planning, and their synergies to develop a "potential sustainable UGI" framework?
- **RQ2**. What is the understanding level of the native multi-stakeholders (experts and community) for CC, UR and UGI concepts in the local built-in environment?
- **RQ3.** How to identify and empirically quantify the level of importance of each "sustainable UGI indicator" with regards to their applicability and scale for building an environmentally friendly urban neighbourhood under MSPP?
- **RQ4**. What are the key UGS elements that robust resilience and quality standard of specific UGI indicators for SCRM.
- **RQ5.** What is the "applicable sustainable UGI framework model" under "native MSPP" for green and climate-resilient city-states in the KP region?

These research queries give the perception about sustainable urban development and building green, resilient cities by establishing a connection between UGS, ESF and community well-being; to minimise climatic challenges, specifically flooding at the urban scale in the KP area. Subsequently, it provides a composite sustainable UGI indicator-based framework, endeavouring to intertwine theoretical knowledge and practical application of GI for an analogy to mainstream an effective natural-based CC adaptation and mitigation strategies for implementation and achievement of environmental goals. Such an effort would contribute to formulating a multi-scalar green network system; that restructured the landscape mosaic patterns according to the native environment. Moreover, it enhances the potential resilience of UGS, which positively contributes to the enrichment of the effectiveness and efficiency of the "Sustainable UGI Indicators" against the anticipated environmental challenges. This has ultimately led to the proactive and pragmatic UL-UG policies and strategies; that help to improve the urban ecology system, serve the community, and mitigate the high flood risk in the catchment areas.

The scientific research questions and objectives introduced in the above section- can be tested through below three stages; explained in the below section "contribution and structure of dissertation".

Stage I: **Introduction**

Stage II: **Contributions**

Stage III: **Conclusion**

1.7. Contributions and Structure of work

This dissertation is written cumulatively. Figure 1- presents an outline of the contributions, research interests, core methods, as well as published research outputs (three stages criteria). The dissertation comprises five main chapters, including a discussion and conclusion. The study is structured into three main parts:

i. Introduction:

Chapter-1 is about the introduction of this dissertation that describes the genesis of the problem and research motivation. Moreover, this chapter outlines the research objectives and questions on which this dissertation focuses. Finally, the chapter concludes by giving an overview of the dissertation's structure and layout. Chapter-2 illustrates the theoretical background of UGI, climate resilience, and multi-stakeholder participation concepts in land use planning and develops a "potential UGI indicator-based framework model" based on "TBL" sustainability. The framework serves as the foundation for the empirical part of this cumulative dissertation.

ii. Contributions:

This section constitutes chapter 3: the core part of the study, and presents the brief results from the author key publications and all original scientific work that have undergone a double-blind peer review process and published in international (impact factor) journals. These publications contribute to the goal of developing novel methods and explicit techniques to assess and visualise the developed potential "sustainable UGI indicator-based framework" tailored to the local context under the MSEP. An MSEP is an effective method of engaging native stakeholders to understand the development of green space infrastructure to address sustainable climate risk management. This, in turn, contributes to meeting the objective of naturally alleviating the high risk of natural hazards and building an eco-regional paradigm in KP territory that improves ESFs and human health and well-being at both individual and neighbourhood levels.

iii. Conclusion:

The concluding chapter 4 of the dissertation discusses and summarises the main conclusions from all publication-based results in the context of the need for research and the objective of the dissertation. It also sheds light on the green policy implications and recommendations that can aid in reinforcing the adaptive capacity and resilience to natural hazards in urban areas. This helps identify a viable opportunity for a green growth urban development plan, particularly in KP, Pakistan. Finally, the final Chapter 5 delves into the challenges faced during the research process and highlights the strengths of the research. The need for further research studies for GI planning in Pakistan is also discussed.

Lastly, the final section of the dissertation constitutes the bibliography, publications by the author, and the appendix, providing a comprehensive and thorough conclusion to this (important) research work.

1.8. Methods & Techniques

This cumulative study is grounded on a mixed-methods approach and predominantly positioned towards empirical quantitative-dominant research. However, the qualitative approach is also used for "conceptual framing and empirical research" (*see* Figure 1). By triangulating both methods, the study endeavours to bolster and verify the accuracy of its results.

A comparative case study was conducted, employing cross-examination techniques that involved experts in top-down planning and community members in a bottom-up household setting (Rayan et al., 2022a). The MSPP study, at a local level, is considered more effective in understanding the complexity of human-ecosystem interactions (CABE, 2010; o'Brien et al., 2004). A human-nature study guide on "how to use" NBGI strategies? That enables bolstering the adaptative capacity of the urban system and ameliorating the high risk of multi-climatic disasters. The methodology is adopted, providing a holistic and in-depth investigation of the research inquiries within a real-life context. Furthermore, it helps to establish a rational perspective among the actors, facilitating the development of a "sustainable UGI indicator-based framework model". This approach proved instrumental in comprehending the complexity of research topics, especially when there is a lack of relevant information (Yin, 2003, 2009).

Urban regions are the key focus of this empirical study, as they are highly vulnerable to in-daunting climatic challenges. This study is centred on a multi-stakeholder engagement process (MSEP) that brings together local planning experts, including policymakers, academics, and practitioners, alongside household members of the community. By adopting this approach, the study aims to gain a holistic understanding of multi-stakeholders' perspective to answer the primary and overarching sub-questions.

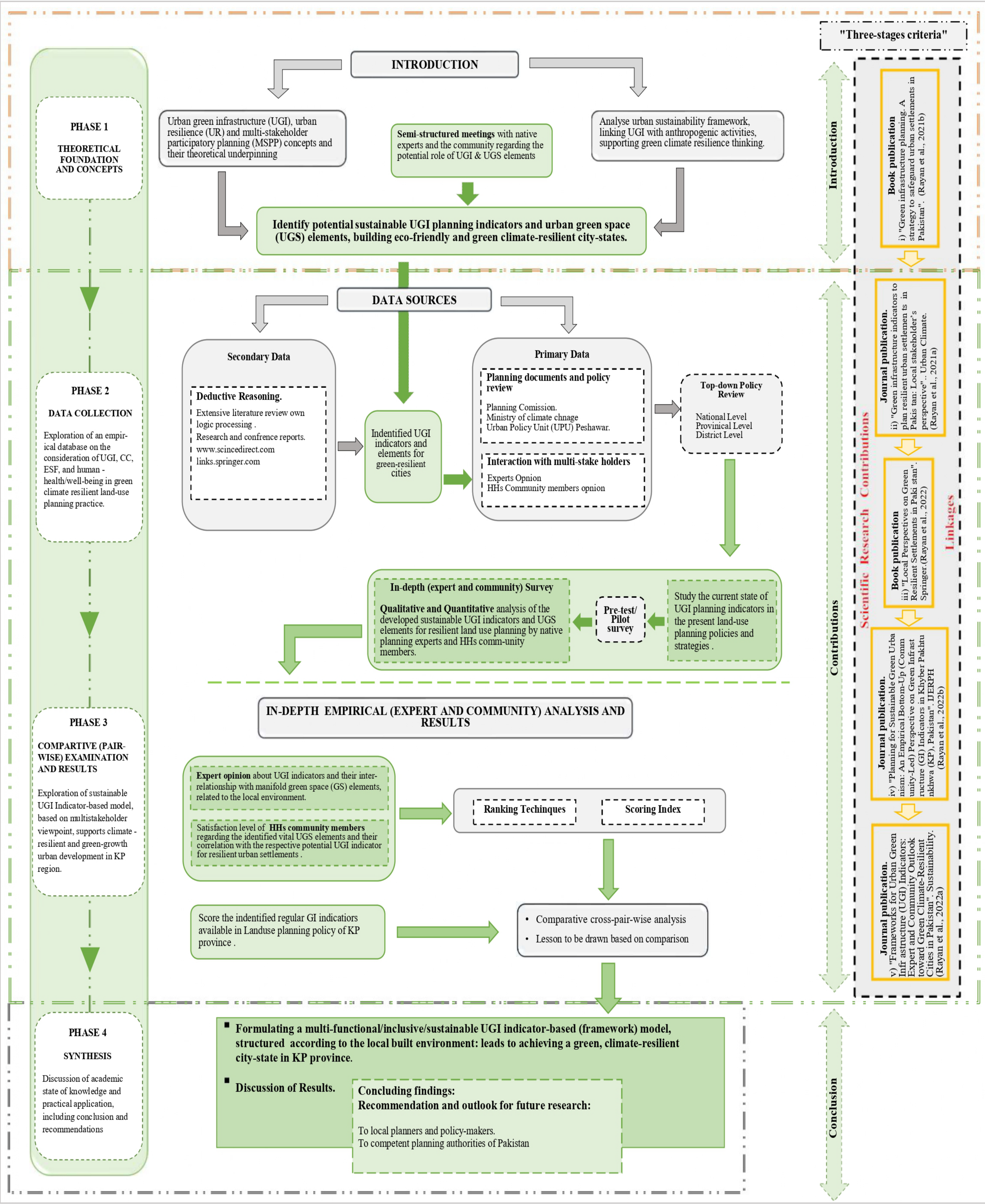


Figure 1: Research process, Contribution and Conceptual structural frame of the dissertation.

Source: Author' owns.

In this dissertation, two survey techniques were employed to operationalise an in-depth empirical study in the KP region effectively. The first technique was an “experts-based perception survey” (Rayan et al., 2021a), while the second was a “community-based empirical survey” executed especially in Peshawar, Mardan, and Charsadda (Rayan et al., 2022b), major districts of KP province. The data were collected through face-to-face interviews with community members at household (HHs) levels using a structured survey questionnaire (Appendix D). Notably, the research proactively aimed to include the maximum number of possible female heads of (HHs) by employing volunteer enumerators with local cultural knowledge of the region (Rayan et al., 2022d) because KP region's HHs are mainly male headed (KPBOS 2018). Along with this, survey questionnaires were distributed to representative institutes at both national and provincial levels in Pakistan, along with corresponding URL links (Rayan et al., 2021a, 2022).

The empirical investigations embedded the insightful perspective and satisfaction levels of native multi-stakeholders, including local planning experts and members of the community, help to explore the essential role of the potential taxonomy of “UGS elements” in upholding and strengthening the quality standard of respective “sustainable UGI indicators” amidst climate variability in a native urban environment. It is worth noting that each “UGS element” possesses a unique quality and may not necessarily increase the resilience of a specific “UGI indicator” against potential environmental hazards like urban flooding or effectively address SCRM. The efficacy of UGS structures relies heavily on their specific configuration and spatial context, as highlighted in various studies (Ahern, 2007; EC-European Commission, 2015; Gill et al., 2007; Pauleit et al., 2019; Rayan et al., 2022; USEPA, 2010). Moreover, the effectiveness of these GS is also influenced by diverse native stakeholder groups (with varying cultures, education, vision, and interest, etc.) involved in the examination process. These stakeholder groups play an instrumental role in determining the effectiveness of UGS structures in mitigating CC (Rayan et al., 2022b).

This validates the finding obtained from the exploratory holistic MSPP approach that has led to the development of an inclusive, “sustainable UGI indicator-based framework” tailored to the local socio-cultural, economic, and environmental conditions (Rayan et al., 2021a; 2022b). Such a framework facilitates building a “new sustainable cultural paradigm” that supports the development of green growth, thus enabling the creation of a green, environment-friendly, and climate-resilient city-state in the KP province and beyond.

SECOND CHAPTER

[Source: Author Own]

"Look deep into nature, and then you will understand everything better."

— Albert Einstein—

2. Theoretical and conceptual perspective on green infrastructure planning, urban resilience and multi-stakeholders' participation and their framing

The contents of this chapter (comprising of the figures and tables) have already been published in a peer-reviewed book chapter (see the citation below).

Rayan, M., Gruehn, D. & Khayyam, U. (2021): "Green Infrastructure Planning. A Strategy to Safeguard Urban Settlements in Pakistan". In: Jafari, M., Gruehn, D., Sinemillioglu, H. & Kaiser, M. [Eds.]: Planning in Germany and Iran. Responding Challenges of Climate Change through Intercultural Dialogue. Mensch und Buch Verlag. Berlin, pp. 197-220.

In this chapter, the state of the research regarding GI, an innovative nature-based solution for building a climate-resilient city, is first introduced and then based on it, the key elements of the study, i.e., urban climate resilience, ecosystem health, and multistakeholder participation are explained with reference to UGI. Finally, this section holistically operationalises the notions of (both) central building blocks (UGI, climate resilience and multi-stakeholder participatory planning) as a strategic planning concept and formulates conceptual "multi-functional UGI-indicator-based framework" based on "TBL" sustainability principle. Such a scientific conceptual base framework proposed potential (composite) core sustainable UGI planning indicators and green space (GS) elements, backed by a) theoretical investigation, (b) conceptual models (developed by the author) and (c) the nine (cross-cutting themes) derived from the due inclusion of the concerned native multi-stakeholder's perspective (through semi-structured meetings) in terms of the ability of nature-based green initiatives in addressing SCRM.

The integrative sustainable UGI model proposed here contributes to synthesising central core ideas and contextualising them in the native built-in context and stimulating the effectual and holistic MSPP approach, which leads to accomplishing the main aim/objective of the dissertation [2].

2.1. Defining Green Infrastructure (GI)

GI is relatively a new term, but it is not a novel approach, and it is viewed differently by different users in different contexts due to its wide range of applications in the urban

[2] Key publications are cited at the start of a section for which relevant contributions by the author are available. The full text can be accessed in the appendix. All key publications are written by the author in the capacity of the lead and corresponding author, and each publication contains more than 30,000 characters. Beyond the prerequisite (publishing three scientific articles) of the thesis, to partially fulfil the requirements for acquiring the PhD degree. I also published book chapters, which contributed to the genesis of the key publications and are relevant to the problem; the index of publications is listed in the bibliography.

environment (Davies et al., 2006; Lafortezza et al., 2013; Naumann, et al., 2011; Wright, 2011). Therefore, it is common that one may come across different interpretations of GI (Davies et al., 2006; Hehn et al., 2015; Roe & Mell, 2013; Weilenmann et al., 2005; Wright, 2011) within the existing literature. According to Benedict and McMahon (2006), GI refers to "an interconnected network of natural areas and other open spaces (e.g., such as squares, pedestrian areas, cycling areas) that conserves natural ecosystem's values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife. Their work has decisively shaped the GI approach, and based on their definition, GI strongly emphasises the ecological and biodiversity factors. At the European scale, the EU working group on GI strategy define (promulgated) GI as "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services" (EC 2013).

The global studies evolve a clear picture of GI, affirming that it has strong associations with the environment, and its emphasis is on the linkage between the ecological and the social components (Benedict & McMahon, 2006; Davies, MacFarlane, et al., 2006; Tzoulas et al., 2007; Weber et al., 2006) across manifold spatial scales, from the city to the regional and national levels (Hansen & Pauleit, 2014; Mell, 2010). Even though GI definitions are more diverse and broader and can be outlined and assessed differently depending on the context (Davies, MacFarlane, et al., 2006), however, there are also some core principles and themes that underpin the concept (Benedict & McMahon, 2006; Lafortezza et al., 2013; Mell, 2010; Naumann et al., 2011; TEP, 2005; Tzoulas et al., 2007; Wright, 2011). The below (table 1) illustrates some selected connotations of GI from the theoretical studies.

Table 1: Green infrastructure definitions

a)	GI is a "…. natural life support system—an interconnected network of waterways, wetlands, woodlands, wildlife habitats and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for. . . communities and people" (Benedict & McMahon, 2002).
b)	GI refer to "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water and provides a wide array of benefits to people and wildlife" (Benedict & McMahon, 2006).

c)	Davies et al. (2006) describe GIs as the "physical environment within and between our cities, towns and villages. It is a network of multi-functional open spaces, including formal parks, gardens, woodlands, green corridors, waterways, street trees and open countryside. It comprises all environmental resources, and thus a green infrastructure approach also contributes towards sustainable resource management".
d)	As stated by Tzoulas et al. (2007), GI comprises "of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales".
e)	As per the European Commission, GI is "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings" (EC 2013).
f)	GI is the "network of natural and semi-natural areas, features, and green spaces in rural and urban, and terrestrial, freshwater, coastal and marine areas, which together enhance ecosystem health and resilience, contribute to biodiversity conservation and benefit human populations through the maintenance and enhancement of ecosystem services. Green infrastructure can be strengthened through strategic and co-ordinated initiatives that focus on maintaining, restoring, improving, and connecting existing areas and features as well as creating new areas and features" (Naumann et al., 2011).
g)	GI is outlined as "Our nation's natural life support system – an interconnected network of protected land and water that supports native species, maintains natural ecological processes, sustains air and water resources and contributes to the health and quality of life for America's communities and people" (Williamson, 2003).

Source; Author compilation

Based on the definitions presented above, it is noted that these GI definitions are broadly consistent and overlapping; the following elements are often cited as constituting GI: connectivity, multifunctionality, accessibility, biodiversity, human-natural benefits, and sustainability. Also, it is highlighted that GI is part of a broader ecological network framework that contributes to (environmental, sociocultural, and economic) sustainability. As per Jongman & Pungetti (2004) definition, ecological networks (EN) refer to "systems of nature reserves and their interconnections that make a fragmented natural system coherent, so as to support more biological diversity than in its nonconnected form". Moreover, EN is recognised as an invaluable planning tool that facilitates the development of sustainable urban communities and a greener environment (Ignatieva et al., 2011).

2.1.1. Theories corresponding to the emergence of the GI concept.

The notion of "Green Infrastructure" (GI) is not novel in (the field) of planning research and practice. Its origins can be traced back to the efforts of nature conservation and planning, as witnessed (in the late 1800s) in Frederick Law Olmsted's works (Benedict & McMahon, 2006). Olmsted was a landscape architect and a pioneer in urban green space management. He developed multi-functional landmark projects like, "New York Central Park" and "Emerald Necklace" in Boston. In 1903, Olmsted affirmed that "no single park, no matter how large and how well designed, would provide the citizens with the beneficial influences of nature". Moreover, it was specified that green spaces (i.e., parks) needed "to be linked to one another and to surrounding residential neighbourhoods" (Benedict, 2002). So, the idea of interlinking GSs to benefit the community and biodiversity stirred the "Greenways" planning movement (Mell 2010). Subsequently, the "Greenway" planning movement and the "Garden city" movement (idyllic urban theory), presented by Sir Ebenezer Howard (an English urban planner) in the UK, both movements had laid the foundation for the formation of the GI concept.

In the context of 'GI', studies have indeed established that this terminology, was explicitly first emerged in the mid-1990s in the US having the aim to protect urban regions against natural calamities (e.g. flooding) by building natural green spaces (often called green systems) as stormwater retention areas (Benedict & McMahon, 2006; EEA, 2011; Mell, 2013; Naumann et al., 2011). Furthermore, to identify and manage the creation of greenways, some research institutions in the US, such as the 'Conservation Fund' and other organisations, developed a much broader understanding of GIs: an "environmentally preferable approach to stormwater (management)", and (along with that) they identified other functions and benefits related to GI in planning to protect the ecology and natural systems (EEA, 2011). The first design proposals to implement GI in North America were grounded on the (basic idea) of nature conservationist goals (McKinney, 2002; Roe & Mell, 2013). Since 'GIs' origins can be observed in the "Greenways" movement in the US (Benedict & McMahon, 2002; Mell, 2010, 2013), which played a pivotal role in promoting the network-based approach to green space management aimed at enhancing the local urban environment in various ways. This result gained special attention among practitioners, planners, and political groups. For instance, Charles Little states in his book "The Greenway in the United States" that GI is "the expansion of the greenway system" and "a new infrastructure category" (Little, 1995). Also, Benedict and McMahon, and Williamson's author's work, contributed invaluably to the rise of GI alongside Greenways, as Greenways' planning is primarily associated with recreational and ecological functions, an idea similar to GI (Benedict & McMahon, 2002, 2006; Williamson, 2003).

At the European Union's (EU) level, the GI terminology was first promulgated in 2009 through the Commission White Paper, "Adapting to Climate Change"(EEA, 2011). The EU institution and its legislative documents (regulations, directives, recommendations, decisions etc.) use the "GI" concept in connection with landscape resources, primarily focusing on ecological connectivity. The global studies affirm that in a European context, the term GI has developed a holistic and cross-disciplinary character, and it has been embedded into different areas of planning practices across different spatial scales (ideally nested), resulting in influencing planning policies and strategies from the local to regional/national level (EEA, 2011; Lafortezza et al., 2013; Mell, 2017). The development of GI planning in Europe is regarded as central to promoting biodiversity (BD), adapting it to local contexts, and maintaining, enhancing and reestablishing urban ecosystems (ESS). It is, in fact, considered one of the six principal objectives of the EU biodiversity strategy for 2020 (European Commission, 2011, 2013). Also, the EEA (European Environment Agency) sees GI as essential in counteracting the depletion and fragmentation of natural areas and augmenting the interconnectedness of green and open spaces within and outside NATURA 2000 networks (European Commission, 2013). This approach is not only beneficial for the environment but also contributes to the social and economic well-being of communities, paving the path towards sustainable cities (Europen Commission, 2017).

In Germany, GI planning has emerged as an opportunity to create more cohesive UGS networks. The primary objective of this approach is to improve the resilience of urban ecosystems by promoting biodiversity and enhancing the benefits of nature and landscape for both local and global communities. These endeavours have been triggered by a series of green initiatives, policies, and strategies, such as the "Federal Defragmentation Programme 2012 [Bundesprogramm Wiedervernetzung]" (BfN, 2014), "Nature Conservation Initiative 2020 [Naturschutz-Offensive 2020]" (BMUB, 2015a), "Federal Green Infrastructure Concept [Bundeskonzept Grüne Infrastruktur (BKGI)]" (BfN, 2017)" and "Green in Cities - for a liveable future [Grünbuch Stadtgrün: Grün in der Stadt – für eine lebenswerte Zukunft]" (BMUB, 2015b) — aims to achieve the protection of nature and the promotion of ecosystem services. Nevertheless, to enhance the concept of GI within the framework of sustainable development, more research has been conducted in Germany to deepen its understanding (of the human–nature relationship) in the process of land use development. The objective is to establish a framework for enhancing the natural ecosystem functions and services, including climate regulation, preventing natural disasters such as floods and droughts, mitigating the urban heat island effect, stormwater management, and developing multi-functional green spaces for recreational purposes. By achieving these objectives, the socio-ecological well-being of the region can be improved (Lafortezza & Sanesi, 2019; Rolf, 2020).

It is worth mentioning that Germany has a decentralised legislative system, which includes four levels of planning structure. Each level has its own set of clearly defined responsibilities; fundamental principle like, subsidiarity is applied across all levels of planning to maintain a consistent and uniform structure (Blotevogel et al., 2014). In 2006, the Federal Republic of Germany implemented a federal reform bill redefining the roles of the federal and state authorities (Hu et al., 2020). In that same year, a policy paper entitled “Concepts and Strategies for Spatial Development in Germany” was issued by the ministers of all 16 Länder ('self-governing states') at a spatial planning conference (MKRO). This paper is widely regarded as the official beginning of GI planning in Germany, with a strong emphasis on the sustainable development of large green areas at the federal level (Mell et al., 2017).

The systematic implementation of GI planning (at the federal level) exhibits rationality and coherence upon which all other spatial scales are built. Additionally, due to the multi-layered (sectoral) landscape planning and management system in Germany, GI is fostered at various scales and levels through the use of diverse strategies and techniques. First, at the upper “federal level”, GI planning primarily involves setting broad policies, guidelines and codes that serve as a foundation for planning at the state, regional, and local levels. The federal concept of “Green infrastructure” is an example of this approach, which defines GI as a “sustainable tool that aims to protect nature and promote ecosystem services” (BfN 2017). Then, the second level of planning, called State-level planning, regional and local plans are created with consideration of national objectives. This helps to ensure that the planning procedures and content are consistent across all levels.

The third layer, known as “regions”, focuses on detailed planning objectives within a designated territory. This includes creating concepts and plans for multi-functional biotope networks and open green spaces (GS), such as the “Emscher Landscape Park in the Ruhr Area” (Pahl-Weber & Henckel, 2008; RVR, 2014; 2016). This level is referred to as a laboratory for “experimental regionalism” where informal approaches and integrative partnerships are encouraged to find pragmatic solutions for GI planning (Fürst, 2011; Gualini, 2004). The fourth and final layer is local-level planning. This involves the implementation of formal landscape plans across a designated area in coordination with comprehensive land use plans created by local planning authorities (BBR 2000).

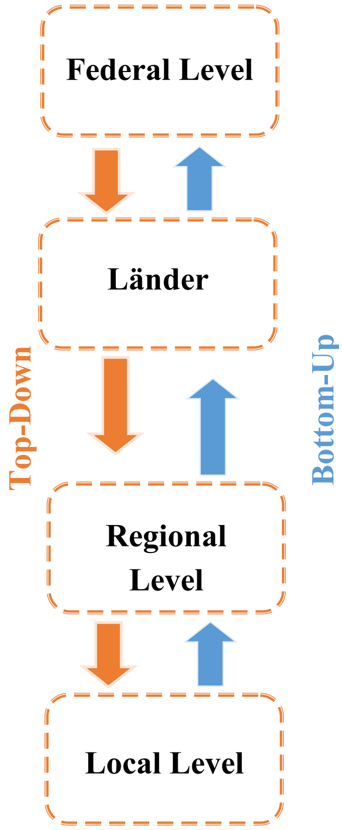


Figure 2: GI Planning Framework in Germany (adapted from BBR, 2000; Mell et al., 2017)

The storyline: the German planning system is relatively stable (Dembski, 2020) and widely acknowledged for its decentralised and multi-layered approach (BBR, 2000; Mell et al., 2017; Rolf, 2020). Under this system, landscape planning plays a crucial role in developing and maintaining GI. Moreover, it is worth noting that the effectiveness of GI planning in Germany is closely linked to the successful integration of the GI concept with the country's landscape planning system. This is because both concepts share similar objectives, such as supporting environmental decisions, promoting ecological awareness, assessing nature and landscapes (Albert et al., 2012, 2014), and enhancing the health and well-being of people's (Mell, 2010; MEA, 2005).

In landscape planning and management, green infrastructure (GI) is mainly centred around improving landscapes in ways that benefit both humans and the environment at a range of scales. This approach, which emphasises socio-ecological and economic regeneration, is favoured by many researchers, academicians, planners and practitioners who work with landscapes (Farina, 2000; Mell, 2010; Roe & Mell, 2013). Some experts view GI as a re-articulation of existing ideas of UGS (Davies et al., 2006; Mell, 2017; Rayan et al., 2021a). Others see it as an old idea presented in a new way, “old wine in new bottles” (Davies et al., 2005). Furthermore, Davies et al. (2006) also posit that GI holds significant potential, serving as a reference point for various topics, including ecological networks, landscape ecology, human well-being, and sustainable development. This approach represents a novel direction of thought that can be further refined, expanded and linked with green nature-based solutions, being considered a promising approach in urban areas to conserve, restore and manage semi-natural and natural landscapes (Hansen & Pauleit, 2014; Pauleit et al., 2019). Moreover, this approach helps to enable an urban environment that supports climate change adaptation (Demuzere et al., 2014), and stormwater runoff reduction (W. Liu et al., 2015), one of the primary objectives of UGI planning.

2.1.2. Principles of GI

The planning of green infrastructure (GI) is gaining widespread recognition among experts, policymakers, and the public alike, both in developed and developing areas, because of its ability to create more environmentally friendly and livable cities (Rayan et al., 2022a). GI not only strengthen social and ecological connections between urban and rural areas but (also) promotes a balanced relationship between human activities and the environment (Rayan et al., 2022a). Moreover, this approach benefits the bolstering of ESFs, the conservation of biodiversity, and the improvement of the health and well-being of inhabitants. It has become a vital planning framework, potentially addressing climate uncertainties and establishing a sustainable, green, resilient city-state (Ignatieva et al., 2011; Rayan et al., 2021a).

The terminology of "GI" may be comparatively new in sustainable development (SD) planning, but not a novel concept (Wright, 2011). Consequently, there has been discussion (among experts) in the literature on whether a singular definition and conceptual foundation of GI is essential or if a more comprehensive interpretation would be more effective in engaging multi-stakeholders and addressing typical attributes of a GI planning approach (Ahern, 2007; Hehn et al., 2015; Horwood, 2011; Roe & Mell, 2013; Wright, 2011). Although different experts have different conceptualisations and definitions of GI. It is acknowledged (widely) that GI aims "to create multifunctional networks of green spaces" (Pauleit et al., 2017). Multifunctionality, connectivity and multi-scale are core principles (see table 3). These principles are deemed fundamental to the (GI) concept and most frequently studied in the research literature cited (Ahern, 2007; Benedict & McMahon, 2002, 2006; DG-ENVI, 2012; Hehn et al., 2015; Horwood, 2011; Llausàs & Roe, 2012; Rayan et al., 2021b; Roe & Mell, 2013; Wright, 2011). Apart from the core principles, one general principle is participation, that can be comprehended and interlinked with all three principles of GI planning (Kambites & Owen, 2006). Importantly, all key principles highlight the need to involve stakeholders in planning and managing natural green spaces (DG-ENVI, 2012; Naumann, Davis, et al., 2011), and to this end, they endorse the inclusion of a wide range of participatory planning processes in decision-making. Moreover, Kambites & Owen (2006) identified sustainability, resilience, and assimilation as the primary goals (see table 2) that underlie the principles and actions (functions) of green infrastructure.

Table 2: The planning goals, principles, and functions of green infrastructure (GI)

Goals	Principles		Functions and Features		
	Specific	General	Abiotic	Biotic	Cultural
Building climate resilience, Sustainability and Integration	Connectivity. Multi-functionality. Multi-scale.	Participation	Water, sunlight, oxygen, Soil, Temperature	Fauna Flora	Cultural Identity, Aesthetic Health

Source: Authors' adaptation from (Kambites and Owen,2006) and (Ahern, 2007).

Table 3: GI planning principles

Connectivity	*Connectivity,* in GI planning, refers to the interlinkage of green spaces (GS) at multiple scales and (spatial) levels - both functionally and structurally, aimed to serve (both) humans and other habitats/species (Ahern, 2007; Benedict & McMahon, 2002; Wright, 2011). Functional Connectivity is related to species' behaviour and ecological processes. Structural Connectivity, in contrast, refers to the elements of the landscape and how they are spatially arranged and linked (Hansen & Pauleit, 2014). Moreover, this incorporates both (vertical and horizontal) Connectivity (EEA, 2011; EC, 2013; Roe & Mell, 2013). In the planning context of the German landscape, Connectivity is addressed through (two instruments), habitat networks (also named biotope networks and, in German, Biotopeverbund), which focus on the facilitation of habitat/species movement, interactions and conservation, and the second approach, multifunctional greenways systems (in German: Grünzüge), to prevent urban sprawl and provide recreational and climatic functions (Von Haaren et al., 2008; Von Haaren & Reich, 2006). In sum, Connectivity enhances the quality of life, place, and nature over diverse landscapes (Mell 2010; Rayan et al., 2021b).

Multifunctionality	In the context of GI, *multifunctionality* refers to the ability to provide innumerable functions in the same spatial region. These intertwining functions (of green spaces) consider ecological, social-cultural, economic/ abiotic, and biotic dimensions in concert. Therefore, multifunctionality concept is viewed as a pivotal pillar of GI planning (Pauleit et al., 2011; Kambites & Owen, 2006). Also, It is comprehended as a key concept while planning sustainable land use (Benedict & McMahon, 2006; DG-ENVI, 2012; Lafortezza et al., 2013; Pauleit et al., 2019). Multifunctionality not only facilitates the boost of the synergies within green spaces (GS), ensuring a wider range of benefits, but also stimulates the efficacy of GS spatially in the urban agglomeration, addressing different environmental challenges (Rayan et al., 2022; Hansen & Pauleit, 2014). The Urban Landscape Strategy of Berlin uses the term “multi-coding” to refer to “multifunctionality”, which exhibits that green areas in cities have diverse cultural significance (meanings) for different people: “Transferred to urban open spaces, multi-coding is the overlay of interests and functions; instead of a mono-functional juxtaposition, it creates space that is usable in multiple dimensions”[3] (Berlin, 2012).
Multi-scale	In Green Infrastructure (GI), the *multi-scale* principle is centred around adaptability and flexibility. It acknowledges that GI planning can be deemed for various (multi-layered) spatial levels, ranging from city regions to neighbourhood communities. The goal of GI planning is to establish connections and synergies across different spatial scales in concert, not only within city-regions but also beyond them (Ahern, 2013; Davies & Lafortezza, 2017; Kambites & Owen, 2006; Mell et al., 2017; Pauleit et al., 2011).

[3] “Berlin, S. (2012). Strategie Stadtlandschaft Berlin–natürlich urban produktiv, Berlin, 2012. Online Verfügbar Unter: Http://Www. Stadtentwicklung. Berlin. De /Umwelt/ Landschaftsplanung/ Strategie_ stadtlandschaft/ Download/Startegie Stadtlandschaft-Berlin. Pdf Letzter Besuch Der Seite Am, 25, 2012”.

Green-grey integration	The principle of integration refers to the coordination and linkage of green space infrastructure with other urban structures, commonly referred to as grey infrastructure, such as transport systems and utilities. This approach ensures seamless coordination and mutual integration of the two infrastructures, maximising efficiency and effectiveness (Davies & Lafortezza, 2017; Hansen et al., 2017, 2019; H. W. Kim & Tran, 2018).

Source; Authors compilation

In the broader discourse on GIs, these key principles (as mentioned above) are, in fact, the ones that are most often cited in the literature. Benedict and McMahon (2002, 2006) and Ahern 1995 were considered among the pioneers in developing principles (connectivity, multifunctionality) for successful GI planning and implementation, laying the basis in the literature (Ahern, 1995; Benedict & McMahon, 2002, 2006), along with multiscale, which is also considered another key principle, widely accepted by academics, practitioners and implementing organizations (Davies & Lafortezza, 2017; Kambites & Owen, 2006; Mell et al., 2017). In addition, Mell conducted a comprehensive review (year 2015) on this aspect and probed the use of various GI principles in the US., UK., Europe, and other regions of the World. Mell highlights sustainability, accessibility, urban context, and the importance of discussion (participation) with advocacy agencies (both governmental and non-governmental) and stakeholders as recurring features in addition to multifunctionality and connectivity (Mell, 2015).

Green Infrastructure (GI) is a comprehensive and strategic planning approach which seeks to protect and enhance urban green and open spaces, taking into account (both) ecological and socio-economic factors. Its holistic approach makes it more effective in dealing with greater complexities and challenges associated with climate change adaptation and environmental protection than traditional, mono-functional planning methods (Ahern, 2013; EC, 2013; Kambites & Owen, 2006). Although GI principles have been developing for over a decade, it's still an evolving concept. Mell (2013) recommends that for successful and effective GI planning, it is important to take a proactive approach and assess how it can add value to the green policy framework (Mell 2013). Furthermore, GI planning is also viewed as a “melting pot” for innovative planning approaches that strive to improve climate resilience and ecological compensation as well as provide multiple potential co-benefits to inhabitants (Hansen & Pauleit, 2014).

2.1.3. GI Typologies

Urban green infrastructure (UGI) encompasses a broad array of components, features, characteristics, functions, and services that have led to a wide variety of typologies. These (green) elements differ in respective spatial levels and the hierarchical scales (see table 4 and fig 3): mainly classified into sites (e.g., neighbourhood, city and regional) scales (Ahern, 2007; Benedict & McMahon, 2002, 2006). UGI has received greater attention within (both) social and environmental sciences due to its multi-functional, multi-scale and connective characteristics in coping with climatic catastrophes and ongoing urbanisation.

Figure 3: Elements of Urban Green Infrastructure (UGI) at multiple scales.
Sources: Author compilation from (Ahern, 2007; Benedict & McMahon, 2002, 2006)

Table 4: UGI elements at multiple scales

At a regional scale: UGI is the network of the ecological corridor and land conservation.	**At the urban scale:** UGI includes urban forest/tree canopy, urban parks, Botanical gardens, parkways, and boulevards elements.
At a neighbourhood scale: UGI comprises local parks, pocket parks, constructed wetlands, and green alleys.	**At site scale:** It includes rain gardens/ bio-infiltration, green living walls and roofs, stormwater planters, and rainwater harvesting systems.

Sources: Author compilation from (Ahern, 2007; Benedict & McMahon, 2006)

According to Davies et al. (2006), GI planning is classified into three spatial levels (see fig 4). The lower most level is individual (green) elements, classified as parcels and considered watercourses or park features. The next levels are linked elements that serves as a network connection to connect individual green elements and allows species to move. Cultural and ecological greenways and riverways are examples of linked elements that can be applied to various-sized areas, like neighbourhoods or cities. Finally, the uppermost tier is GI, which embodies the networks of interconnected green elements conceived at a regional scale. The principles of GI can be assessed in multiple typologies of green and open spaces at different spatial levels, providing multiple potential co-benefits (Ahern, 2007, 2013; Rayan et al., 2021b).

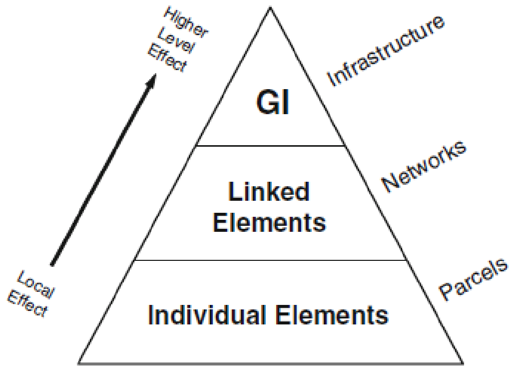


Figure 4: Spatial levels in GI planning.
Sources: Davies et al., 2006

The "Green infrastructure" is a large-scale, environment-focused planning framework that identifies "hubs", "links", & "sites" - three distinct features that make up a GI network. Benedict and McMahon introduced this model in 2002 and 2006 (see fig 5), while Ahern (2007) refers to the spatial structure surrounding the GI network as a "matrix" (Ahern, 2007). These fundamental landscape elements can be natural/semi-natural or man-made and come in various sizes and shapes. Hubs are homogeneous, nonlinear structures that serve as core anchors of the GI network, providing origins/destinations for habitats (biodiversity) and ecological processes. In general, "hubs" are large, protected areas, such as natural reserves, protected areas, regional or national parks, urban forests, and forests etc., that serve different environmental and societal benefits. On the other hand, "sites" are small areas in GI networks that offer ecological and social benefits, from preserving wildlife habitats to providing opportunities for green nature-based recreation (Benedict & McMahon, 2002, 2006).

Finally, "links" are linear structures, different in content and physical form, that tie hubs and sites in a unified system and enable GI networks to work. Links serve as a corridor between ecosystems and man-made landscape elements, maintaining ecological processes and the health of biodiversity. They come in diverse forms and functions, like landscape linkages, conservation corridors, ecological and cultural greenways and (green) belts (Benedict & McMahon, 2002, 2006), which not only facilitate the counter habitat fragmentation and wildlife (flora and fauna) migration between fragmented hubs and sites, but also conserve native ecosystems and provide opportunities for outdoor recreation for the benefit of urban and rural residents.

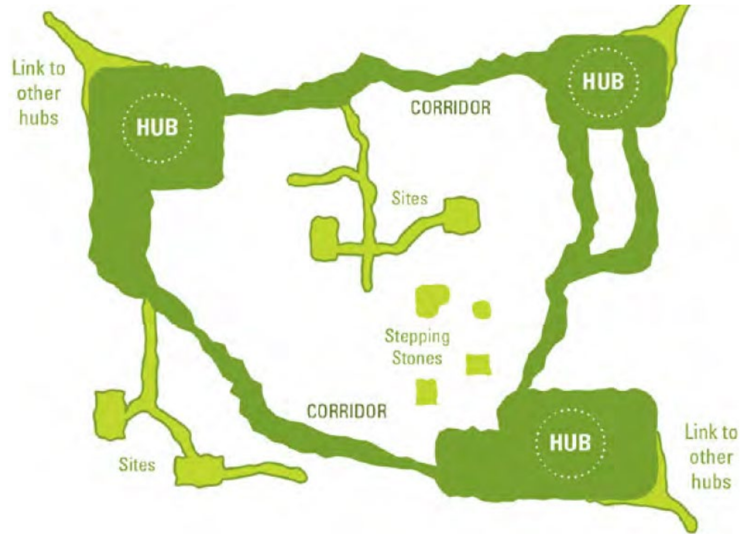


Figure 5: GI network components.
Sources: Diamond Head Consulting, 2014

There have been multiple efforts by researchers to classify different typologies of GI (see for example: Ahern, 1995; Davies et al., 2006; EEA, 2011; Lafortezza et al., 2013; Millennium ecosystem assessment, 2005; Naumann et al., 2011; Tzoulas et al., 2007). These efforts involve field research and synthesis of existing data-driven by stakeholders, academics, and practitioners. Interestingly, it is worth noting that GI elements acknowledged by all authors move along a so-called green-grey continuum (Davies et al., 2006). This implies that GI is more than just traditional green and open spaces. It also encompasses other structures, like footpaths, cycle paths, and green roofs, that serve vital ecological goals while fulfilling other functions (Mell 2010). Although elements of GI exist at the local level, their interconnections create synergies and effects beyond the local level (Davies, MacFarlane, et al., 2006; Lafortezza et al., 2013; Lafortezza & Sanesi, 2019). It maintains and enhances the quality of life, the quality of place and the quality of environment (micro and macro) at different spatial scales (Mell, 2010; 2013). Furthermore, It also acts as a key enabler for efficient and sustainable land use management, particularly in densely populated urban areas where land is scarce or under pressure (EEA, 2011; 2017).

The GI model emerged as a nature-based approach to climate adaptation, bolstering the multifunctionality and connectivity of green spaces and enhancing cities' resilience to environmental risks (EC, 2013; Rayan et al., 2022, 2022b). It encompasses an array of multi-functional and multi-dimensional natural and man-made features like rivers, urban parks, forests, and green routes (Davies, et al., 2006; Lafortezza et al., 2013). The Landscape Institute's Position Statement provides a comprehensive list of potential GI elements (EEA, 2011; Landscape Institute, 2009). It groups the (GI) typologies into three broad scales (see Table 5). Furthermore, the Green Surge initiative (2013-2017) compiled an extensive inventory of UGS, which features forty-four UGS elements categorized into eight broader groups according to their scale, location, and function (Olafsson & Pauleit, 2018; Rall et al., 2015). These classifications are "building greens; private, commercial, industrial, institutional UGS and UGS connected to grey infrastructure; riverbank green; parks and recreation; allotments and community gardens; agricultural land; natural, semi-natural and feral areas; blue spaces" (Rall et al., 2015).

Table 5: GI Typologies

Local, neighbourhood and village scale	Town, city and district scale	City-region, regional and national scale
Street trees, verges, and hedges	Business settings	Regional parks
Green roofs and walls	City/district parks	Rivers and floodplains
Pocket parks	Urban canals	Shorelines
Private gardens	Urban commons	Strategic and long-distance trails
Urban plazas	Forest parks	Forests, woodlands, and comm-unity
Town and village greens and commons	Country parks	forests
Local rights of way	Continuous waterfronts	Reservoirs
Pedestrian and cycle routes	Municipal plazas	Road and railway networks
Cemeteries, burial grounds, and Churchyards	Lakes	Designated greenbelt and strategic gaps
Institutional open spaces	Major recreational spaces	Agricultural land
Ponds and streams	Rivers and floodplains	National parks
Small woodlands	Brownfield land	National, regional, or local landscape
Play areas	Community woodlands	designations
Local nature reserves	(Former) mineral	Canals
School grounds	extraction sites	Common lands
Sports pitches	Agricultural land	Open countryside
Swales, ditches Allotments	Landfills	
Allotments		
Vacant and derelict land		

Sources: Author compilation from (Landscape Institute, 2009)

2.1.4. Functions, Services, and Benefits of GI

Green Infrastructure (GI) has the potential to safeguard, restore, and develop ecosystems, thereby promoting biodiversity, social and territorial harmony, and sustainable development while also improving the environmental standard and quality of life (DG-ENVI, 2012; EEA, 2011; Lafortezza et al., 2013; MEA, 2005; Tzoulas et al., 2007). GI functions have been classed as environmental, socio-cultural and economic (EEA, 2011; Pauleit et al., 2011; Rayan et al., 2021a; Roe & Mell, 2013; Wright, 2011) or abiotic, biotic and cultural (ABC) (Ahern, 2007; Mell, 2010; Rayan et al., 2021b). These functions bring various benefits to both humans and nature (Rayan et al., 2022a). Boyd & Banzhaf (2007) describe the function as an "intermediate product" of an ecosystem. To (better) comprehend the various functions and services in GI, the ecosystem cascade model could be applied (Haines-Young & Potschin-Young, 2010). The model clearly distinguishes between GI functions and services, as illustrated in Figure 6. According to the model, "Landscape Structure or Processes", such as wetlands or net primary productivity, form the basis for "Functions" such as controlling, storing, and slowly releasing water. These "Functions" can lead to the development of "Services" for communities, such as flood protection. These services contribute to the human benefit and economic "Valuation" of those services, such as "willingness to pay for wetland protection" (Hansen & Pauleit, 2014). Thus, it is evident that ecosystem functions and services are closely connected to the ES benefits they provide (De Groot et al., 2010; Wong et al., 2015).

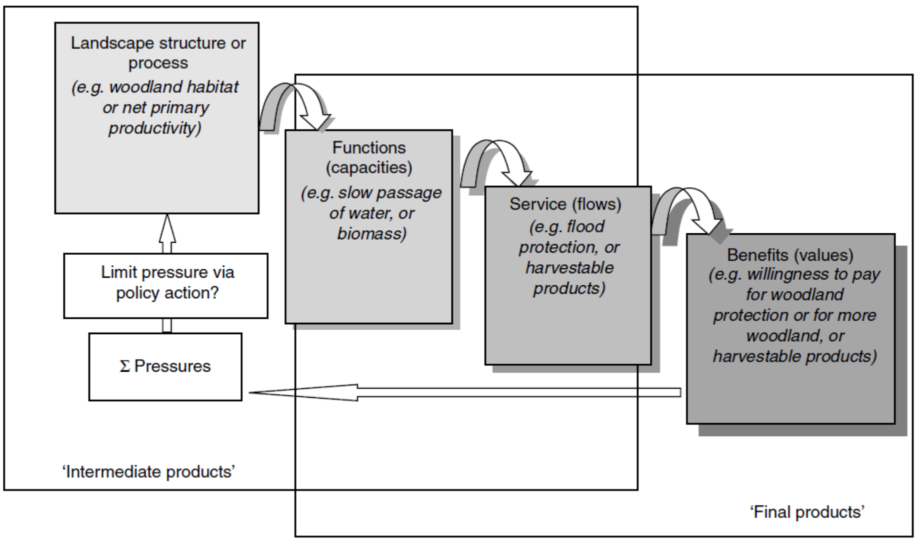


Figure 6: Ecosystem cascade model linking ecosystems to well-being.
Sources: Haines-Young & Potschin-Young, 2010

It is essential to understand that the significant advantages of GI come from the tying the binds of individual green space (GS) elements and their synergies rather than from each (individual) GS element alone. The cumulative effect of interconnected GSs elements within the GI system can enhance the capacity of ESs to deliver services and functions across different landscape scales effectively. This, in turn, leads to a sustainable and resilient urban environment that benefits (both) the ecology (Foster et al., 2011) and the local community's well-being (Lafortezza et al., 2013, 2017; Tzoulas et al., 2007). The EU Commission (2013) tends to stress (within the policy) the value of utilising natural and semi-natural GI as a multi-scalar (climate change) adaptation and mitigation strategy in urban regions, especially in environmentally challenged areas. Also, (GI) is garnering attention in research communities as a cost-effective and nature-based solution (as compared to traditional infrastructure that enables cities to re-nature and become more sustainable and resilient in the face of climate uncertainties such as storms, droughts, heavy precipitation, flooding, and urban heat island (UHI) effects (Demuzere et al., 2014; Foster et al., 2011; Gill et al., 2007; Rayan et al., 2022b; Sturiale & Scuderi, 2019).

Green space infrastructure (GSI) helps connect urban and rural areas and creates (appealing) environments for (both) living and working. Global studies affirm that GSI benefits such as air and water quality (Nowak et al., 2006; Pauleit et al., 2019; Yang et al., 2008), mental, and physical wellness (Bratman et al., 2015; Kardan et al., 2015; Pretty et al., 2005), social inclusion and community awareness and provides opportunities for a range of recreational and social activities (Giles-Corti et al., 2005; McDonnell et al., 2007; Weldon et al., 2007). Furthermore, GSI has great potential and plays a key function in the revitalisation process of urban regions, delivering a variety of social and ecological functions and benefits while reducing (environmental) conflicts (James et al., 2009; Mell, 2015; Rayan et al., 2021b; Wright, 2011). Also, it is widely acknowledged as an effective (planning) strategy that reconnects and strengthens the relationship between humans and nature (Rayan et al., 2021a), which has been affected due to (un-balanced) anthropogenic activities (Desa, 2014, 2019; European Commission, 2013). The relationship between humans and nature emphasises the importance of implementing ("nature-based") green initiatives to strengthen the resilience of the "urban environment" to withstand and adapt to both present and forthcoming challenges posed by climate change (Foster et al., 2011; Rayan et al., 2021a; Rayan et al., 2022; Roe & Mell, 2013). Furthermore, by creating synergies between humans and nature, raise awareness among local inhabitants about the importance and necessity of GIs initiatives.

Global studies endorse that green spaces have more efficient infiltration, storage, and adaptative capacity (15%-64%) than mono-functional 'grey' infrastructure (EEA, 2011; Hansen et al., 2017; Rayan et al., 2021b). Therefore, it is not naive to say that the need for time is to synthesise green (soft) and grey (hard) infrastructure in a way that should complement each other and lead to supporting both environmental and non-environmental policy while enhancing urban resilience and sustainability (Mell 2010b; Rayan et al., 2022a). GI, therefore, is in an almost unique position. Its importance in adapting landscapes to counterbalance CC impact is of utmost significance. It also has the potential to create spaces that promote social inclusion, better public health and conserve the cultural heritage of a region (Ahern, 2007; Benedict & McMahon, 2012; EEA, 2011; EC, 2013; Olafsson & Pauleit, 2018). Moreover, these (nature-based) green strategies make an imperative contribution to the economy, attracting tourists and positively influencing real estate values (Gruehn, 2006; Gruehn et al., 2006; Hoffmann

& Gruehn, 2010). It is evident that GI serves (all dimensions) of ”triple-bottom-line” (TBL) sustainability and, along with that, connects to other important topics such as participation and resilience (see table 3 above) (Kambites & Owen, 2006; Lafortezza et al., 2013; Llausàs & Roe, 2012; Rayan et al., 2022b).

The upsurge in urbanisation and the impact of anthropogenic activities has embedded unprecedented pressure on green spaces, resulting in ecological imbalances, disruptions to ecosystem health, loss of biodiversity, and adverse effects on human well-being. To address these challenges, planners, policymakers, and academics focus more on GI planning strategies and programs at all spatial levels to ameliorate the disturbed socio-ecological well-being of any region (Lafortezza et al., 2013; Mell et al., 2017; Monteiro & Ferreira, 2020; Rayan et al., 2022; Williamson, 2003). The use of NBS has proven to be an essential element in resilient land-use planning (Rayan et al., 2022a; Rouse & Bunster-Ossa, 2013) when (effectively) tackling socio-environmental issues (Baycan-Levent et al., 2002; CABE, 2010; Enger, 2005; Harnik, 2006; Kim, 2010). It offers several co-benefits, such as regulating micro-climates, lowering the carbon footprint, managing stormwater, promoting biodiversity, and enhancing human well-being (EC, 2013; Mell, 2013; Pauleit et al., 2019; UN-SDG, 2019).

Even though nature-based green infrastructure (NBGI) has numerous advantages and is valuable, despite many city planners and politicians tend to undervalue it. This is mainly because, it does not generate immediate financial revenue (like, taxes), unlike grey infrastructure (Faehnle et al., 2014; Mackrodt & Helbrecht, 2013). Unfortunately, this often leads to budget cuts for planning and managing GI, as the benefits NBGI are not always tangible, easily measured or transferable (Hanley et al., 2009; Mazza, Bennett, Nocker, et al., 2011), making it challenging to justify their expenses. However, it is essential to note that the benefits of GI are often in the form of external effects (EC, 2013; EEA, 2011). This means that those who pay for its provision may not be the ones who benefit most, especially in terms of regulating services such as sustainable climate-risk management (SCRM) and health and wellness benefits (Mazza et al., 2011; Rayan et al., 2022b; Tzoulas et al., 2007).

Moreover, global research studies underpin that the cost-benefit ratios (CBRs) of (multiple) GI elements (in urban areas) for fostering urban resilience and addressing climate uncertainties are under-researched. This is because, the (cost-effectiveness) of GS elements involves extensive examination (through CBRs models) and comparison with other potential (green or soft) possibilities to evaluate their effectiveness for specific services (Mazza et al., 2011) in a particular native spatial environment (Rayan et al., 2021a). The positive CBRs of GI elements can be acknowledged through integrated and multifaceted planning, connecting a large-scale network of (“natural and semi-natural”) green spaces and communities (e.g., EU-wide Natura 2000) to provide a broad range of social and ecological benefits (EC, 2013). Achieving such (human–nature) integration requires raising awareness among various multi-stakeholders regarding the significance of green (nature-based) infrastructure (Matthews et al., 2015; Mell et al., 2017; Monteiro & Ferreira, 2020; Rayan et al., 2022); as an indispensable urban amenity that enhances the ecological resilience of cities.

2.2. Green Infrastructure and Multi-Stakeholder Participation

Nature-based (green) infrastructure planning has significant benefits for the environment, socio-culture, and economy (Davies et al., 2006; Demuzere et al., 2014; Lafortezza et al., 2013). These benefits improve the quality of life (QoL) in urban neighbourhood's (Benedict & McMahon, 2002; Eckstein et al., 2018; Mell, 2010, 2013). Therefore, it is essential to foster community cohesion (involve all members of society) in the planning and implementation process of green growth development to ensure that it satisfies their essentials. This emphasises the importance of multi-stakeholders' participation in decision-making tailored to the specific situation, focusing on effectiveness and integration (Rayan et al., 2021a; Scott, 2011). Nevertheless, determining the best approach for participation remains challenging, and the question remains as to what constitutes the ideal participation process. To address this Luyet et al., (2012) identified "who, when, and how?" as the key considerations in the multi-stakeholder participatory planning (MSPP) process, thus providing a list of factors to consider.

It is important to understand that there isn't a universal ("one-size-fits-all") solution that helps select suitable participation techniques or tools. Nevertheless, Luyet et al. (2012) offer valuable insights to guide the decision-making process, as illustrated in Table 6. The framework evolved by Luyet et al. set out the five-step ladder[4] of involvement, also known as the "degree of involvement", for multistakeholder participation. These levels include "information, consultation, collaboration, co-decision, and empowerment". It is crucial to determine the appropriate level of involvement as it impacts the entire process, including the (selection) of the appropriate participatory technique (Maier et al., 2014). Assigning an inappropriate level of participation to a multi-stakeholder can result in conferring (too-much or not-enough) authority to a stakeholder or using an inadequate participation technique, which can lead to an unsuccessful participation process.

The concept of "participation" has been interpreted differently across the scientific community (Luyet et al., 2012; Maier et al., 2014). According to the World Bank (WB), it is define as "a process through which stakeholders influence and share control over development initiatives and the decision and resources which affect them"(WB, 1996). The participatory planning (PP) approach is a constantly evolving process (both;

---

[4] "The metaphor of a ladder was employed by Arnstein in 1969 for citizen participation. He was the first main contributor to this topic, and he structured the degree of participation into three main classifications (e.g., Nonparticipation, Tokenism and Citizen Power) with eight sub-stepping" (Arnstein, 1969; Wilker et al., 2016).

theoretically and practically), resulting into new aspects and methods emerging over time, making it a highly intricate subject. For efficient implementation, it is imperative that the PP process need to be bespoke to fit the specific (project) built-in context (Luyet et al., 2012). The MSPP approach is acknowledged as an effective tool for promoting and strengthening community ownership in the planning, management, and decision-making process for nature-based green infrastructure (GI). This approach is vital for building an environmentally friendly and climate-resilient urban environments in climatically challenging urban interfaces (Baycan-Levent et al., 2002; CABE, 2010; Davidson, 1998; Harnik, 2006; Rayan et al., 2022).

Table 6: Participatory planning (PP) techniques and their potential involvement levels.

Participation technique	**Information**	**Consultation**	**Collaboration**	**Co-decision**	**Empowerment**
Newsletter	■				
Reports	■				
Internet webpage	■	■			
Cognitive map	■	■	■		
Presentations, public hearings	■	■	■		
Interviews, questionnaires & surveys	■	■	■		
Field visit & interactions	■	■	■		
Geospatial/decision support system	■	■	■	■	
Scenario analysis		■	■	■	■
Consensus conference		■	■	■	■
Workshop		■	■	■	■
Citizen jury		■	■	■	■
Participatory mapping			■	■	■
Focus group			■	■	■
Role playing			■	■	■

Sources: Adapted from Luyet et al., 2012.

The global studies endorse that green infrastructure (GI) facilitates inter- and trans-disciplinary planning that integrates the knowledge and participation of multi-stakeholder (experts and community) to address the needs of (diverse) social groups (Landscape Institute, 2009; Olafsson & Pauleit, 2018). Involving the native inhabitants and ensuring their satisfaction is essential for successful GI planning. However, there is a need to probe more innovative participatory techniques (Faehnle et al., 2014; Rayan et al., 2022a) to enhance the socio-ecological wellness of urban and rural regions (Hansen & Pauleit, 2014; Lafortezza & Sanesi, 2019; Rolf, 2020; Westphal, 2003). Moreover, Benedict & McMahon (2002, 2006) further emphasise the significance of engaging multi-stakeholders, such as “communities, private landowners, public agencies, and conservation institutions”, in the planning of nature-based GI. However, it is unfortunate that not all countries (in the world) prioritise involving multiple stakeholders in decision-making processes. In some cases, public authorities propose a minimal participation approach, ignoring the outcomes when devising policies and strategies for urban landscape and greening infrastructure (ULGI) (Fors et al., 2015;

Mazza et al., 2011; Nizamani & Shah, 2004; Rayan et al., 2022a; Wilker et al., 2016). This is disconcerting because planners and decision-makers often overlook the importance of incorporating “local knowledge, beliefs, attitudes, and preferences” (Rayan et al., 2022b) of stakeholders. Indigenous/local knowledge is an invaluable resource in a holistic, participatory process, particularly when designing innovative, natural, green landscape-based strategies for adapting to and mitigating the effects of climate change (Demuzere et al., 2014; Rayan et al., 2022a; Shoup & Ewing, 2010). The effectiveness of the MSPP approach hinges on how planners and decision-makers implement it and their willingness to involve multiple stakeholders (Faehnle et al., 2014; Mackrodt & Helbrecht, 2013).

The importance of GI, PP and urban (climate) resilience in Europe is increasingly recognised, as highlighted in the European Union's GI Strategy, thus strengthening “Europe's natural capital” (EC, 2013). GI principles (alongside the PP approach) have already been incorporated into the landscape planning policies in Germany, the UK, and the Netherlands, with wide implementation at the municipal level as (nature-based) green strategies for sustainable climate-risk management (SCRM). It is to develop (climate) resilient urban regions (BfN, 2017; BMUB, 2015; Gruehn, 2006; Lafortezza et al., 2013; Mell, 2017; Monteiro & Ferreira, 2020; Rayan et al., 2022a). Cities like, Amersfoort in the Netherlands and Stuttgart in Germany have demonstrated how various natures of local engagement[5] in GI planning projects enhance social inclusion and planning efficiency. For instance, in Amersfoort, the local government and the community worked together in a collaborative effort to transform the “Elisabeth site,” an old hospital, into a vibrant urban park. They also expanded a nearby park, further enhancing the city's green space. To ensure that all stakeholders had an equal voice in the project, a “core group” was established. This inclusive approach encouraged all participants to work creatively and generate ideas for the joint redevelopment and management of the plan. To facilitate productive discussions, the open space method and world café methodology were employed during meetings, allowing participants to share insights on sub-themes in small groups (Aalbers & Sehested, 2018; De Wilde et al., 2014; Mattijssen et al., 2019; Wilker et al., 2016). Another successful example of a participatory approach is the “Industrial Heritage Route” project in (the Stuttgart region, Germany). The project is one of a series of master plans designed to create a route that connects significant “industrial heritage sites and specially designed open spaces”. The aim is to engage the local public, including historians, experts, and community members, in a bottom-up participatory process that gathers their perspectives and knowledge. By doing so, the project aims to generate public acceptance for the route.

[5] The nature of public engagement in local planning processes is subject to various factors that differ from country to country, including historical, cultural, and governance aspects. Nevertheless, it is crucial to acknowledge that legal and regulatory frameworks also (perform) a significant role in shaping participatory processes (Rymsa-Fitschen et al., 2014).

Methodologies (including workshops, site visits, local meetings, informal regular round tables and weblogs) were employed to ensure success (Cilliers, 2016; Wilker et al., 2016).

However, in many developing countries, specifically Pakistan, there is a lack of research and development aimed at achieving a successful transition to green-growth urban development using a PP approach. This is attributed to ineffective legislation and enforcement by planning authorities in the region. Furthermore, the institutionalisation of pragmatic, proactive UL-UG policies and a legal framework for resilient land-use planning remains absent (Ahsan, 2018; Khayyam & Waseem, 2021; Rayan et al., 2021a, 2021b; Shahid et al., 2018). These issues are connected to a non-collaborative and unilateral environment with undue influence that is prevalent in the country (Ahmad & Anjum, 2012; Ashfaque & Awan, 2015; Nizamani & Shah, 2004; Rayan et al., 2022). Currently, no sustainable initiatives are being undertaken in Pakistan, particularly in the KP province, to promote climate-resilient cities through nature-based green-growth development under the PP approach. As such, it is essential to raise awareness and knowledge among all stakeholders, including decision-makers, experts, and the local community, to better understand the correlation between GI, PP, and climate resilience concepts in the landscape planning process. This will enable the remodelling and restructuring of resilient land-use planning in accordance with the native built-in environment, resulting in the creation of sustainable human settlements.

To achieve this, the (study) suggests a highly interactive and holistic MSPP approach (at the early stages of the planning process) that integrates a bidirectional sustainable development pathway involving both top-down planning experts and bottom-up community input. Through this approach, we can gain a better understanding of the potential role of NBGI in creating climate-resilient cities. Promoting community involvement in the planning process, the management of UGS can be improved, leading to greater community ownership and acceptance of green action projects (GAPs) in the local neighbourhood. To further add, this holistic MSPP approach helps to determine, validate, and implement (nature-based) green adaptation strategies as per the local built environment. These strategies aim to enhance the quality, standard, and health of the ecosystem and its inhabitants (Rayan et al., 2021a, 2021b, 2022a, 2022b, 2022c). Ultimately, this led to achieving a proactive and long-term strategy for SCRM in an environmentally challenged urban interface.

2.3. Green Infrastructure and urban climate resilience:

This study discusses that resilience is interpreted as the foremost goal of the GI planning approach (see above Table 3) and adopting well-functioning ecosystem-based strategies can effectively support and strengthen urban climate resilience at multiple spatial levels. The idea of resilience is multifaceted and can have different meanings depending on the context, with various definitions and interpretations in (both) academic and policy (Jordan, 2009; Manyena, 2006; Meerow et al., 2016). The notion of “resilience” originates from the study of ecological systems in the 1970s (Holling, 1973) and comes from the Latin word “resilier”, meaning “to bounce back” (Klein et al., 2003). According to Holling, the concept of “ecological resilience (R_{ecol}) determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters”—all still persistent and valid. In this framework, resilience is portrayed as the system's characteristics and persistence or the probability of extinction is the outcome (Holling, 1973).

To better comprehend the notion of “resilience” and its various applications, particularly in the realm of urban research and policy contexts, it's worthwhile to refer to the definitions provided by the “United Nations Office for Disaster Risk Reduction (UNISDR) “and the “Intergovernmental Panel on Climate Change (IPCC)” and “European Union (EU)”. The UNISDR describes “resilience” as “The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to- and recover from the effects of a hazard in a timely and efficient manner. IT is possible by including through the preservation and restoration of its essential basic structures and functions” (UNISDR, 2012). Alternatively, the IPCC characterises “resilience” as “the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change” (IPCC, 2014; Pörtner et al., 2022). Additionally, the EU 2020 Biodiversity Strategy's Impact Assessment highlights that resilience means “the ability of an ecosystem to buffer and adapt to changes as well as recover after being disturbed”(European Commission, 2011; Mazza et al., 2011).

Over the past few decades, various fields of study (particularly those focused on urban areas) have established unique interpretations of “resilience theory” in the face of constantly rising climate challenges. These fields entail a range of disciplines, including “engineering, social sciences, and environmental sciences”. In engineering, resilience is often evaluated based on a system's capacity to return to a stable state following a disruption or as the inverse of the recovery time, as explained by Holling (1986,1996). In the social sciences, it pertains to a community's ability to manage external disturbances resulting from political, social, and environmental changes. In environmental science, it is defined as the speed at which a system can recover its structure and function after experiencing stress or disruption (Adger, 2000).

The proliferation of the theory of resilience (especially in the field of management of hazards and urban planning and policy circles) has gained significant attention, thus resulting into multiple connotations. However, preponderantly, “resilience” stands for a system's ability to withstand pressures and disturbances, while (still) maintaining its structure and functioning efficiently. It encompasses self-organisation, learning, and adaptation to change, all (of which are) essential for an urban system to remain robust and productive. The management of changes and adaptation to current and future climate risks are also (key) aspects of resilience (Ifejika Speranza, 2010). Moreover, according to the Resilience Alliance (2007), there are three key characteristics of resilience:

- A system's capacity to maintain itself under varying conditions.
- The capability of self-organisation.
- The capacity for development and improvement of learning and adaptive capacity.

Additionally, “resilience” is viewed as a multi-layered concept, extending from the individual level to the global level (Alliance, 2007; Jordan, 2009).

In recent years, operationalising resilience concept to plan and prepare for an uncertain future under the impacts of CC in urban regions has gained significant attention. It is because, cities are central to climatic challenges and often particularly vulnerable to catastrophes of various scales and impacts (Adger, 2000; Godschalk, 2003; Wilkinson, 2012). It is noteworthy and evident that certain countries and cities, particularly those in developing (low and middle-income) nations, are more susceptible to the (impact) of extreme climatic uncertainties and natural cataclysms. This is primarily due to outdated planning policies, insufficient resources, and undue influence, leading to significant economic and human losses. It is crucial to acknowledge that these climate change challenges are not uniformly dispersed across the globe, even within the same country (IPCC, 2014; Pörtner et al., 2022; Rayan et al., 2021b, 2021a). Unprecedented urbanisation has led to transformations in land cover and natural landscape greying. These detrimental effects of unbalanced anthropogenic activities and the resulting strain on the natural environment due to CC have had a severe impact on the socio-environmental systems of urban regions. This underlines the need for NBGI planning, and the concept of resilience is interpreted as the foremost goal of NBGI planning.

Research suggests that urban green infrastructure (UGI) initiatives have become an increasingly favoured concept for strengthening urban resilience (UR) to CC in vulnerable urban environments (Davies et al., 2006; Rayan et al., 2022; Tzoulas et al., 2007). UGI (stands) as a vital and applicable planning instrument in addressing sustainable climate risk management (SCRM) at multiple spatial levels in the region (Rayan et al., 2022b; 2022). The global study has explored that the well-thought-out (urban) green spaces (UGS) infrastructure strongly influences and strengthens UR and provides multiple benefits to communities. These benefits include but are not limited to the mitigation of flood risk, optimisation of stormwater management, enhancement of air quality, reduction of UHI effects, and improvement of the health and wellbeing of inhabitants by re-connecting the community with multifunctional UGS (Tzoulas et al., 2007; rayan 2021; Benedict & McMahon, 2002). This social-ecological relationship between humans and nature helps to raise awareness and educate native residents about the importance of innovative NBGI initiatives, such as wetlands, water-absorbent forest landscapes, parks, and green roofs/walls, which strengthen the adaptive capacity of urban systems, thereby alleviating the high risk of anticipated climate threats of (unbalanced) anthropogenic changes. Ultimately, this leads to a green and resilient environment at both the city and national levels. These green practices provide benefits, often grouped into "provisioning", "regulating", "supporting", and "cultural services", employing the well-known "ecosystem services" framework (Ahern, 2007; Hansen & Pauleit, 2014; Pauleit et al., 2017, 2019).

When considering NBGI as an adaptation and mitigation tool for climate change, every potential typology of UGS should qualifies according to the native-built socio-cultural and ecological environment for planning safer, healthier, and climate-resilient urban regions. By implementing innovative green nature-based planning strategies (under SCRM), a comprehensive multi-functional green space network can be established at various temporal and spatial scales. These (green) networks (serve) significantly bolster the resilience of urban systems and (as a result) minimise their vulnerability to climate stressors (Mell, 2010, 2015; Rayan et al., 2022a; Wilker et al., 2015). Urban systems are composed of four interdependent components, namely: (a) "governance networks"; (b) "networked material and energy flows also referred to as urban metabolism" (c) "urban infrastructure and form", and (d) "socio-economic dynamics" (Kennedy et al., 2007). These (four) components interact seamlessly across different spatial and temporal scales (as illustrated in Figure 7) of the conceptual model developed by Meerow et al., (2016). This schematic model offers a valuable framework for structuring discussions about (the) intricate and multi-scalar aspects (i.e., socio-ecological, and socio-technical) of cities. In a nutshell, this inclusiveness and linking of different urban system institutions and levels (vertically and horizontally); brings adaptive thinking (among the inhabitants) for resilience enhancement and justice in climate adaptation, which leads to a greater understanding of global sustainability.

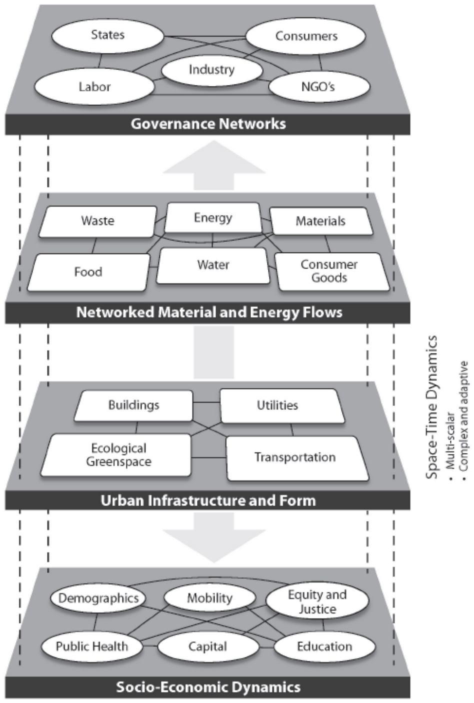


Figure 7: Conceptual diagram of the urban system. Based on Dicken (2011), proposed by Meerow et al. (2016).

Green infrastructure planning is (mainly) attractive to policy/ decision makers—as an essential urban amenity. It provides concrete (nature-based) strategies for the improvement of (various) aspects of the resilience of cities (Benedict & McMahon, 2002, 2006; Cutter et al., 2008; Kearns et al., 2014). Similarly, on a broader scale, it is acknowledged that UGI could be instrumental in fragmenting the political landscape boundaries (Davies et al., 2006; Davies & Lafortezza, 2017), and also it could be placed at the centre of SCRM to counter (constantly rising) climate threats (Rayan et al., 2022b), which in turn, lead to enhancing the health of the urban ESF and ESS to promote sustainable human settlements (Lafortezza et al., 2013; Mell, 2015, 2022; Walker & Salt, 2012; Weber & Allen, 2010). These innovative green strategies can pave the way for balancing anthropocentric and ecocentric activities, not only in a region's vulnerable urban interface, but also beyond (Demuzere et al., 2014; Matthews et al., 2015; Monteiro & Ferreira, 2020; Rayan et al., 2022a).

Resources for green (nature-based) infrastructure and resilience building [under the multi-stakeholder engagement process (MSEP)] This leads to challenging decision-making on the potential taxonomies of vital UGS, which fits best in the native built-in (socio-ecological and economic) environment and contributes an essential value to the long-term socio-ecological resilience of cities. For example, if optimising stormwater management is a primary determinant of a region, we need to identify an urban green space (UGS) element (based on the spatial context) that has an excellent functional linkage to this respective variable. This lead to intricacies in highlighting the potential trade-off between the social-ecological goals of various urban green space (UGS) infrastructures. This is because each (individual) UGS element has a distinct characteristic and does not meaningfully enhance and strengthen the resilience (health) of any green growth planning indicator against the potential climactic challenges in the natively built-up environment (Rayan et al., 2021a; Rayan et al., 2022; USEPA, 2010). Likewise, studies also confirm that the efficacy of the UGS element (usually) depends on two main factors (e.g. specific configuration and spatial context) of each region (Ahern, 2007b; EC-European Commission, 2015; Gill et al., 2007; Hansen et al., 2019; Pauleit et al., 2017) in which they are examined.

Consequently, this research study considers the need to synthesise GI, climate resilience, and MSPP concepts (holistically) in the planning process to "develop a rich body of multi-functional/inclusive UGI indicator-based framework model". Such a model should be grounded on "triple bottom line (TBL)" sustainability and encompass "sustainable UGI indicators" and their linkage to the key taxonomy of UGS, adapted to the native built-in (spatial) environment. To achieve this, this research has developed a scientific framework (based on the due inclusion of the bidirectional sustainable development pathway) that identifies potential "sustainable (primary and secondary) UGI indicators and UGS elements" by blending two conceptual frameworks (DPSIR and GI) as proposed in earlier published study (see Rayan et al., 2021b). Further, this framework is based on nine cross-cutting themes (presented in Table 9) that evolved from semi-structured meetings conducted in Pakistan with native multi-stakeholders (Rayan et al., 2021a). Both (DPSIR and GI conceptual) frameworks (Fig 10 and Fig 11) are developed by scrutinising the conceptual models of urban sustainability and green infrastructure, through a criterion (recommended by the author) grounded on multidisciplinary theoretical study and discussion with local multi-actors (experts and communities) on the potential scope of NBGI development as a component of an eco-friendly and climate-resilient environment.

Moreover, and to add further, this model will help to determine the vital taxonomies of UGS for each sustainable UGI infrastructure (in accordance with the indigenous built-in environment) in terms of their applicability and scale in tackling SCRM. Additionally, the model offers evidence and validation of the variety of UGI indicators and GS that are essential and non-essential (in native urban environments) to mitigate climate change challenges in urban areas. Ultimately, this fosters a balanced and harmonious relationship between climate change, urban green spaces, eco-system functions and health and well-being of human at macro, micro and meso levels, resulting in a safer, greener and more resilient urban environment.

2.4. Conceptual Frameworks

A conceptual framework, in research, is an effective and analytical tool for tackling real state-of-the-art problems. It offers a comprehensive approach for analysing and addressing identified issues through logical deduction. This synthesis of interconnected components and variables provides a powerful lens for confidently viewing and resolving challenges. Using a conceptual framework based on causality has important benefits in research projects and (adds) support to the decision-making process.

This section of the dissertation, study the causal chain (CN) frameworks for Urban sustainability (US) – a means of structuring and organising indicators in a (way) that is meaningful to policy-makers and the native community. Furthermore, are examined in relation to climate change, urban ecosystems and human health and well-being and provide a framework for developing an interdisciplinary research agenda. The objective of this empirical examination is to formulate a conceptual framework that is proved to support and strengthen the complex interdependence among "CC, UGS, ESFs and human health/well-being" (Rayan et al., 2021b).

2.4.1. Frameworks for Urban Sustainability (UG)

Efforts towards sustainable development (SD) are ongoing since decades, focusing on creating effective methods for implementing concepts like (GI, urban resilience, participatory planning, CC mitigation and adaptation, social cohesion, and green economy, etc). The result establishes theoretical models and tools to support cities in becoming more resilient against climate change. Experts in this (scientific) field employ indicator-based assessment methods to evaluate and enhance urban sustainability across all spatial levels. Indicators are a simple, measurable tool that can help create sustainable cities that are both eco-friendly and provide support for long-term human health, wellness, and "quality of life" (QoL) in both urban and rural areas (DG-ENVI, 2012; EEA, 2011a; Rayan et al., 2021a; Tzoulas et al., 2007). The selection of appropriate indicators, however, is an intricate process as they play a vital role in achieving urban sustainability goals. According to (Zhang et al., 2003), fundamentally, (urban sustainability) indicators should include three key assessment tools: a pilot tool; a performance tool; and an explanatory tool[6] (Shen et al., 2011). Furthermore, several international organisations, including the UN (2004), WB (2008), and the EU Strategy for Sustainable Development (2002), have also endeavoured to define these urban sustainability indicators (EU SDS, 2002; SEDAC, 2007; UN Habitat., 2004; WB, 2008). Whilst there are many different frameworks for measuring urban sustainability. However, no individual set of indicators can be applied uniformly to all cities and towns. (OECD, 1991). This is because, each city differs significantly in terms of its spatial, contextual, socio-demographic, and ecological characteristics (Ahern, 2007; Ahvenniemi et al., 2017; EC, 2015; Shen et al., 2011).

[6] "Explanatory tools translate the principal concepts of sustainable development into practical (real-world) applications; Pilot tools, on the other hand, help in creating the policies that encourage sustainable development. Finally, Performance assessment tools, on the other hand, can help assess the effectiveness of these efforts" (Shen et al., 2011).

Urban sustainability indicator frameworks (USIFs) are often multidimensional, synergising the socio-ecological and economic aspects, enabling a holistic development process. In determining Urban sustainability frameworks, various organisations, such as the OECD and the EEA, employ the causal networks (CN) approach “[e.g., Pressure–State–Response (PSR) and Driving force–Pressure–State–Impact–Response (DPSIR)]”. PSR is considered the first framework proposed by OECD (1993), and in 1999 EEA transformed PSR into DPSIR. The reason is that PSR model struggles to explain some of the complex relationships in (the field) of social studies (Jago-on et al., 2009). These CNs functions as a universal frame of reference; and involve a series of feedback and causal loops to acquire optimal information for a better decision (EEA, 1999; Niemeijer & de Groot, 2008; OECD, 1993, 2001). The ultimate (goal) of these conceptual frameworks is to establish a balanced equilibrium between human-centred and eco-centred activities, promoting sustainability.

In the PSR framework, the pressure indicator act as a basis that elucidates the problems resulting from anthropogenic activities, state indicators observe the environment quality, and response indicators represent how people react to these environmental changes. Notably, this framework continues to be widely used by the “OECD for its core set of environmental indicators” (Jago-on et al., 2009; OECD, 1993; Rayan et al., 2021b; Segnestam et al., 2003).

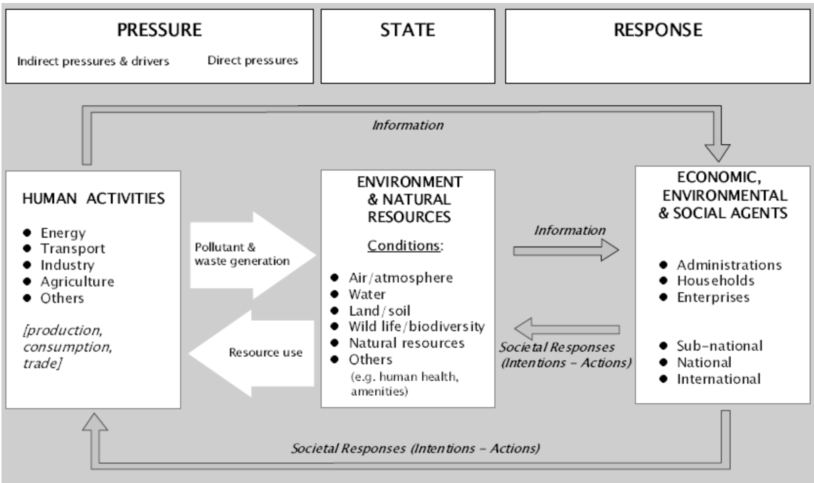


Figure 8: The PSR Framework
Source: OECD, 1993

The most well-known and globally recognised causal networks (CN) framework is the DPSIR framework. It is used as a source to address specific environmental issues and to identify an appropriate response. The “driving force” indicators lead to economic and human activities that exert environmental pressure, thereby affecting various natural systems, i.e. (air, water, soil, etc.) and their natural and biochemical conditions. Concerning the impact indicators, illustrate the degree of environmental damage to the ecosystem, health and wellbeing of mankind, and socio-economic performance of society. Finally, the formulation of indicators, goals, and priors are administrative or social 'responses' to these environmental concerns.

In the (realm) of urban sustainability, the DPSIR model proves highly effective. This model takes into (account) multiple factors across different dimensions to address intricate issues related to (both) human and ecosystem health. This model enables us to better comprehend and visualise the inter-relationships between different indicators (Niemeijer & de Groot, 2008), allowing us to manage the intricacies of real-world interactions quite effectively (EEA, 1999; Fry, 2003; Liu et al., 2018; Rayan et al., 2021b; Sekovski et al., 2012). Not only does the DPSIR model integrate indicators, but it also provides a comprehensive explanation of how urban sustainability operates from multiple perspectives. Policy and decision-makers can benefit greatly from this resource when seeking to regulate urban cities sustainably.

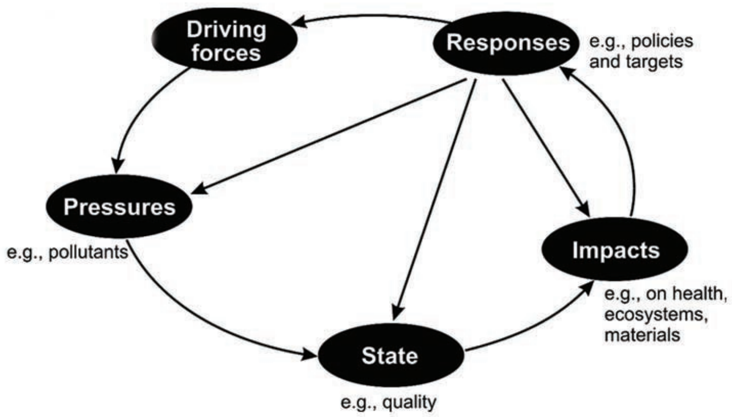


Figure 9: The DPSIR Framework
Source: EEA, 1999

To conclude, it is widely agreed that the CN framework is an essential (tool) for comprehending the intricate relationship between human activities, natural resources, and ecosystems in urban environments. It is widely acknowledged as a means of evaluating the sustainability of urban development.

2.4.2. Models for Green Infrastructure (GI)

Green infrastructure (GI) planning has (great) potential and performs a pivotal role in enhancing the ecosystem, preserving biodiversity and improving the inhabitants mental and physical health (Beatley, 2000; Bratman et al., 2015; Leichenko, 2011; Tzoulas et al., 2007). Besides, it (has) a significant effect on the planning process, bolstering the resilience of urban systems against the constantly rising (anticipated) environmental challenges (such as storms, droughts, heavy precipitation, flooding, urban heat island (UHI) effects etc.) resulting from (un-balanced) anthropogenic activities (Demuzere et al., 2014; Gill et al., 2007; Rayan et al., 2022; Sturiale & Scuderi, 2019). Green infrastructure undoubtedly contributes an (essential) role in promoting a healthy ecosystem in urban areas. This, in turn, leads to a healthier environment, providing "physical, psychological, social and community health" benefits to the inhabitants residing within them (Lafortezza et al., 2013; Meerow et al., 2016; Naumann, Anzaldua et al., 2011; Rayan et al., 2021b; Williamson, 2003). Along with that, GI contributes to enhanced socio-economic benefits for the (native) livelihoods. Furthermore, the (nature-based) GI planning proves to be a vital element, linking (both) imperative ecosystem and human wellness (concepts) holistically (Lafortezza et al., 2013; Mell, 2017; Monteiro & Ferreira, 2020), in a way that helps to provide an in-depth insight into the intricate correlation and dynamics of "Socio-Ecological Systems (SES)". Multiple integrative conceptual models have been developed to establish a nexus between GI, ecosystem, and human health and well-being (as seen in Table 7).

Table 7: Conceptual Frameworks (interlinking GI, Ecosystem, and health/well-being of the Inhabitants).

Authors	Framework	Green Infrastructure (GI)	Inhabitant healthcare
Pickett et al., (1997) and Grimm et al., (2000)	Co-relationship among human and eco-system.	Structure & process of an ecosystem and sociocultural and economic resource	Socio-ecosystem
Millennium Ecosystem Assessment (2003)	Links among Eco-System Services (ESS) and human wellbeing.	Provisioning, eco-system (functions and services), regulating social and cultural services.	Security, access to basic resources, health, good social connection, and liberty to choose.
Tzoulas et al., (2007)	Integrating Urban Green Infrastructure (UGI), eco-system, and human well-being.	Eco-system function and health (water, soil, and air cleansing/ decontamination).	Social, economic, emotional, psychological, and physical well-being.

Source: Authors' adaptation from Tzoulas et al., (2007)

In 1997, a cohesive human ecosystem framework was suggested for examining the urban SES. This framework provides a comprehensive analysis of urban systems, viewing them as intricate networks that comprise social, biological, and physical components (Pickett et al., 1997). It is fragmented into two parts; the first one enlightens social structure, which encompasses social cycles and institutions; the second one clarifies resource system, which comprises the structure and process of an ecosystem, along with sociocultural and economic resources. The model was updated by (Grimm et al., 2000) based on land-use changes that occurred due to the interrelationship among both systems (socio-ecological). Although this model was developed from socio-ecological considerations and elucidated the UGI concept in broader ways, the co-relationship between humans and ecosystem health is not adequately addressed (Rayan et al., 2021b; Tzoulas et al., 2007).

In 2003, an alternative integrated framework was established by the Millennium Ecosystem Assessment (MEA), which attempts to interlink humans and ecosystems (health/well-being) using economic and social drivers to examine their impacts on them (Millennium Ecosystem Assessment, 2003). The MEA further categorises ecosystems and humans (health/well-being) into multiple classes, broadening the framework's scale. However, differentiating the various health aspects within this framework, such as biological, psychological, and epidemiological, proves challenging. Fortunately, in 2007, Tzoulas et al. created an inclusive and composite framework (of QoL) that integrates UGI, "ecosystem, and human well-being" (individual or communal). The framework establishes the positive (environmental, social, and economic) benefits by integrating UGI with the ecosystem and inhabitants' health (Tzoulas et al., 2007). By doing so, this approach offers an opportunity to improve the external environment in urban and peri-urban areas, benefiting the people's physical, psychological, and emotional health.

Several studies have consistently demonstrated that innovative (natural-based) solutions, like GS, can perform a pivotal function in enhancing public health and strengthening the resilience of urban socio-ecological systems (Lafortezza et al., 2013; Meerow et al., 2016; Pakzad et al., 2017; Rayan et al., 2021a, 2021b). This, in turn, can effectively alleviate the negative impact of environmental challenges and their impacts on human health and wellbeing.

2.5. Development of Conceptual Base Frameworks/Models

To recapitulate the core outcomes from the above (multidisciplinary) theoretical literature review to promote further empirical research in "developing a sustainable UGI indicator-based framework", as well as ensuring the inclusion of native multi-stakeholder participation (MSPP), "each adapted to the local context to build a green climate-resilient city-state", this research has developed two conceptual frameworks. These conceptual frameworks are grounded on linking GI, resilience, ESFs, and people wellness (Rayan et al., 2021b). Along with this, eleven cross-cutting concepts evolved from semi-structured meetings with native planning experts and community members in Pakistan. These concepts include "green space networks, energy management, water management, the green economy, wildlife and biodiversity, organic food, mitigation and adaptation, ecosystems, social cohesion, and resilience" (see Table 9). Policymakers, practitioners, academicians, and community members all participated in the Participatory Planning (PP) process, intending to explore the potential of natural and biologically-based GI strategies to foster a long-term eco-friendly and resilient environment in the urban interface of the Khyber-Pakhtunkhwa province and *beyond* (Rayan et al., 2021a).

The first framework, known as the DPSIR model (see: Figure 10), the affinity between UGI and human-centered activities, creating cities that are resilient to climate change. The primary driving forces (D) that contribute to urban vulnerability are climate change, urbanisation, deforestation, and economic growth. These forces induce pressures (P) that transform the urban landscape, reducing natural greenery and leading to natural catastrophic events such as flooding, droughts, and the urban (HI) effect. This, in turn, leads to the culmination of the deteriorating state (S) conditions of the "urban environment", ultimately impacting (I) the health of natural resources, ecosystems and human well-being. To address this, potential sustainable UGI indicators have been selected to build resilient urban regions against climate change. The response (R) is the development of UGI indicators, setting up green action goals (short-term, medium-term and long-term) and proactive and pragmatic implementation and monitoring plans. In summary, this model is designed to mitigate environmental stress, upsurge ESF, and improve human well-being at the individual and neighbourhood scales (Rayan et al., 2021b).

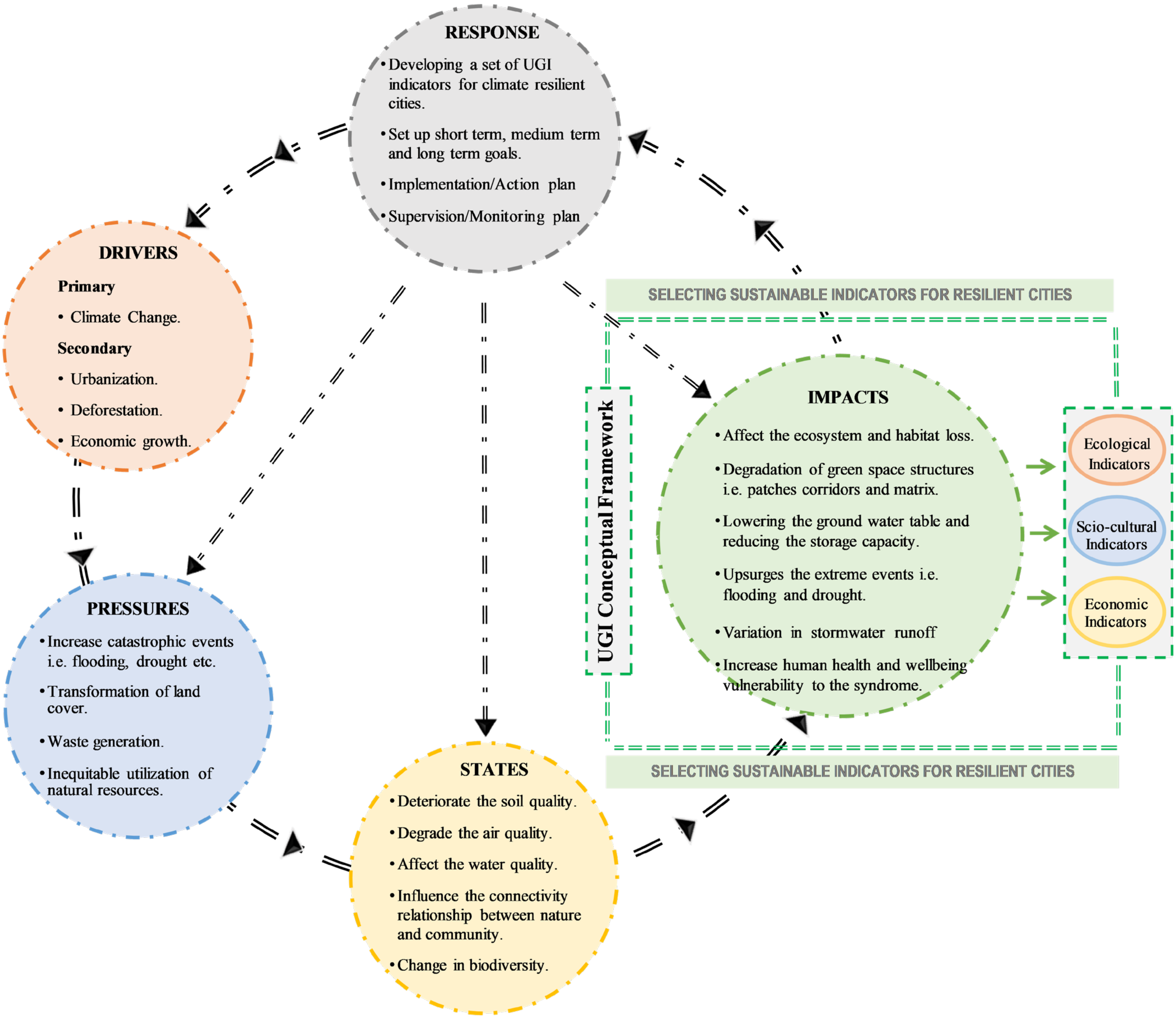


Figure 10: "Linking anthropogenic activities to UGI for resilient cities".
Source: Authors' own (Rayan et al., 2021b)

The second “GI conceptual model” is proposed by this research study. It is based earlier very initial work presented in Tzoulas et al. (2007) model, that is then further enhanced by this study on including three more fundamental elements:

(a) climate resilience strategies,

(b) ESFs, and

(c) the GI elements (*see:* Figure 11).

Furthrrmore, this study has also revised the “taxonomies of urban GI elements and ecosystem health models”, which were earlier developed by Ahern (2007), Davies et al. (2006), USEPA (2010), Gill et al. (2007), and Lu & Li (2003). In the updated work by this study the elements of “quantity, quality, and variability of ecosystem functions” are further worked out and enhanced to opitmal results. The noval mode of GI, presented by this research, helps to establish a strong correlation among these four said systems and provides resilience against unbalanced anthropocentric activities more efficiently. In addition, the significant contribution of this dissertaion is the presentation of the model to effectively alleviate the prolonged negative strains on the socio-ecological systems, in any region with similar characteristics (Rayan et al., 2021b).

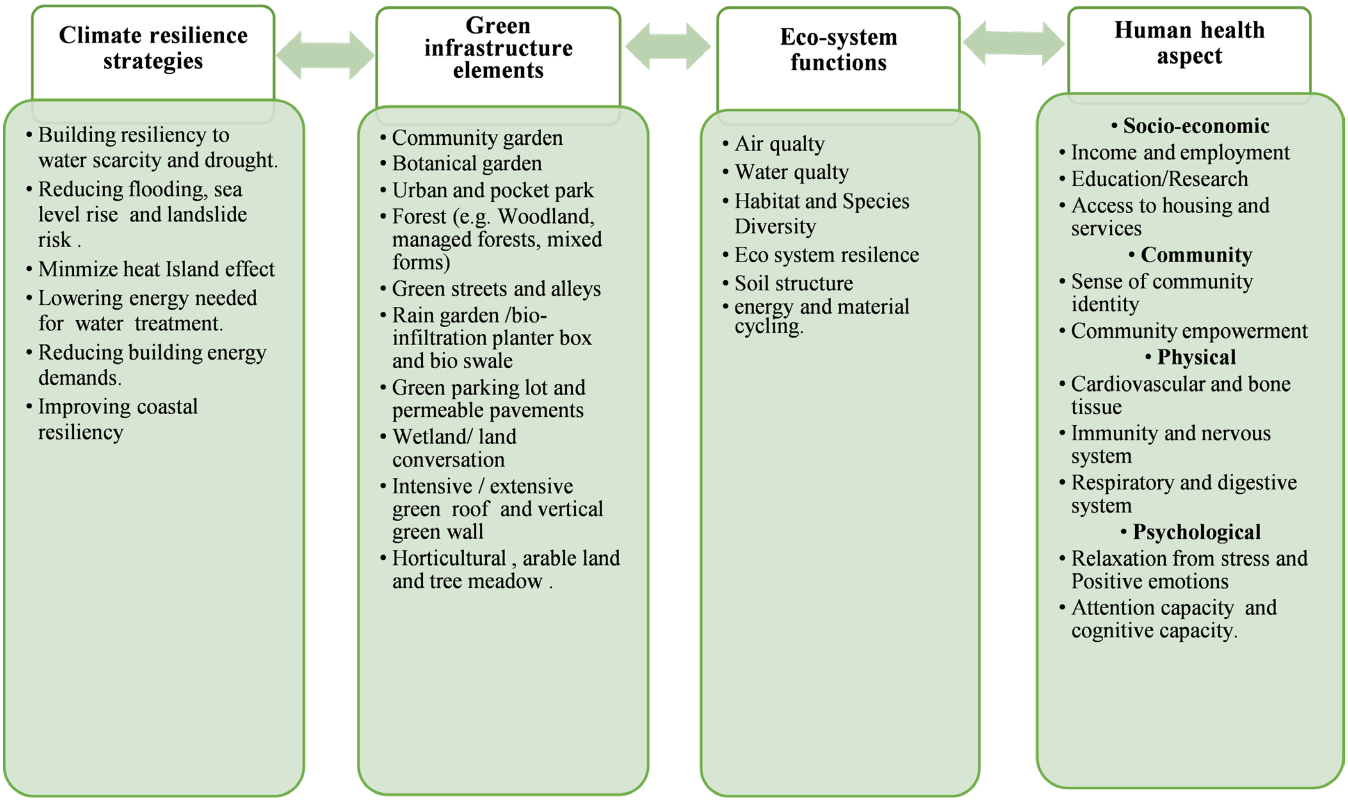


Figure 11: “Conceptual base model: climate resilience strategies, ESF, human wellness, and GI”.
Source: Author own (Rayan et al., 2021b)

Table 9: Concepts developed during the native multi-stakeholders' discussions

Mitigation to climate change	Adaptation to climate change	Water management
Green space networks	Ecosystem functions and services	Wildlife and Biodiversity
Urban resilience	Organic food production	Energy-efficient building
Social cohesion /unity	A green economy	

Source: Author own (Rayan et al., 2021b)

The consolidated integration of both conceptual DPSIR and GI frameworks/models (Rayan et al., 2021b) and cross-cutting notions (originated from multi-stakeholder discussion) (Rayan et al., 2021a) intends to help identify a total of "twenty-two potential (primary and secondary) sustainable UGI indicators", strategically grouped into (i.e., ecological, socio-cultural, economic) categories, and, "ten vital taxonomy of UGS elements". This formulates a cohesive, potential "UGI indicator-based framework" based on "triple bottom line (TBL)" of sustainability (Rayan et al., 2021b). Such a model is backed by a (native) multi-stakeholder perspective or participatory planning (PP) processes tailored to the native spatial context. This model enables local dwellers to participate in the development of multi-functional urban GS. It highlights the value of using NBGI strategies to strengthen the adaptive capacity of urban systems and build resilience to (ever-rising) environmental challenges. This approach is not limited to Khyber Pakhtunkhwa (KP) province and can be applied to other regions with similar characteristics (Rayan et al., 2022, 2022a, 2022b). Additionally, some anecdotal outcomes have been observed; further research is required to (objectively) gauge the health benefits for both eco-systems and humans (EC, 2013; EEA, 2017; Lafortezza et al., 2013; Pauleit et al., 2019), resulting from UGI, in relation to the built environment.

2.6. The Potential Sustainable UGI Framework: *Building climate resilient cities.*

Indicators are vital in simplifying complex data intricacy, improving understanding, and facilitating communication among diverse groups of stakeholders such as policymakers, practitioners, academics, and local community members, as widely suggested in the similar domain (Huang et al., 2015; Rayan et al., 2021b; Segnestam et al., 2003; Wu & Wu, 2012). Additionally, Ahvenniemi et al., (2017) and Hansen et al., (2019) emphasises that indicators perform a pivotal function in creating cities that prioritise the well-being and quality of life (QoL) for the habitants, while also being eco-friendly and resilient to climate change (DG-ENVI, 2012; EEA, 2011; Tzoulas et al., 2007). An appropriate selection of indicators fulfils an educational role (Pintér et al., 2018), and it helps to comprehend better the concept of GI, urban (climate) resilience, and MSPP when it comes to planning for sustainable urban developmen. Therefore, the author utilised (quantitative-based) indicators to emphasise and extract essential data regarding the potency of NBGI initiatives in adopting SCRM strategies corresponding to the built-in environment of "Peshawar, Mardan and Charsadda districts" of the Khyber Pakhtunkhwa region (Rayan et al., 2021a; Rayan,et al., 2022b).

Grounded on multidisciplinary theoretical study, conceptual models developed by (Rayan et al., 2021b) and cross-cutting concepts evolved from semi-structured meetings with local multi-stakeholders (three-level groups encompassing policymakers, experts and the community) in Pakistan helped to identify an initial set of "twenty-two" potential "sustainable UGI indicators" (Rayan et al., 2021a). These UGI indicators include "ten ecological, six socio-cultural, and six economic indicators", some of which are grouped under main headings (as shown in the Table 9) along with the "ten vital taxonomies of the UGS elements", which are "community garden (CG)", "botanical garden (BG)"; "urban park (UP)"; "forest (FO)"; "green streets (GR)"; "rain garden and bio-swale (RG)"; "green and permeable parking area (GPA)"; "wetland (WL)"; "green roof and green wall (GRW)"; and "horticulture (HO)" (Rayan et al., 2021b). The research emphasises the importance of both (innovative and indigenous) natural and human-induced environmental significance for promoting resilient land use planning, ultimately diminishing the negative impact of climatic cataclysm, promoting an eco-friendly state and ensuring sustainable human settlements in the catchment areas of KP province.

The proposed UGI indicators and elements of GS are primarily quantitative. They are set based on native planning experts' (Rayan et al., 2021a) as well as on community members' (Rayan et al., 2022b) responses. Through empirical research, the study aims to assess the significance of each sustainable "UGI indicator and element" in addressing SCRM in a reality-based scenario. The research establishes, develops and tests the correlation between the "UGI indicators" and the "taxonomy of UGS" in the built environment to manage incremental climate stresses. This process validates the scientific and "sustainable UGI framework" that best meets the environmental, socio-economic and cultural context of the study region. The framework strengthens the link between "climate resilience strategies, GS, ESF and human wellness" in the catchments. This endeavour promotes a balanced correlation between human-centred and eco-centred activities, not only in the urban interface of North West Khyber Pakhtunkhwa province but also in other regions across the country with similar characteristics (Rayan et al., 2022a).

Furthermore, this in-depth empirical study delves deeply into the understanding of local stakeholders' knowledge with regard to their interpretation of UGI, UR, CC, and adaptation concepts in the indigenous built context. The study posed four questions to evaluate the perspectives of local planning experts and the community and their confidence in each of the potential options, as outlined in Table 8. The objective is to gain valuable insight into stakeholders' views and to establish a logical standpoint at the local level for defining “cross-cutting notions”. Such endeavours aid in identifying “sustainable UGI indicators and elements”, ultimately leading to the development of a multi-functional, “sustainable UGI indicator-based framework” tailored to the native context (Rayan et al., 2021a; Rayan et al., 2022a). This, in turn, strengthened a sense of multi-stakeholder ownership in the planning and decision-making process for the NBGI initiative, effectively addressing socio-environmental issues resulting from CC at the grassroots level.

Table 8: Questions appeared in community and expert survey**.**

1	“What does climate change mean for you”?
2	“What does adaptation to climate change mean for you”?
3	“What does urban resilience mean for you”?
4	“What does green infrastructure mean for you”?

Source: Author own (Rayan et al., 2021b)

This dissertation would have the credit to inevitably opening a new area of research that would be extended to successively delve deeper into (more) innovative and holistic Multi-Stakeholder Participatory Planning (MSPP) approaches, which are not much institutionalised and practised in the country as a whole (Ashfaque & Awan, 2015; Ahsan 2018; Nizamani & Shah, 2004; Rayan et al., 2022a), especially when it comes to planning nature-based green landscape (NBGL) techniques (adapted to the local context) for CC mitigation. It is to build a greener and climate-resilient city-state in northwest Pakistan, including the “Peshawar, Mardan, and Charsadda” counties and *beyond*. Furthermore, the novelty factor of this research study is the inception to bridge the planning gaps among the local multi-stakeholders, enhancing scientific and practical knowledge about creating sustainable communities using NBGL. Likewise, this study has (for the first time) has tackled both top-down and bottom-up approaches — to build an eco-regional cultural paradigm that promotes and monitors green urbanism at macro, micro, and meso levels in Pakistan: a country with enormous environmentally challenged urban regions.

Table 9: Proposed UGI Indicators-based framework

"**This section encompassed questions with the aim of identifying UGI indicators, interlinked with multiple GI elements and technologies for resilient land-use planning. Indicators are classified according to the "triple bottom line" of sustainability, which highlights the importance of the natural and manmade environment in land-use planning**".

Categories	Green Infrastructure Indicators	Reference	"**Green infrastructure elements and technologies**". "**Please rate your opinion between 1 and 10 on the Likert scale**". "1. Extremely Unimportant, 2. Moderately- Unimportant, 3. Slightly-Unimportant.4. Unimportant, 5. Low, 6. Slightly Important, 7. Moderately-Important, 8. Important, 9. Extremely Important"									
			"**GI 1**"	"**GI 2**"	"**GI 3**"	"**GI 4**"	"**GI 5**"	"**GI 6**"	"**GI 7**"	"**GI 8**"	"**GI 9**"	"**GI10**"
	I. "Optimizing storm-water management "											
	"Increasing pervious surfaces".	"Green infrastructure is suitable for handling rainfall (Buishand, 2007) Increased rainwater retention and flooding (Wise et al , 2010)"										
	"Minimizing, retaining and organically purifying rainwater runoff".											
	II. "Reducing the urban heat island effect"											
	"Increasing the percentage of green surfaces".	"Lowering the mean radiant temperature via trees and other plants. (Jacobs et al., 2015) "										
	"Applying evaporative materials on roof, walls and ground surfaces".											
	III. "Air quality improvement (e.g., pollutant removal, altering wind flow)"											
Ecological	"Implementing green impermeable screens in a street canyon and planting a higher concentration of green trees".	"Nowak et al., 2006 and Yang et al., 2008) Green screens reduce air pollution in urban environments (Pugh et al., 2012; Wise et al, 2010)"										
	IV. "Noise quality improvement"											
	"Applying a green sound barrier for limited and higher noise reductions (i.e., for limiting noise, thick hedges with a small piece of grassland can be provided and for higher noise, broadleaved deciduous trees and a thick border of bamboo can be provided)".	"Dense vegetation structures reduce noise intensity. (Samara and Tsitsoni, 2011) Limited noise reduction. (Van Renterghem et al., 2014)"										
	V. "Reduced carbon emissions (e.g., avoiding greenhouse gas emission through cooling)"											
	"Planting a higher concentration of trees for shade	"Urban green spaces lower emissions										

	and using evaporating material for hard landscaping".	(Weilenmann et al., 2005)"
	VI. "Improve energy efficiency in buildings"	
	"Optimize green energy0saving techniques".	"Green roofs improve building energy consumption (Mentens, 2006; Akbari and Taha, 1992)".
	VII. "Enhanced soil quality and erosion".	
	"Intensification of permeable surfaces and optimization of soil stability".	"(McKinney, 2006)"
	VIII. "Enhance and protect urban biodiversity"	
	"Promote the connectivity and mobility between urban green spaces".	"Biodiversity is the baseline component in GI planning (Weber et al., 2006)". "Promoting conservation (Adam,1994)".
Socio-cultural	**I. "Food production (e.g., urban agriculture, kitchen gardens, and community gardens)"**	"Gardening offers relief from work stress (Hartig et al.,2014)" "Introducing urban food forestry (Clark and Nicholas, 2013)".
	II. "Improving social well-being".	
	"Optimizing the opportunities for recreation and social interaction and enhancing the attractiveness of the city".	"Green spaces should be close to residences and enhance city attractiveness. (Giles-Corti et al., 2005)"
	"Enhanced attractiveness of the city (diverse landscape features)".	"Taking ownership of green spaces (Weldon et al., 2007)"
	III. "Improving physical and mental well-being (i.e., visual and physical access to green spaces have a positive relationship with stress reduction and anxiety)".	"Green exercise is more psychologically beneficial (Pretty et al., 2005, Bratman et al., 2015)". "Neighborhoods living with a higher density of trees (Kardan et al., 2017)".
	IV. "The provision of outdoor sites for education and research".	"(McDonnell et al.,2008)"
	V. "Improving accessibility and connectivity to encourage cycling and walking opportunities".	"People walk 20% more in green spaces (De Vries et al., 2010)"
Economic	**1. "Amplified property values".**	"(Shoup and Ewing 2010)"
	II. "Savings in healthcare cost".	"(Shoup and Ewing 2010)"

III. "Reduced energy consumption (e.g., cooling and heating demands)".	"(Weilenmann et al., 2005) (Mentens, 2006, Akbari and Taha, 1992)"
IV. "Reduced risk of flood damage".	"(Gordon-Walker et al, 2007; Wise et al, 2010)".
V. "Reducing private car use by increased walking and cycling (e.g., shifting travel mode)".	"(McPherson and Muchnick, 2005; De Vries et al., 2010)"
VI. "Value of air pollutant removal/ avoidance".	"(Pugh et al., 2012; Wise et al., 2010)"

"Keys: (GI 1: Community Garden; GI 2 = Botanical Garden; GI 3 = Urban and pocket park; GI 4 = Forest; GI 5 = Green streets and alleys; GI 6 = Rain Garden/bio-infiltration, planter box and bioswale; GI 7 = Green parking lot and permeable pavements; G8 = Wetland/land conversation; GI 9 = Intensive/extensive green roof and vertical green wall; GI 10 = Horticultural areas, arable land, and tree meadows)".

Source. Author own (Rayan et al., 2021b; 2022a).

THIRD CHAPTER

[Source: Author owns]

"Show me a healthy community with a healthy economy and I will show you a community that has its green infrastructure in order and understands the relationship between the built and the unbuilt environment".

— Will Rogers —

3. Publication - Based Results

The following chapter briefly presents selected results/outcome from the author's key (three) publications that address the research - objectives and questions of this dissertation. These scientific papers have undergone a double-blind peer review process for quality assurance and they have been published in renowned international (impact factor) journals. The key publications were produced between 2021 and 2022, mainly based on this independent research. The publications are available/accessible in their original published structure or, in one case, for copyright reasons, in the author's version that are to be found in the appendix to this dissertation.

These publications were primarily authored by Muhammad Rayan, with the invaluable supervision and guidance of Professor Dietwald Gruehn and Dr. Umer Khayyam, in order to accomplish the research goals and answer the research questions this reseasrch has posed. Their expertise and support remained crucial in ensuring the quality and accuracy of these publications.

3.1. Green Infrastructure Indicators to plan Resilient Urban Settlements in Pakistan: Local Stakeholder's Perspective.

Rayan, M., Gruehn, D., & Khayyam, U. (2021a). Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective. Urban Climate, 38, 100899. https://doi.org/https://doi.org/10.1016/j.uclim.2021.100899. (see Appendix A).

This article is based on results from the (top-down), expert-based perception field study and the input from the local planning experts who have provided their perspectives on potential "sustainable UGI indicators" and their functional linkage with vital taxonomies of "UGS elements", in the built-in environment, to cope with gradual climatic stress. The author has written an article out of this dissertation on the said theme (approx. 46,252 characters in total without illustrations).

Urban Green Infrastructure (GI) is recognised as a cost-effective and innovative nature-based spatial planning strategy that improves the resilience of urban settlement systems against climate-related cataclysms and enhances ecosystem functions (ESF), biodiversity conversations and human health/well-being at both (individual and neighbourhood) levels (Ignatieva et al., 2011; Rayan et al., 2021a; Benedict & McMahon, 2002, 2006; DG-ENVI, 2012).

This research is an effort towards developing an inclusive, “sustainable UGI indicator-based framework” (adapted to the indigenous environment) and grounded on native experts' input under the PP methodology. The (UGI) framework provides valuable insight and measures the satisfaction levels of planning experts. It also presents an opportunity to connect residents with innovative, multi-functional GS uniquely tailored to the local built-in environment. Human-nature interaction probes how multiple taxonomies of Nature-Based Green Landscape (NBGL) initiatives can help reduce vulnerability to climate hazards, including floods and droughts, and promote a greener, friendlier environment in the upset urban regions of the KP regions. The Global studies (also) endorse that UGS infrastructure can perform multiple functions, but their effectiveness (usually) hinges on two key drivers (e.g., “the specific configuration” and “the spatial context”) of each region (Ahern, 2007; EC-European Commission, 2015; Gill et al., 2007; Hansen et al., 2019; Pauleit et al., 2017) — where they are examined.

This (emperical) study adopted a case study-based methodology grounded on the local expert-based-perception survey, i.e., policymakers, practitioners, and academicians. The objective is to define the “relative importance index” (RII) of the respective UGI indicator, evaluating its applicability and scale, specifically for a sustainable and eco-friendly urban environment. The findings shed light on the essential and non-essential UGI indicators (in terms of environmental, societal, and economic factors) and their relationship with different types of UGS (as endorsed by the planning experts) in order to cope with climatic changes in the (native) built urban context.

The study collected responses from 172[7] (out of 212) questionnaires, with a 95% “confidence level (CI)” and a “margin of error (MoE)” of ±5%. The questionnaire was designed with a focus on UGI, UR, and CC adaptation, taking into account the importance of the local context. It was divided into three sections: A-C[8], as detailed in Appendix A: Fig 2. To ensure the questionnaire's inclusivity and appropriateness, a pre-test/pilot survey was conducted among “local government representatives, two expert consultants, three academicians, and three community members”. Based on their feedback, the survey design was slightly revised (see Appendix A: Annex C) to make it more appropriate, easy to understand, and time-efficient without losing its contextual

[7] “The rest of the questionnaires were excluded since the mandatory questions were not answered”.

[8] “Section A: aimed at verifying the participant's profile, knowledge, and experience. The category of 'trans' as a third gender was included as officially recognized by government of Pakistan. Section B: encompassed four questions, explained in (table 8). Which verifying and validating the local stakeholder perspective on the proposed possibilities and definitions of the UGI, climate change, climate change adaptation, and urban resilience. Section C: are classified into the three subsections (ecological, socio-cultural, and economic), and each section includes multiple questions with the aim of rating and identifying the importance level of specific sustainable UGI indicator and its interrelationship with multiple green elements. Potential UGI indicators and elements were developed by the author in his preceding research studies. This resulted in selecting the most vital green elements that enhanced the quality standard of a particular UGI indicator and build resilient urban regions against natural hazards like flooding”(Rayan et al., 2021a).

meaning. The study utilised purposive sampling[9] to select "nine distinct expert strata", as illustrated in Table 2: Appendix A, to sort the specific participants.

The statistics characteristics of the expert's study affirmed that 45.9% were feminine and 54.1 % were masculine. However, none of them identified as third-gender "diverse"[10]. The sample was diverse in terms of socio-economic backgrounds and included representatives from all eight sectors (for details, see Appendix A: Table D.1).

Two methodologies, the "Relative Importance Index (RII)" and the "Interquartile Range (IQR)", were employed to analyse the data in this study. The results divulge good reliability ($\alpha > 0.7$) and internal consistency (see Appendix A: Table 7), indicating that the study met the desired threshold level (Cortina, 1993; Hair Jr. et al., 1998; Peterson, 1994).

This study is an effort that led to the development of a "multi-functional UGI indicator-based framework" model based on the "triple bottom line of sustainability", to be deployed in the native/study area's built context. Such a scientific framework (based on the native planning experts' perspective) is intended as an aid, giving an idea about UGI's environmental performance and its relationship with CC, ESF, and local inhabitants' health and well-being in the study region. Besides, it fosters community cohesion and a sense of stewardship in bottom-up green initiative planning, improving the environmental resilience of cities and benefiting residents during climatological catastrophes. The empirical result is considered as a first pioneering step that embeds (the GI) study (under the PP approach) in its relevant local context of "Peshawar", "Mardan" and "Charsadda" districts of KP region (Rayan et al., 2021a)— a non-collusive and unitary environment with an undue influence that a country hold (Ahmad & Anjum, 2012; Ashfaque & Awan, 2015; Rayan et al., 2022). This reality makes this study novel.

i. Results and Findings:

The planning (expert-based perception) study outcome thus has two main components: the first section answers to native (planning) experts' comprehension of CC, CC adaptation, UR, and UGI concepts in their (relevant) local context. This elucidates what these concepts are meanful to local experts. Four questions have been asked to understand the respondents knowledge of the potential options, verifying several optimal possibilities under the PP method (as summarised in Appendix A: Fig. 3-6).

---

[9] "Within the (purposive sampling) the snowball technique was employed to identify specific participants. Each respondent further recommended another local expert with appropriate knowledge and expertise of (sustainable, innovative, natural green landscape-led, and participatory (citizen-led) approaches for climate change adaptation and mitigation) to gather relevant information, as accepted" (Singh, 2007).

[10] "This category was offered (here) since the government of Pakistan officially recognises the identification of "trans" as a third gender" (Nasir Iqbal, 2009; Guramani, 2018a, 2018b)

These results are regarded as a benchmark to delineate the “cross-cutting” concepts at the grassroots scale in the studied region.

The second section *(clustered into two sub-groups)* identifies, at the first level, the importance (IMP) of “sustainable UGI indicators” (see Appendix A: Table 7). At the next level, the key taxonomies of “UGS” have been identified to strengthen the potential resilience and health of each corresponding “UGI indicator” in the native-built context against anticipated climate variability (see Appendix A: Table 8a and 8b). The IMP level of each (indicator and element) was measured by employing RII and IQR techniques, as well as the application of a nine-point importance scale criterion (on an RII data set), ranging from “extremely unimportant” to “extremely important” (see Appendix A: Table 3). The scale incorporates both positive and negative weights to account for the variance in the IMP levels between the set indicators and elements, since not every green space element has an excellent functional link and enhancement factor in the resilience health of the corresponding “UGI indicator” to cope climatic changes in the urban environment.

Based on the empirical results, ecological indicators appear to be more widely accepted than the other two categories - socio-cultural and economic. Most of the ecological indicators are ranked as (IMP or E-IMP) (see Appendix A: Table 7). Furthermore and importantly, the research outcome reflects a significant variation in the list of selected key elements of UGS for each respective sustainable “UGI indicator” (see Appendix A: Table 8b). This validated and supports the earlier statement (as outlined above) that each “UGS element” has a unique quality and does not significantly increase the resilience of a particular (sustainable) “UGI indicator” in the face of gradual climate change. It's worth noting that the efficacy of UGS is directly influenced by “local spatial,” “contextual” and “socio-demographic factors,” which vary from one area to another.

In conclusion, the primary objective of this study is to achieve a high degree of consensus among native planning experts as stakeholders under the top-down planning approach to establish a “sustainable UGI indicator-based framework”. This approach bridges the planning gaps and enhances the scientific knowledge and understanding of all native stakeholders and the responsible agencies in planning NBGI initiatives for SCRM. It further leads to the strengthening of urban settlement systems “(resilience and functions)” against the constantly increasing environmental challenges. Moreover and importantly, this inclusive and multi-functional scientific (UGI) model, “(which is)” tailored to the native conditions, facilitates building a new eco-regional “cultural paradigm” that encourages GAPs at neighbourhood and city levels. Besides, it paves the way for a balanced equilibrium between anthropocentric and eco-centric activities “(not only)” in the urban regions of the (environmentally challenged) Khyber-Pakhtunkhwa, but also (in principle) the entire country.

3.2. Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan.

Rayan, M.; Gruehn, D.; Khayyam, U (2022b). Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan. Int. J. Environ. Res. Public Health 2022, 19, 11844. https://doi.org/10.3390/ijerph191911844 (see Appendix B).

This article is based on results from the bottom-up community-based empirical survey, that has targeted local communities from three central counties/districts "(Peshawar, Mardan, and Charsadda)" in the KP region, Pakistan. It is to provide locals' perspectives on the importance level of potential "sustainable UGI indicator" and their functional linkage with the vital taxonomies of UGS in the built context. It helps in coping with the gradual environmental stress. The author has written this article of his dissertation (approx. 55, 078 characters in total without illustrations).

This empirical, community-driven study emphasised the role of residents in creating an inclusive and sustainable UGI model that complies with the standards of a greener, climate-resilient city in the northwest region of Khyber Pakhtunkhwa (KP). The scientific (UGI model) offers valuable insights into the community's satisfaction level, significance, and practicality of "UGI indicators" and the (vital taxonomy) of UGS in accordance with the indigenous built-in context, to withstand the (climate-induced) pressure arising from imbalanced anthropogenic activities. The bottom-up driven UGI model breeds a community PP approach, which is not being institutionalised and practised in Pakistan (Ashfaque & Awan, 2015; Nizamani & Shah, 2004; Rayan, et al., 2022b), that possesses non-collaborative, unilateralism, weak laws, and enforcement planning environment (Ahmad & Anjum, 2012; Atta-ur-Rahman & Khan, 2013; Rayan et al., 2021b).

This research has explored the potential role of UGI indicators and their functional linkage with the vital classification of UGS (based on the built environment of Peshawar, Mardan and Charsadda districts) under a community participation approach. This led to the authentication of the "sustainable UGI indicator-based framework" that best meshed with the region's social, economic, cultural and environmental conditions. Such an effort would inevitably open up further new domains of studies aiming to explore innovative community PP initiatives in greater depth. These research studies are indispensable for planning NBG mitigation strategies, addressing long-term SCRM in the upset urban areas of the country (generic) and Khyber Pakhtunkhwa province (specific).

The Northwest (KP) region of Pakistan is undoubtedly highly vulnerable to natural disasters, mainly urban flooding (Atta-ur-Rahman & Khan, 2013; Eckstein et al., 2020; NDMA, 2012). which leads to significant (human and economic) losses (EPA-KP, 2022; NDMA, 2022; Rayan, et al., 2022a). This vulnerability stems from the unique topography and geophysical location (of the area), thereby increasing its exposure to natural calamities of various scales and effects (See Appendix B: Fig 1) (Khayyam & Noureen, 2020; Ahsan, 2018). The region's susceptibility to natural catastrophes is further exacerbated by weak institutional, the dearth of well-defined legislative frameworks, reactive planning approaches, poor implementation of planning reforms, and most importantly, the absence of PP (Ahmad & Anjum, 2012; Ahsan, 2018; Ashfaque & Awan, 2015; Khayyam, 2020; Naeem et al., 2018; Rayan, Gruehn, et al., 2022b). These challenges emphasise the dire need for proactive and pragmatic (UL-UG) policies and strategies for resilient land-use planning that help to mitigate the high exposure to multi-climatological vulnerabilities and promote an eco-friendly environment for sustainable human settlements in the northwest territories of KP.

This (bottom-up emperical) study employed an in-depth household (HHs) community survey executed in three major counties of Khyber Pakhtunkhwa, namely, Peshawar, Mardan, and Charsadda (see Appendix B: Fig 2). The case study-based approach was grounded on the (native) inhabitants' inputs to gauge their insightful perspective on the UGI model. A multi-stage sampling technique was employed to achieve the research objectives. A two-tiered scale criterion (see Appendix B: Table 1 and Table 2) was adopted to specify the Tehsil and Union Council (UC) in the study areas. Furthermore, the snowball strategy[11] was employed to identify a particular sample household (HH) as a reference point, and every fourth HH from the benchmark was selected as the HH sample for data collection (see Appendix B: Fig 2).

In-total, 192 HHs (CI 95%, ± 5% MoE) were administered. Of these, (64 HH) were from "Mardan", (57 HH) from "Charsadda" and (71 HH) from "Peshawar" tehsils (see Appendix B: Table 2). A structured questionnaire (Appendix D), themed around UGI, UR and adaptation to CC in the relevance of local context was deployed. It was designed with three sub-sections; A–C (see Appendix B: Fig 3). The demographic characteristics affirmed that (65.6%) of participants identified as male, (22.4%) as female and (12%) opted not to disclose their gender. No participant identified as "Diverse"[12]. The respondents hailed from a diverse socio-economic background, as detailed in Appendix B: Table 3. [It's worth noting that the proportion of male respondents was higher than that of females (KPBOS, 2018), which can be attributed to

[11] "This methodology was employed as no official lists of the residential houses (affected by climatic uncertainty) within UCs exist".

[12] "This category was offered (here) since the government of Pakistan officially recognises the identification of "trans" as a third gender" (Nasir Iqbal, 2009; Guramani, 2018a, 2018b)

the fact that most households in the KP region are predominantly male-headed] [13]. Nonetheless, this study effectively involves the maximum number of possible females as household heads through volunteer enumerators with knowledge of the local (socio-cultural norms) of the studied area (Rayan, et al., 2022b).

The (field data) investigation relied on RII and IQR methodologies. The outcomes proclaim a high level of reliability (alpha > 0.88) and internal consistency (see Appendix B: Figure 7) (Cortina, 1993; Hair Jr. et al., 1998; Peterson, 1994). With the RII and IQR (methods), the the significance of each indicator of UGI and UGS was determined (according to the local built-in environment) under community PP. This methodological approach aligns with previously published research studies that utilised a (top-down approach) led by native planning experts (Rayan et al., 2021a). The research contributes to validating the scientific UGI model, based on sustainability "Triple Bottom Line (TBL)", which best fits the (indigenous) built context of (Peshawar, Mardan and Charsadda) study region. Such a model promotes community stewardship and (allows) the re-establishment of a nexus between inhabitants (and their understanding) and the multifunctional GS. This interaction between people and the ecosystem allows for the understanding of innovative NBGL practices (based on indigenous knowledge) that can reduce vulnerability to environmental stresses and enhance the resilience and functions of the urban settlement system in the region. Ultimately, it is to establish a greener and climate-resilient region in the KP, under a community PP methodology, to promote community stewardship and empowerment.

i. Results and Findings:

The empirical study conducted at the HH level, in the community, has two key components. The first part delves into the native community's comprehension of multiple cross-cutting themes within their relevant context. These themes (include CC, adaptation to CC, UR, and UGI), and the study aims to clarify what these concepts mean to the local inhabitants. Four questions were asked to comprehend the participant's familiarity and level of confidence in each potential alternative, verifying several optimal possibilities (helps to outline the imperative concepts) under the (bottom-up) participatory planning (PP) approach (See Appendix B: Fig. 5-8). These results serve as a gauge/benchmark to define the notion of cross-cutting themes at the grassroots level in the studied area.

It is important to acknowledge that when comparing the emperical results of (bottom-up) community-led research with (top-down) local planning expert studies,

[13] "The other reasons behind this relatively low number are (a) The female-headed HHs are very low, and the majority of HHs are male-headed in the area; (b) The native social and cultural norms are challenging to gain access to females; (C) Societal restrictions make it challenging for outsider's (e.g., the author) to interact directly with females in the area".

there are differences in the (importance levels) assigned to potential possibilities by both the groups. For instance, in the expert study, four (1,2,3,14) potential possibilities are perceived as an influential gauge to define the notion of UGI (See Appendix A: Fig. 6), while in the community-based study, vice versa (See Appendix B: Fig. 8). This endorses and encourages the "holistic" representativeness of the MSPP concept (to build a rational stance among the multi-stakeholders) and authenticates the outcomes in a realistic and practical-based scenario.

In the second section; there are two sub-groups to consider. The initial (level's) objective was to recognise the importance of "sustainable UGI indicators" conditioned to native environments and commune understanding (see Appendix B: Table 6). The following (level) objective was to lay down the (key) taxonomies of UGS that would help bolster the potential resilience and health of UGI indicators within the natively built-in context, against constantly rising environmental threats (see Appendix B: Table 7).

To ensure the utmost accuracy in measuring the IMP of each particular "UGI indicator" and "UGS element", we employ (RII and IQR) techniques alongside a nine-point importance (scale) criterion[14] to determine the precise degree of IMP within the stated "UGI indicators" and "elements". This is (important) because, not every UGS element improves the "functional linkage" and "health" of the corresponding indicators while coping with climatic changes in urban settings. The performance of UGS elements is intertwined with "local spatial", "contextual", and "socio-demographic" determinants (Ahern, 2007; EC-European Commission, 2015; Gill et al., 2007; Pauleit et al., 2019; Rayan et al., 2022; USEPA, 2010). These vary between regions.

The emperical findings indicate that most UGI indicators belong to the "IMP and M-IMP" classes, while only one environmental indicator falls into the "E-IMP" class under the community PP. Interestingly, when comparing these empirical research results to those of top-down planning experts (Rayan et al., 2021a), we observe that the IMP levels assigned to (sustainable UGI indicators) differ. For instance, ecological indicators received higher acceptance levels/satisfaction approval votes (SAV) in the expert study, while the community-based study (Rayan, et al., 2022b) exhibited the *vice-versa.*

In addition, a diverse and comprehensive catalogue of (key) UGS "(for UGI indicators)" has been outlined, taking into account the spatial environment of the KP. This exemplifies the perspectives of (the native community members') on comprehending the functional interrelatedness between the multiple "UGS taxonomy" and "UGI indicators" in the nativist-built context/landscaping in the face of climatic hazards. At this juncture, it's important to note that a comparison of the research

[14] "The (scale) ranging from extremely unimportant to extremely important, includes (both) positive and negative weights to gauge the significance levels of specified UGI indicators and UGS elements accurately".

findings of this study (Rayan, et al., 2022b) with the insights of the local experts (Rayan et al., 2021a) reveals different optimal trade-off possibilities for each individual UGS and its affinity with each particular indicator. However, in most instances, there was an overlap/agreement between the levels of collective understanding.

Overall, this research study represents a strong tendency to accentuate and endorse a community PP[15] method, which is still not effectively institutionalised and practised in Pakitan, to build up a "sustainable UGI framework", relevant to the locally built-in (ecological and socio-economic) environment. Such a (UGI) framework enables the formation of an ecological-regional "paradigm" that facilitates the effective implementation of a nature-based GAP, resulting in leading-edge improvements in ESF and enhanced QoL for the inhabitants of "Peshawar", "Mardan", and "Charsadda" counties of Khyber Pakhtunkhwa Province and *beyond*.

3.3. Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan

Rayan, M.; Gruehn, D.; Khayyam, U (2022a). Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan. Sustainability 2022, 14, 7966. https://doi.org/10.3390/su14137966 (see Appendix C).

The third empirical article employed "Multi-Stakeholder Engagement Processes (MSEP)" to engage local (planning experts and community members) in establishing a rational standpoint among stakeholders. The objective was to ensure the feasibility of a "sustainable UGI indicator-based framework model" within a real-life context. The final step involved merging and localisation, integrating the bidirectional sustainable development pathway i.e., "top-down and bottom-up" PP approach — studying NBGI values in the KP region. It identifies the importance level of respective "UGI indicator" and greenspace element. The article is approximately 54,949 characters in length, excluding any accompanying illustrations.

This research strives to study a "sustainable UGI-indicator-based framework" anchored on the due and balanced inclusion of the natively concerned multi-stakeholder inputs (under the PP approach), which is missing in Pakistan's non-collaborative and unilateralism (with undue influence) environment (Ahmad & Anjum, 2012; Ashfaque & Awan, 2015; Rayan et al., 2022a; Nizamani & Shah, 2004). The MSEP examination

[15] "The PP method is (recognised as) the best tool for promoting community stewardship in (planning, management, and decision-making processes) for NBGI initiatives to achieve socio-ecological resilience in urban neighbourhoods".

sought to identify and conceptualise the similarities between native experts and community perspectives on UGI indicators (see Appendix C: Table 4). It further leads to the identification of important taxonomies of UGS (for each corresponding UGI indicator) (see Appendix C: Table 5), contingent on the region's societal, cultural and environmental conditions, ensuring environmentally sound and climate-smart urban communities in KP Province and *beyond*.

The efficiency of the structural characteristics of GS leans on each region's spatial contextual factors (Ahern, 2007a; EC-European Commission, 2015; Gill et al., 2007; Hansen et al., 2019), where they are examined. In light of this, a holistic and participatory methodology (promoting a sense of community stewardship) is required to (not only) endorse research outcomes in a realistic realm but also to ensure a logical stance that resonates with all stakeholders (See Fig 12). This systematic approach should culminate in forging a UGI model centred on the “TBL of sustainability”, tailored to the local context (see Appendix C: annex A). It is to suggest pragmatic, efficient, innovative and indigenous nature-based green (NBG) solutions. This (in turn) alleviates vulnerability to climatic stresses like, urban flooding, drought, and the UHI effect (Beatley, 2000; Foster et al., 2011a; Gill et al., 2007; Rayan et al., 2022) and strengthens the socio-ecological resilience of urban regions of (KP) province, Pakistan (Rayan et al., 2021a).

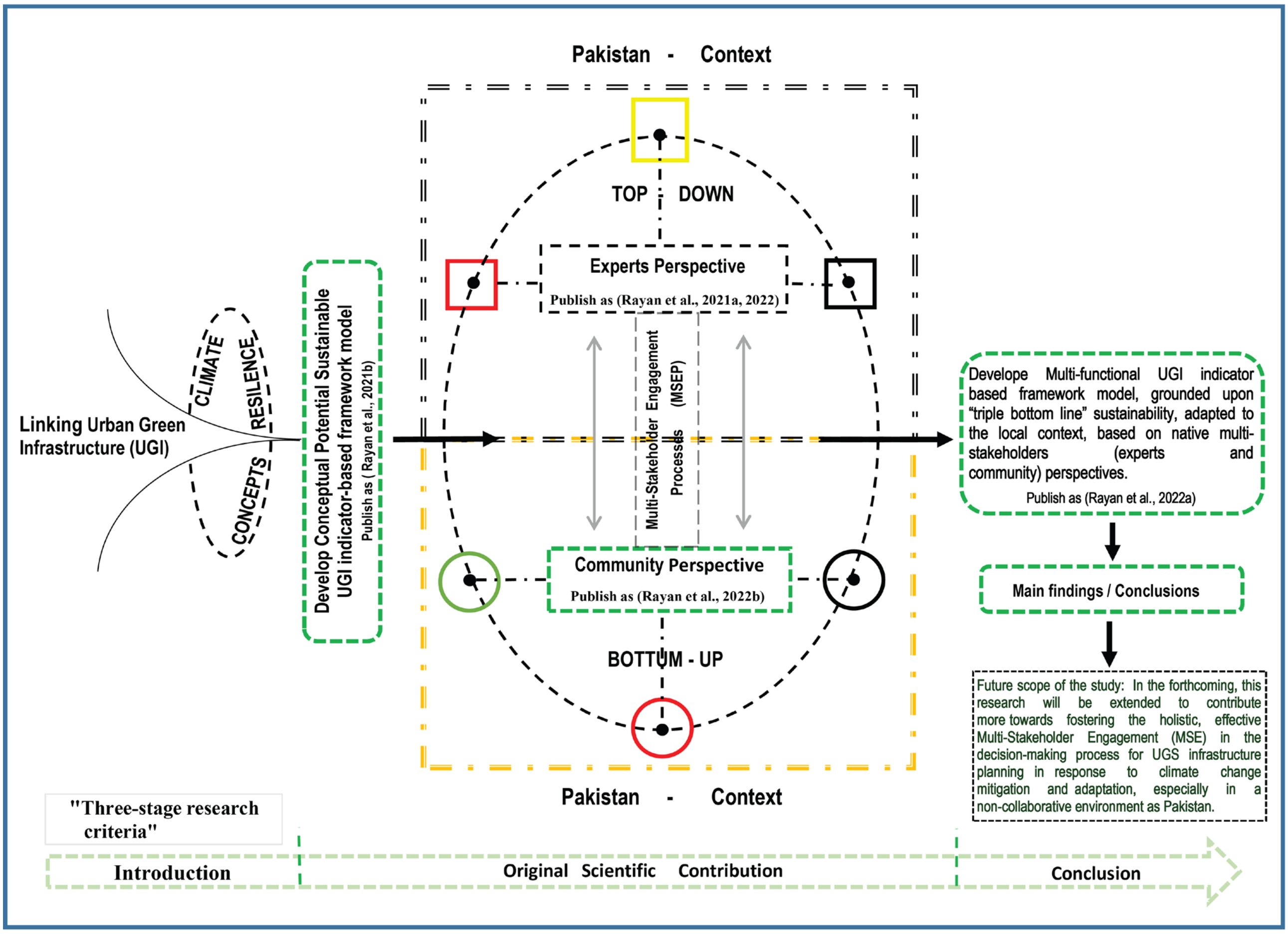


Figure 12. Conceptual framework. Source: Author own (Rayan et al., 2022a)

The MSPP is less focused in Pakistan at all the three-tiered planning levels: national, provincial, and local (Ashfaque & Awan, 2015; Rayan et al., 2022a, 2022b) than in other countries like the Netherlands, Germany, and the UK (Enger, 2005; Harnik, 2006; Kim, 2010; Mell, 2017; Monteiro & Ferreira, 2020). The lack of engagement has been linked to the weak planning process, an outdated and unbalanced legislative planning framework and weak implementation issues, yet in actuality, they are also tied up with the limited community's knowledge and understanding of CC, UR GI, and PP methodologies (Hussnain et al., 2019; Khayyam & Waseem, 2021; Rayan et al., 2021a; Wakil et al., 2016; Ahsan 2018). This leads to perpetually negative pressure on landcover, degrading and depleting KP's natural green cover. Ultimately, this poses a (threat) to the region's ecosystem functions, services and the wellness of inhabitants at macro, micro, and meso levels. Developing such NBGL adaptation/mitigation strategies (under SCRM) remains of utmost importance in KP regions, which are “not only” susceptible to climatic challenges (Khayyam & Munir, 2022; NDMA, 2012, 2022; Rayan et al., 2021b), but also at high risk due to their geospatial position..

This research study is viewed as a first “pioneering step” in acknowledging the holistic representativeness of the native MSPP approach, engaging both (native experts and the community) in the formation of a “sustainable UGI indicator-based framework” (see Appendix C: Figure 2) on the issue of global CC. It is embedded in the local context “Peshawar”, “Mardan”, and “Charsadda” counties within the north-western parts of KP province (Rayan et al., 2022a). The (UGI) model performs an (instrumental) role in facilitating long-term SCRM and strengthens the area's resilience against climatic challenges in a more (cost-effective) way than the so-called traditional mono-functional “grey” infrastructure. This makes it a unique and novel study.

i. Results and Findings:

This study inevitably leads to new areas of investigation that contribute to the practical application of scientific and indigenous/local multi-stakeholder (expert and community) research knowledge, which remains necessory to understand the relationship between NBGL initiatives and CC mitigation and adaptation, according to the native built environment. This cumulative and empirical research study has defined a vivid quantitative research approach (see Appendix C: sections 2.4 and 3.2), determining the importance (IMP) levels of each sustainability dimension, along with ensuring a functional and viable set of UGI indicators and a vital taxonomy of GS (for respective specific indicator) tailored to local (built-in) environments and the native multi-stakeholders comprehension. All this aimed to understand the environmental performance of the respective (UGI indicators and elements) in coping with constantly rising climatic challenges.

The study findings unequivocally illustrate that the holistic (MSPP) approach gives utmost priority to the sustainability (ecological and economic) aspects (with RII scores of 0.835 and 0.807, respectively) in comparison to the socio-cultural dimensions, which are of moderate importance, RII=0.795 (see Appendix C: Table 4). Furthermore, identify a (set of) core taxonomy of "UGS (RII ≥ 0.77)" as key for strengthening the quality and health threshold level of individual "UGI indicators" against climatic challenges in natively built environments (see Appendix C: Table 5). The outputs exhibit a a wide variance pattern in the (IMP level) of the definitive list of sustainable UGI indicators as well as in the selected taxonomy of vital green elements, thus confirming that each GS structure has distinct quality characteristics and cannot significantly reinforce the resilience of a distinct UGI indicator to cope with CC Yet, the determined key GS (See Appendix C: Table 5) that perform a pivotal role in strengthening the resilience of respective UGI indicators in addressing SCRM - the most essential and foremost outcome of the cumulative and empirical MSPP examination (Rayan et al., 2022a).

In conclusion, the results of this research divulged that under the holistic MSPP, the juxtaposition of UGI indicators with key elements of the UGS has led to the formulation of a comprehensive and sustainable "UGI indicator-based model". This framework is structured explicitly as per native built environs — the core primary objective of this study. Such a framework not only supports and bolsters the holistic representativity of the multistakeholder PP method but also fosters a sense of ownership by the community in the planned decision-making process for NBGL strategies to efficiently address socio-ecological challenges (at the grassroots level) stemming from CC. These (nature-based) green adaptations have the potential to evolve new "eco-cultural paradigm", which ensures a balance between anthropocentric and eco-centric activities, explicit to the (environmentally challenged) urban interface of the Khyber Pakhtunkhwa, the region and also the country as a whole.

FOURTH CHAPTER

[Source: Author Own]

"Research is to see what everybody else has seen, and to think what nobody else has thought".

—Albert Szent-Gyorgyi —

4. Discussion of Results and Conclusions

In this Chapter, the publication-based results are discussed and reconnected to the state-of-the-art, research goals/objectives and (correspondigly) the research questions (see chapters 1.5. and 1.6). It is done in the form of a synoptic integration. The chapter is thoughtfully structured around the five research questions that are posed in the cumulative dissertation. It is to effectively highlight the significant contributions made towards advancing scientific knowledge in the (fields) of UGI planning as an indispensable urban amenity that bolsters community cohesion and a sense of stewardship and enhances the socio-ecological resilience of urban neighbourhoods, against climatic stressors in the province of KP, Pakistan. Furthermore, it effectively ties together the primary findings and key insights gained and expounds on their interrelated connections. Finally, the study's limitations and the scope of further research and desiderata are highlighted in Chapter 5.

RQ1. *What is the theoretical and conceptual evolution of GI planning–urban resilience–MSPP (nexus) for resilient land-use planning, and their synergies to develop a "potential" sustainable UGI framework model?*

This dissertation addresses its first RQ by conducting a thorough literature review 'sourced' from a peer-reviewed book chapter by Rayan et al. (2021b). The study reveals that eco-friendly and climate-resilient city studies frequently discuss the notion of NBGI, which is followed by resilience, ecosystem, community wellness, vulnerability, and community cohesion. These concepts are widely adopted, discussed, and accepted in the research circles. Esteemed planners and researchers (Benedict & McMahon, 2006; Lafortezza et al., 2013; Mell, 2010; Naumann, Davis, et al., 2011; TEP, 2005; Tzoulas et al., 2007; Wright, 2011) have frequently cite the said concepts in their publications. Moreover, these concepts are further supported by reputable organisations such as the EEA, EU Commission, EU-DG-ENV, BfN, BMUB, IPCC, and others, lending them significant influence in the field of NBGI.

Notably, these publications have profoundly impacted the theory of GI, particularly in the 'realms' of urban resilience, multi-stakeholder participatory planning (MSPP), and urban sustainability policy. Moreover, the study underscores that NBGI is 'proven' an essential urban amenity that enhances wellness of inhabitants, while (also) fortifying the resilience of urban socio-ecological systems against the unceasingly rising threat of climatic catastrophes. In general, "GI" is a part of a broader ecological network (EN) framework that contributes to (environmental, socio-cultural, and economic) sustainability. The innovative nature-based green strategies have garnered favour among multiple researchers, academicians, planners, practitioners, policymakers, and the general public/community who work towards the development of eco-friendly living practices for resilient urban communities and a sustainable 'greener' environment.

As much of the 'reviewed' literature on GI is focused on theoretical evolution and applied/case-studies, the empirical foundation of linking GI-climate resilience-MSPP concepts, especially in the native built-in environs, is still unclear from the land-use planning perspective. It is, therefore, essential to adopt a holistic approach to examine the nexus and synergies concepts to establish a 'potential' UGI framework tailored to the native built ecosystem. Such a 'UGI' framework takes into account the input of all 'native' multi-stakeholders (experts and community) through the MSPP approach.

Research on urban CC adaptation and mitigation is a global phenomenon. However, cities in developing countries of Asia (exclusively, Pakistan) are facing challenges due to weak institutional shield, lack of a clear legislative planning process, lack of an efficcient framework, poor implementation process and non-existence of participatory planning (PP) practices dominated by undue economic and political influences (Ahsan, 2018; Alvi & Khayyam, 2020; Bano & Khayyam, 2021; Naeem et al., 2018; Rayan et al., 2021b, 2021a; Khayyam, 2016) resulting in the adoption of urban greening (UG) policies and strategies, predominantly based on the international, rather than local context, for promoting urban resilience and sustainability. These factors pose challenges in the 'realm' of land-use planning and surge unprecedented pressure on land cover — resulting in ecological imbalances, disruptions to ecosystem health, loss of biodiversity, and adverse effects on human wellness.

Global research has acknowledged that the efficacy of green spaces (GS) and structural attributes are interwoven with spatial contextual determinants that vary from region to region. (Ahern, 2007; EC-European Commission, 2015; Gill et al., 2007; Pauleit et al., 2019; Rayan et al., 2022; USEPA, 2010). Therefore, defining UG policies and strategies adapted to the natively built context is essential to enhance the social-environmental wellness of a region. The deployment of the MSPP approach promotes a sense of community stewardship and facilitates the successful implementation of GAPs. It also effectively addressing socio-environmental issues at grassroots levels, emerged inlieu of climate change.

This study's unique approach is holistically examining (both top-down vs bottom-up) methodologies, at once and cross-comparions of the results of of them, and developing a sustainable UGI framework under native MSPP. This empirical examination is neither conducted in Pakistan, nor (particularly) at the KP regional level. This research is novel also at the front that the scientific UGI model precented by this research study recommends UGI indicators that grounded upon the "TBL" of sustainability, their spatial functional linkages with multi-functional GSs and connection with the native built-in environment at the KP level—a highly unfortified region against daunting climatic challenges. Such green nature-based adaptations achieve a harmonious balance equilibrium between "anthropocentric" and "eco-centric" measures, aiming to promote a (long-term) greener and resilient environment, not only in the urban areas of KP but across Pakistan. Such nature-base adaptation are extremely desired in a country (Pakistan) having enormous environmentally challenged urban regions.

***RQ2**. What is the understanding level of the native multi-stakeholders (experts and community) for CC, UR and UGI concepts in the local built-in environment?*

In the second RQ, the study investigates how (both) native planning experts (Rayan et al., 2021a) and the native community (Rayan et al., 2022b) understand multiple cross-cutting themes. This research has tackled a wide range of cross-cutting themes which are; UGI, UR, CC, and adaptation to CC in the local built environment. This in-depth empirical research has yielded valuable insights into the perspectives of native multi-stakeholders regarding each potential abovementioned concepts. It elucidate the significance levels of the concepts in the real-life context. These results serve as a yardstick for finalising cross-cutting themes at the grassroots level as per their significance to local/native community/stakeholders.

It's worth noting that (bottom-up) community-led and (top-down) expert-led studies assign different levels of importance to potential possibilities when comparing their empirical results. For instance, in the expert study, four potential possibilities, such as option one,"Promote networks connectivity and mobility among the urban green spaces", option two, "enhancing the natural ecological processes and sustainability of resources", option three, "Enhancing and maintaining the level of biodiversity", and option fourteen,"Reconnecting people with the landscape through innovative design by developing mixed-use spaces that service entire populations" are perceived as an influential gauge to define the notion of UGI (See Appendix A: Fig. 6), but the "community-based empirical study" does the contrary (See Appendix B: Fig. 8).

Furthermore, in defining UR, the community-based statistical investigation represents that 3/4 of the possible options, i.e., "Ability of a system to resist, absorb and recover from natural hazard in an efficient manner", Option three, "Strengthening the urban neighborhood against the environment changes", option four, "More effective Land use Planning and Zoning", option five, "Adaptation to climate change",option six, "Promote green infrastructure initiatives" and option eight, "More efficient governance and planning capabilities" are acknowledged with high positive scores/ satisfaction approval vote (SAV) (See Appendix B: Fig. 7) and are deemed to be influential threshold in measuring UR in the native environment. On the contrary, the experts deemed option (one) as a highly significant attribute (See Appendix A: Fig. 5). These findings validate and foster the holistic nature of the MSEP methodology, thus establishing a rational standpoint among the native multi-stakeholders. These study's contributions ultimately leads to verifying and validating the research outcomes that are tailored to the built-in context.

Undertaking such endeavours cultivates a sense of shared responsibility among the community and enables customised NBGI solutions. Ultimately, this leads to the development of sustainable and resilient urban centres.

RQ3. *How to identify and empirically quantify the degree of importance of each sustainable UGI indicator, in terms of the applicability and scale to build an eco-friendly urban environment under MSPP?*

The third research question sought to probe and gain a deeper insight into the perspectives of local stakeholders (policymakers, experts and community) regarding the potential role of sustainable UGI indicators (Rayan et al., 2021a; Rayan et al., 2022b). The study recognises the importance of UGI indicators localised to the local context and naive multi-stakeholder comprehension. These empirical findings validated the applicability and scalability of sustainable indicators, particularly in developing greener and climate-resilient urban centres in the KP region under MSPP (Rayan et al., 2022a).

The study found that experts (Rayan et al., 2021a) and communities (Rayan et al., 2022) have different perceptions and values when it comes to "sustainable UGI indicators", with experts placing greater importance on environmental indicators and the community valuing other indicators more. This endorses a holistic (MSPP) approach, and under the empirical study of MSPP (by involving planning experts and the local community), the environmental and economic aspects of sustainability received a "high" degree of acceptability (with relative importance index (RII) scores of 0.835 and 0.807, respectively) than the socio-cultural aspect (Rayan et al., 2022a). In addition, the study identified "(22) potential UGI indicators" for sustainability, categorised into three groups based on their significance level. Eleven indicators were classified as "important", nine were "moderately important", and only two were deemed "extremely Important" (See Appendix C: Table. 4). The results yield valuable insights into the significance of each corresponding indicator and sustainable dimension within the native built-in environs under MSPP.

Such an effort contributes to promotings green-growth, besides adding-on to building long-term sustainable climate-risk management (SCRM) to fight the ever-rising climate stressors in KP (Pakistan) and other regions.

RQ4. *What are the key UGS elements that robust resilience and quality standard of specific UGI indicators for SCRM.*

The global studies affirm that each (individual) UGS taxonomy has a distinctive quality and they differently enhance and strengthen the resilience (health) of any green-growth planning indicators in the current climate change challenges (Rayan et al., 2021a; Rayan et al., 2022; USEPA, 2010). The efficacy of the UGS element (usually) depends on two main factors: the specific configuration and spatial context of any region, where they are examined (Ahern, 2007b; EC-European Commission, 2015; Gill et al., 2007; Hansen et al., 2019; Pauleit et al., 2017). This means green space (GS) structures perform multiple functions, each function depending on the socio-cultural and ecological context of a region.

The research question (no 4) strives to develop a vital taxonomy of UGS elements for sustainable UGI indicators, which fit best in the native built-in (socio-ecological and economic) environment and also contribute an essential value to improve the resilience of a specific UGI indicator against the ever-rising environmental hazards. To accomplish this RQ, the empirical study identifies, develops, and tests every taxonomy UGS against the individual sustainable UGI indicator (under MSPP) in order to understand the correlation between the nature-based green landscape (NBGL) initiatives, and climate change adaptation & mitigation, in the native built-in environment. This enables us to foster a collaborative and consensus-driven approach among the (native) multi-stakeholders, for each 'respective' UGS element to address long-term sustainable climate-risk management (SCRM) across environmentally challenged urban region. The results illustrate a broad pattern of variation in the definitive list of selected vital green space elements for respective UGI indicators (See Appendix C: Table. 4) (Rayan et al., 2022a). This outcome stands out as the ‘most significant and foremost aspect of the research’, as it affirms the distinctive quality and unique nature of every 'individual' UGS element (with respective UGI indicators) in addressing climate uncertainties and building an eco-friendly, climate-resilient urban environment in areas such as Peshawar, Mardan, and Charsadda counties of the KP region, Pakistan.

All in all, this emperical examination contributes to achieving an agreement among multi-stakeholders regarding the importance of each respective and potential sustainable UGI indicator and GS element in terms of their applicability and scale in addressing SCRM within the real-life context. This 'then' leads to validating the potential scientific (multi-functional) sustainable UGI framework/model, which best fits the (native) ecological, social economical and cultural conditions of the study region. Such a UGI framework will facilitate building a new sustainable cultural paradigm that supports nature-based green landscape (NBGL) activities to strengthen the adaptative capacity of urban systems and build socio-ecological resilience against (ever-rising) environmental challenges, not only in KP region, but also in other counties having the same features.

RQ5. *What is the 'applicable sustainable UGI framework model' under 'native MSPP' for green climate-resilient city-state in KP region?*

The MSPP approach is acknowledged as an effective tool for promoting and strengthening native multi-stakeholder stewardship (decision-makers, experts, and the local community) in the planning, management, and decision-making process for sustainable human settlements. In this sense, this research study is an inception that breeds the MSPP, integrating a two-way sustainable development path that is native/localised top-down (planning experts) and bottom-up (community) participatory approach. Consequently, this study is a pioneering step in developing a sustainable UGI indicator-based framework model, which is based on the issue of global CC, thereby embedding it in the local context of the study regions i.e., Peshawar, Mardan and Charsadda (Rayan et al., 2022a).

The UGI model allows local inhabitants to reconnect with innovative and multifunctional GS. The human-nature relationships explore the knowledge of using nature-based initiatives (such as wetlands, water-absorbent forest landscapes, parks, green roofs/ walls, etc.) to strengthen the adaptative capacity of the urban systems, thereby alleviating the high risk of anticipated climate catastrophes of various scales and impacts. This ultimately leads to achieving an greener and climate-resilient environment at the urban interface of the KP region, an environmentally challenged province of Pakistan. Additionally, such green adaptations can pave the way to meeting the goal of a balanced correlation between anthropocentric and ecocentric activities. The ultimate contribution is linked to strengthening the intricate reciprocity among climate resilience strategies, GS, ESF, and human wellness at the grassroots level in the study area and beyond.

This research study bridges the planning gaps among the native inhabitants and planning authorities on fostering a two-way (top-down & bottom-up) sustainable development path. This MSPP approach is more participatory and innovative, which seeks to enhance scientific knowledge and awareness (among multi-stakeholders) and gain hands-on experience in planning NBGI initiatives addressing long-term SCRM. This paves the way for developing proactive and pragmatic UL-UG policies and strategies tailored to the local built environment. Furthermore, this (in turn) facilitates the remodelling and restructuring of land-use planning, ensuring a resilient and sustainable human settlement in urban regions of KP province, Pakistan - one of the most affected and (thereupon) most vulnerable regions under climate change.

FIFTH CHAPTER

5. Limitations and Future Research

5.1. Limitations of the Research

Like any other research study, there are always choices and trade-offs (to be made), which can result in certain limitations. Similarly, this empirical research study (Green Infrastructure Planning Framework: An Exploratory Study Towards Resilient Cities in Khyber Pakhtunkhwa Province, Pakistan) is also not an exception when it comes to limitations at all three phases of this research (see Figure 1), yet they were dealt with appropriate successful strategies, which helped to produce best results under this research.

Conducting the literature review was challenging, especially when we strived to avoid bias that may negatively impact the reproducibility of the findings. Factors such as selecting which databases to use, determining the appropriate languages and time frames to consider, carefully choosing search terms and their placement within publications and selecting specific native stakeholders (with appropriate knowledge and expertise) for semi-structured discussions, and also for the empirical top-down (planning experts) and bottom-up (community) study all this can complicate the analysis. To ensure that the review process is transparent and reproducible, it was essential (to thoroughly) document and justify (with rationality) the choices made along the way. In order to mitigate this risk, this empirical study employed the MSPP approach at multiple levels, e.g., at the theoretical foundation (semi-structured meeting), at pre-data collection (pilot surveys), and at the data collection (experts and community surveys) were implemented. These measures were instrumental and helped to validate the insights from theoretical and exploratory research phases, thus avoiding any risk or issues.

Regarding the field survey to collect data from the native community and the planning experts, there were limitations to successfully do the field survey without cost and time over-run the in the difficult ground realities of a developing country, especially Pakistan. Due to limited time and limited resources, this study could only be grounded/extended to three but major Khyber Pakhtunkhwa districts; Peshawar, Mardan, and Charsadda. It, however, remains encouraging that this research has successfully studied urban communities of the most affected districts in the KP province that are facing catastrophic effects of urban flooding, with impacts extended from socio-cultural to economic, and from physical to institutional and *beyond*. This gives a more precise and detailed picture of the current situation of urban GI planning policies for resilient cities and their subsequent effects on the city's residents, environment, and economy.

The researcher experienced some introverted behaviour among local stakeholders, i.e., decision-makers and experts, who were difficult to reach-out, importantly in times of the COVID-19 pandemic. Yet, consistent efforts to connect and reconnect with them over the phone and emails have expedited data collection in due time. Due to the experts' work schedules and health vulnerability, the length and time to respond to the detailed questionnaires were rather long, leading to inclusion of the most mandatory questions to find detailed answers of the all the research questions. It was encouraging that response rate was satisfactory enough to extract in-depth and generalisable results, concerning all the research objectives/questions.

In addition, access to female interviewees or female-headed households in the study area was challenging due to social and cultural norms. It is because the majority of households in the Khyber Pakhtunkhwa region of Pakistan are predominantly headed by men (KPBOS, 2018). Since the local customs do not favour women interacting with an outsider (i.e., researcher), therefore, to ensure required (equal) women's participation in the household community survey, female students from the study districts were involved, trained by the researcher about the jargons and terminologies of the study questions, and then deployed as enumerators for data collection, supervised personally by the researcher on ground. Being from the same area, having the same culture and speak the same (Pushto) language, was added with adequate training from the researcher helped to collect the needed responses. The COVID-19 pandemic outbreak initially made it difficult to consult a larger population and collect data through face-to-face using, yet this research has successfully managed the intended data collection from the field.

5.2. Strengths of the Research

The study is spatially explicit, as it focussed on native multiple experts' stakeholders' "(such as policymakers; practitioners; academicians)" and household community perspectives on the potential function of urban greens space (UGS) infrastructure, as an element of Sustainable Flood Risk Management (SFRM) strategies. Such inquisitiveness, at the neighbourhood-level, are considered efficient in apprehending the intricacy of interactions within linked "human-environmental systems" (O'Brien et al., 2004). Thus, the empirical contributions of this study established a strong basis for a more in-depth understanding of the intricate dynamics of coupling between the vital taxonomy of "UGS" and sustainable "UGI indicators", per the native spatial context, to help mitigate the effects of climatic disasters such as urban flooding.

In addition, the role of the community, experts, and policymakers in the context of NBGL infrastructure solutions, alleviating environmental hazards and promoting urban sustainability (EC, 2013; MEA, 2005) is a challenging task for the planning institutions in urban areas of Pakistan (Ahsan, 2018; Ahmad & Anjum, 2012; Ashfaque & Awan, 2015). This issue is also prevalent in several developing nations and countries in transition. The study attempted to bridge this planning gap, enabling natural-based green climate adaptation learning and action framework in three spatial tiers: Pakistan “(in general)” and KP region “(in particular)”. The outcome is beneficial and serves as a benchmark for developing countries with similar characteristics and issues.

5.3. Future Research

This dissertation has provided a foundation for deeper investigation into the complex dynamics of linking GI planning–urban resilience–MSPP concepts (nexus) “to develop a sustainable UGI framework. This framework/model is developed under MSPP” that recommends UGI indicators, grounded upon the “TBL” of sustainability and their spatial functional linkages with the innovative multi-functional GS, tailored to the native built environment. Such a 'UGI' model bolsters MSPP, taking (into account) the input of all 'native' multi-stakeholders (experts and community) and enables the building of safer, greener and climate-resilient regions (fortified to withstand CC) in the Khyber Pakhtunkhwa region.

It is evident from the (introductory and literature review) sections of this state of the research and the empirical research presented in a cumulative dissertation that there is still a wide range of areas and directions future researches might be conducted. In terms of future research, there are two primary approaches to building upon the research presented in this dissertation. Firstly, there is a need for further research that expands on the outcomes of the individual studies and continues to follow the methodological pathways outlined in this research. Secondly, researches can be executed to build upon the comprehensive advances made by all three studies as a cohesive whole, aligning them towards a shared common direction of addressing long-term SCRM. This collaborative approach contributes to developing resilient urban communities and a sustainable 'greener' environment.

In respect to the UGI frameworks for urban climate change adaptation and mitigation, a unification process needs to be initiated (in order) to investigate the impact of other climatic hazards (e.g. droughts or heat island effects) that would not potentially impede the “physical infrastructure” of green spaces in the manner of flooding. This implies that changes in the nature of the functional nexus (between sustainable UGI indicators and green spaces) under MSPP and the subsequent resilience (health) of green spaces while coping with climatic uncertainties may differ significantly in the urban setting. A more detailed assessment is needed to understand the interlinkages (between the green spaces and UGI indicators) and the complexities of different flows in the native built environment against specific climatic stressors to better grasp the possible 'greener' shifts (under MSPP) in promoting a (long-term) environmentally healthy and climate-resilient environment in the urbane region and their influence, even outside the study region.

One more important area of future study must focus on verifying the quantitative scalability of the respective key taxonomy of UGS in correspondence to the specific natural hazard and its magnitude, e.g., alleviating drought and water scarcity effect in high-density urban clusters; we should know the appropriate and pivotal natural-based green-growth strategies, backed by the native multi-stakeholders understanding and importance level in a built-in environment, lead to improving cities' socio-environmental resilience and benefit inhabitants in periods of natural climatic encounters.

An additional line of research focus could be on the application multiple participatory qualitative methodologies (such as “specialist and community focus group discussions (FGD)”,”workshops”, interviews, “participatory mapping” and “rapid appraisals”) to foster holistic multi-stakeholder participation in nature-based green infrastructure (NBGI) planning. The new research could investigate “which actors should be involved” and “how” and “to what extent” in NBGI planning policies and strategies for resilient cities. Also, to study what kind of participation techniques and their potential involvement (levels) need to be considered in the planning process that improves MSPP in NBGI planning and management. Ultimately, this will exemplify what an 'ideal' MSPP method in NBGI planning look like - improving the noncollaborative and unilateral-planning environments as prevalent in Pakistan.

Finally, in the study and analysis of GS, it is worthwhile to look at various characteristics and species of living roofs and walls in diverse microclimatic zones. This could contribute to a greater understanding of the potential function of planting diverse typologies and scales of living roofs and walls in reducing the heat island stress, the volume and flow of stormwater, and enhancing the urban ecosystems and the inhabitant's wellness. Living roofs and walls are gaining traction, primarily in densely populated agglomerations with limited open spaces (OS). These could be alternatives to increasing the area of GS and improving the ecosystem. They are easily implementable and monitorable and offer significant environmental, social and economic benefits. Therefore, the efficacy of these measures, in the present and under future climatic conditions, needs to be assessed in order to determine if they could be a viable long-term strategy for improving UR under CC in different microclimatic zones.

Bibliography

Aalbers, C. B., & Sehested, K. (2018). Critical upscaling. How citizens' initiatives can contribute to a transition in governance and quality of urban greenspace. Urban forestry & urban greening, 29, 261-275

Adger, W. N. (2000). Social and ecological resilience: are they related? Progress in Human Geography, 24(3), 347–364.

Adams, L. W. (1994). In our own backyard: conserving urban wildlife. Journal of Forestry, 92(10), 24–25.

Albert, C., Haaren, C. V., & Galler, C. (2012). Ecosystem services-old wine in new bottles or an incentive for German landscape planning?. Naturschutz und Landschaftsplanung, 44(5), 142-148

Albert, C., Aronson, J., Fürst, C., & Opdam, P. (2014). Integrating ecosystem services in landscape planning: requirements, approaches, and impacts. In Landscape Ecology (Vol. 29, pp. 1277–1285). Springer.

Ahern, J. (1995). Greenways as a planning strategy. Landscape and Urban Planning, 33(1–3), 131–155.

Ahern, J. (2007). Green Infrastructure for Cities: The Spatial Dimension In Cities of the Future: Towards Integrated Sustainable Water and Landscape Management, edited by V. Novotny and PR Brown. Novotny, Vladimir, 265-283.

Ahern, J. (2013). Urban landscape sustainability and resilience: the promise and challenges of integrating ecology with urban planning and design. Landscape Ecology, 28, 1203–1212

Ahmad, N., & Anjum, G. A. (2012). Legal and institutional perplexities hampering the implementation of urban development plans in Pakistan. Cities, 29(4), 271–277.

Ahsan, A. Urban Flood Risk Management in Pakistan. Islamabad: Daily Times. 2018. Available online: https://dailytimes.com.pk/280433/urban-flood-risk-management-in-pakistan/ (accessed on 8 June 2021).

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? Cities, 60, 234–245.

Akbari, H., & Taha, H. (1992). The impact of trees and white surfaces on residential heating and cooling energy use in four Canadian cities. Energy, 17(2), 141-149.

Akbari, H., & Taha, H. (1992). The impact of trees and white surfaces on residential heating and cooling energy use in four Canadian cities. Energy.

Alvi, S., & Khayyam, U. (2020). Mitigating and adapting to climate change: attitudinal and behavioural challenges in South Asia. International Journal of Climate Change Strategies and Management, 12(4), 477-493.

Arshad, R. R., & Shafi, S. (2010). Pakistan floods 2010: Preliminary damage and needs assessment. Asian Development Bank and World Bank, Islamabad, Pakistan.

Ashfaque, R., & Awan, M. (2015). Final Report-Policy and Legal Reform Study (GEF-Protected Areas Management Project). Ministry of Environment, Government of Pakistan: Islamabad, Pakistan

Atta-ur-Rahman, & Khan, A. N. (2013). Analysis of 2010-flood causes, nature and magnitude in the Khyber Pakhtunkhwa, Pakistan. Natural Hazards, 66(2), 887–904. https://doi.org/10.1007/s11069-012-0528-3

Bano, R., & Khayyam, U. (2021). Industrial air pollution and self-reported respiratory and irritant health effects on adjacent residents: a case study of Islamabad Industrial Estate (IEI). Air Quality, Atmosphere & Health, 14(10), 1709–1722. http://dx.doi.org/10.1007/s11869-021-01051-5

Barros, V. R., Field, C. B., Dokken, D. J., Mastrandrea, M. D., Mach, K. J., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., & Genova, R. C. (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability: Part B: Regional Aspects: Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1–1820). Cambridge University Press.

Baycan-Levent, T., Van Leeuwen, E., Rodenburg, C., & Nijkamp, P. (2002). Development and management of green spaces in European cities: a comparative analysis. Research Memorandum, 2002, 25. http://dx.doi.org/10.9774/gleaf.3062.2001.wi.00010

BBR (Bundesamt für bauwesen und raumordnung) (2000). Urban development and urban policy in Germany: An overview. Available online: https://www.bbsr.bund.de/BBSR/EN/publications/CompletedSeries/Berichte/2000_2009/DL_Berichte6.pdf;jsessionid=B90A6AE29BFE83805CA2E0970537046F.live21302?__blob=publicationFile&v=1. (Accessed on 15.12.2022).

Beatley, T. (2000). Green Urbanism: Learning From European Cities. Island Press.

Benedict, M. A., & McMahon, E. T. (2006). Green Infrastructure: Linking Landscapes and Communities. In Urban Land. Island Press, Washington, DC.

Benedict, M. A., & McMahon, E. T. (2002). Green infrastructure: smart conservation for the 21st century. Renewable Resources Journal, 20(3), 12–17.

Benedict, M. A., & McMahon, E. T. (2012). Green infrastructure: linking landscapes and communities. Island press.

Berlin, S. (2012). Strategie Stadtlandschaft Berlin–natürlich urban produktiv, Berlin, 2012. Online Verfügbar Unter: Http://www. Stadtentwicklung. Berlin. de/Umwelt/Landschaftsplanung/Strategie_stadtlandschaft/Download/Startegie Stadtlandschaft-Berlin. Pdf Letzter Besuch Der Seite Am, 25, 2012. http://dx.doi.org/10.1515/9783038210122.100

BfN (2014). Zerschneidung – Wiedervernetzung. https://www.bfn.de/0306_zerschneidung.html (Accessed on 01.12.2022).

BfN (2017). Bundeskonzept Grüne Infrastruktur. Available online: https://www.bfn.de/sites/default/files/2022-02/bkgi_broschuere_englisch.pdf (Accessed on 01.12.2022).

Blotevogel, H. H., Danielzyk, R., & Münter, A. (2014). Spatial planning in Germany: Institutional inertia and new challenges. In Spatial Planning Systems and Practices in Europe (pp. 103–128). Routledge.

BMUB. (2015a). Grün in der Stadt− Für eine lebenswerte Zukunft. Grünbuch Stadtgrün Berlin. Available online: https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/ministerien/bmub/verschiedene-themen/2015/gruenbuch-2015-dl.pdf?__blob=publicationFile&v=2 (Accessed on 10.12.2022).

BMUB (2015a). Naturschutz-Offensive 2020. Available online: https://www.bbn online.de/fileadmin/Service/8_2%20Infomaterial/Fachmaterialien/naturschutzoffensive_2020_broschuere_bf.pdf (Accessed on 12.11.2022).

Bratman, G. N., Daily, G. C., Levy, B. J., & Gross, J. J. (2015). The benefits of nature experience: Improved affect and cognition. Landscape and Urban Planning, 138, 41-50 http://dx.doi.org/10.1016/j.landurbplan.2015.02.005

Buishand, A., & Wijngaard, J. (2007). Statistiek van extreme neerslag voor korte neerslagduren. KNMI De Bilt.

CABE. (2010). Community-led spaces: A guide for local authorities and community groups. London: CABE Space.

Clark, K. H., & Nicholas, K. A. (2013). Introducing urban food forestry: A multifunctional approach to increase food security and provide ecosystem services. Landscape Ecology, 28(9), 1649–1669. https://doi.org/10.1007/s10980-013-9903-z

Chapin, F. S., Carpenter, S. R., Kofinas, G. P., Folke, C., Abel, N., Clark, W. C., Olsson, P., Smith, D. M. S., Walker, B., & Young, O. R. (2010). Ecosystem stewardship: sustainability strategies for a rapidly changing planet. Trends in Ecology & Evolution, 25(4), 241–249. http://dx.doi.org/10.1016/j.tree.2009.10.008

Chiesura, A., 2004. The role of urban parks for the sustainable city. Landscape and urban planning, 68(1), pp.129-138. http://dx.doi.org/10.1016/j.landurbplan.2003.08.003

Cilliers, E. J. (2016). Mega trends: Creative participation-Combining education and social interaction for public space planning.

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. Journal of Applied Psychology. https://doi.org/10.1037/0021-9010.78.1.98

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. Global Environmental Change, 18(4), 598–606. http://dx.doi.org/10.1016/j.gloenvcha.2008.07.013

Davies, C., MacFarlane, R., McGloin, C., & Roe, M. (2006). Green infrastructure planning guide. Project: Final Report.

Davies, C., Macfarlane, R., Mcgloin, C. ;, & Roe, M. (2005). Green Infrastructure and the City Regions. Discussion Paper. NECF, Dunston. https://doi.org/10.13140/RG.2.1.1191.3688

Davies, C., & Lafortezza, R. (2017). Urban green infrastructure in Europe: Is greenspace planning and policy compliant? Land Use Policy, 69, 93–101. http://dx.doi.org/10.1016/j.landusepol.2017.08.018

Davidson, S. (1998). Spinning the wheel of empowerment. Planning, 1262(3), 14–15.

De Groot, R. S., Alkemade, R., Braat, L., Hein, L., & Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity, 7(3), 260–272. http://dx.doi.org/10.1016/j.ecocom.2009.10.006

Dembski, S. (2020). Germany: A Balanced Planning System? Accessed 15. Jan. 2023 https://www.landcommission.gov.scot/downloads/5fdcb56543ca9_Germany%20-%20A%20Balanced%20Planning%20System%20-%20Case%20Study.pdf

Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Bhave, A. G., Mittal, N., Feliu, E., & Faehnle, M. (2014). Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. Journal of Environmental Management, 146, 107–115. https://doi.org/https://doi.org/10.1016/j.jenvman.2014.07.025

Desouza, K. C., & Flanery, T. H. (2013). Designing, planning, and managing resilient cities: A conceptual framework. Cities. https://doi.org/10.1016/j.cities.2013.06.003

Desa, U. N. (2019). World urbanization prospects 2018: highlights (ST/ESA/SER. A/421).

Desa, U. N. (2014). World urbanization prospects, the 2011 revision. Population Division, Department of Economic and Social Affairs, United Nations Secretariat. http://dx.doi.org/10.18356/cd4eece8-en

De Vries, S. I., Hopman-Rock, M., Bakker, I., Hirasing, R. A., & Van Mechelen, W. (2010). Built environmental correlates of walking and cycling in Dutch urban children: results from the SPACE study. International journal of environmental research and public health, 7(5), 2309-2324. http://dx.doi.org/10.3390/ijerph7052309

De Wilde, M., Hurenkamp, M., & Tonkens, E. (2014). Flexible relations, frail contacts and failing demands: How community groups and local institutions interact in local governance in the Netherlands. Urban Studies, 51(16), 3365–3382. http://dx.doi.org/10.1177/0042098013519832.

Dicken, P. (2011). Global Shift: Mapping the Changing Contours of the World Economy, 6th edn, New York. Guilford Press.

DG-ENVI, E.U., 2012. The multi-functionality of green infrastructure. Science for Environment Policy (In-depth Reports).

Dhakal, K. P., & Chevalier, L. R. (2017). Managing urban stormwater for urban sustainability: Barriers and policy solutions for green infrastructure application. Journal of Environmental Management, 203, 171–181. https://doi.org/10.1016/j.jenvman.2017.07.065

Diamond head consulting. (2014). Biodiversity conservation strategy (BCS). City of Surrey.https://www.surrey.ca/sites/default/files/media/documents/Surrey_BCS_Report.pdf (Accessed on 15.12.2022).

Eckstein, D., Künzel, V., & Schäfer, L. (2021). The global climate risk index 2021. Bonn: Germanwatch.

Eckstein, D., Künzel, V., & Schäfer, L. (2020). Global climate risk index 2021. Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000-2019. http://germanwatch.org/en/download/8551.pdf7

Eckstein, D., Künzel, V., Schäfer, L., & Winges, M. (2019). Global climate risk index 2020. Bonn: Germanwatch, 1–50. Available online: http://germanwatch.org/en/download/8551.pdf (accessed on 11.06. 2021).

Eckstein, J., Ruhnke, R., Pfahl, S., Christner, E., Diekmann, C., Dyroff, C., Reinert, D., Rieger, D., Schneider, M., & Schröter, J. (2018). From climatological to small-scale applications: simulating water isotopologues with ICON-ART-Iso (version 2.3). Geoscientific Model Development. http://dx.doi.org/10.5194/gmd-11-5113-2018

EC. (2013). Green Infrastructure (GI) — Enhancing Europe's Natural Capital. In Communication from the Commission to the European Parliament, the European Economic Council, The European Economic and Social Committee and the Committee of the Regions. https://doi.org/10.1017/CBO9781107415324.004

European Commission. (2011). Our Natural Capital: An EU Biodiversity Strategy to 2020. European Commission: Brussels, Belgium.

EC-European Commission. (2015). Towards an EU Research and Innovation policy agenda for nature-based solutions & re-naturing cities. Final Report of the Horizon2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities. Brussels: European Commission. http://dx.doi.org/10.3030/730426

EEA. (2017). Climate change, impacts and vulnerability in europe 2016–an indicator-based report. Luxembourg: Publications Office of the European Union, 1, 2017. https://www.eea.europa.eu/publications/climate-change-impacts-and-vulnerability-2016. http://dx.doi.org/10.1108/ijccsm.2013.41405baa.003

EEA. (2011). Green Infrastructure and territorial cohesion. The concept of Green Infrastructure and its integration into policies using monitoring systems. Technical Report no. 18/2011, European Environment Agency, Copenhagen, Denmark. http://dx.doi.org/10.18757/ejtir.2011.11.4.2942. Available online:

http://www.eea.europa.eu/publications/%0Agreen-infrastructure-and-territorial-cohesion/%0Aat_download/file.

EEA. (1999). Environmental indicators: Typology and overview Prepared. In European Environment Agency (Vol. 50, Issue 4).

EU SDS. (2002). European Union Strategy for Sustainable Development. Luxembourg: European Communities.

Enger, S. C. (2005). Planning for Parks, Recreation, and Open Space in Your Community. Washington State Department of Community, Trade and Economic Development.

European Commission. (2017). COMMISSION STAFF WORKING DOCUMENT Accompanying the document REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the implementation in 2013-2014 of Regulation (EC) No 561/2006 on the harmonisation of certain social legislation relating.

Elliott, J., Deryng, D., Müller, C., Frieler, K., Konzmann, M., Gerten, D., Glotter, M., Flörke, M., Wada, Y., & Best, N. (2014). Constraints and potentials of future irrigation water availability on agricultural production under climate change. Proceedings of the National Academy of Sciences, 111(9), 3239–3244. http://dx.doi.org/10.1073/pnas.1222474110

EPA-KP (2022). Environmental Protection Agency, Government of Khyber Pakhtunkhwa, Climate Change Policy 2022. Available online: https://epakp.gov.pk/climate-change/ (accessed on 10.11. 2022).

Faehnle, M., Bäcklund, P., Tyrväinen, L., Niemelä, J., & Yli-Pelkonen, V. (2014). How can residents' experiences inform planning of urban green infrastructure? Case Finland. Landscape and Urban Planning, 130, 171–183. http://dx.doi.org/10.1016/j.landurbplan.2014.07.012

Fahad, S., Wang, J., Khan, A. A., Ullah, A., Ali, U., Hossain, M. S., Khan, S. U., Huong, N. T. L., Yang, X., & Hu, G. (2018). Evaluation of farmers' attitude and perception toward production risk: Lessons from Khyber Pakhtunkhwa Province, Pakistan. Human and Ecological Risk Assessment: An International Journal, 24(6), 1710–1722. http://dx.doi.org/10.1080/10807039.2018.1460799

Fahad, S., & Wang, J. (2020). Climate change, vulnerability, and its impacts in rural Pakistan: a review. Environmental Science and Pollution Research, 27, 1334-1338. http://dx.doi.org/10.1007/s11356-019-06878-1

Farina, A. (2000). Landscape ecology in action. Springer Science & Business Media.

Fry, I. (2003). United nations environment programme, global environmental outlook 3. REVIEW OF EUROPEAN COMMUNITY AND INTERNATIONAL ENVIRONMENTAL LAW, 12, 120.

Foster, et al., 2011. The value of green infrastructure for urban climate adaptation. Center Clean Air Policy 750 (1), 1–52.

Fors, H., Molin, J. F., Murphy, M., & Konijnendijk van den Bosch, C. (2015). User participation in urban green spaces—for the people or the parks? Urban For Urban Green 14 (3): 722–734. http://dx.doi.org/10.1016/j.ufug.2015.05.007

Fürst, D (2010): Raumplanung: Herausforderungen des deutschen Institutionensystems: Detmold: Verlag Dorothea Rohn.= Planungswissenschaftliche Studien zu Raumordnung und Regionalentwicklung, Band 1. 266 S. Springer. http://dx.doi.org/10.1007/s13147-015-0366-3

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: The role of the green infrastructure. Built Environment, 33(1). https://doi.org/10.2148/benv.33.1.115. http://dx.doi.org/10.2148/benv.33.1.115

Giles-Corti, B., Johnson, M., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A., & Donovan, R. (2005). Increasing walking:: How important is distance to, attractiveness, and size of public open space? American Journal of Preventive Medicine. http://dx.doi.org/10.1016/j.amepre.2004.10.018

Greiving, S., & Fleischhauer, M. (2022). Climate resilience and environmental justice: state of research and implementation in planning practice in Germany and beyond. Town Planning Review, 93(2), 111–137. https://doi.org/10.3828/tpr.2021.26

Greiving, S., Kuhlicke, C., Albert, C., Bachmann, D., Birkmann, J., Borchardt, D., Fekete, A., Hartmann, T., Hansjürgens, B., & Jüpner, R. (2021). Five Principles for Climate-Proof Municipalities and Cities. 10. https://www.ufz.de/index.php?en=48382 (accessed on 03.06. 2022).

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. science, 319(5864), 756-760. http://dx.doi.org/10.1126/science.1150195

Grimm, N. B., Grove, J. G., Pickett, S. T. A., & Redman, C. L. (2000). Integrated approaches to long-term studies of urban ecological systems: Urban ecological systems present multiple challenges to ecologists—Pervasive human impact and extreme heterogeneity of cities, and the need to integrate social and ecological approaches, concepts, and theory. BioScience, 50(7), 571–584. http://dx.doi.org/10.1641/0006-3568(2000)050[0571:iatlto]2.0.co;2

Gruehn, D., KENNWEG, H., & LUTHER, M. (2006). Bedeutung von Freiräumen und Grünflächen für den Wert von Grundstücken und Immobilien. Endbericht. ARC-Sys-Berichte, 90.

Gruehn, D. (2006). LANDSCAPE PLANNING AS A TOOL FOR SUSTAINABLE DEVELOPMENT OF THE TERRITORY. In Environmental Security and Sustainable Land Use-with special reference to Central Asia (pp. 297–307). Springer. http://dx.doi.org/10.1007/1-4020-4493-3_20

Gordon-Walker, S., Harle, T., & Naismith, I. (2007). Cost-benefit of SUDS Retrofit in Urban Areas. In Environment Agency-Science Report – SC060024. http://publications.environment-agency.gov.uk/PDF/SCHO0408BNXZ-E-E.pdf

Gualini, E. (2004). Regionalization as ‘experimental regionalism’: the rescaling of territorial policy-making in Germany. International Journal of Urban and Regional Research, 28(2), 329–353. http://dx.doi.org/10.1111/j.0309-1317.2004.00522.x

Guramani, N. (2018). Senate unanimously approves bill empowering transgenders to determine their own identity. DAWN. https://www.dawn.com/news/1393766 (accessed on 05.02.2021).

Guramani, N. (2018). National Assembly passes bill seeking protection of transgender rights. DAWN. https://www.dawn.com/news/1406400 (accessed on 05.02.2021).

Godschalk, D. R. (2003). Urban hazard mitigation: Creating resilient cities. Natural Hazards Review, 4(3), 136–143. http://dx.doi.org/10.1061/(asce)1527-6988(2003)4:3(136)

Hanley, N., Barbier, E. B., & Barbier, E. (2009). Pricing nature: cost-benefit analysis and environmental policy. Edward Elgar Publishing.

Hansen, R., & Pauleit, S. (2014). From multifunctionality to multiple ecosystem services? A conceptual framework for multifunctionality in green infrastructure planning for Urban Areas. Ambio, 43(4), 516–529. https://doi.org/10.1007/s13280-014-0510-2

Hansen, R., Olafsson, A. S., Van Der Jagt, A. P. N., Rall, E., & Pauleit, S. (2019). Planning multifunctional green infrastructure for compact cities: What is the state of practice? Ecological Indicators, 96, 99–110. http://dx.doi.org/10.1016/j.ecolind.2017.09.042

Hansen, R., Rall, E., Chapman, E., Rolf, W., & Pauleit, S. (2017). Urban green infrastructure planning: A guide for practitioners. Green Surge.

Haider, M., & Badami, M. G. (2010). Urbanization and local governance challenges in Pakistan. Environment and Urbanization ASIA, 1(1), 81–96. http://dx.doi.org/10.1177/097542530900100107

Haines-Young, R., & Potschin, M. (2010). The links between biodiversity, ecosystem services and human well-being. Ecosystem Ecology: A New Synthesis, 1, 110–139. http://dx.doi.org/10.1017/cbo9780511750458.007

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). Multivariate Data Analysis, 5th edPrentice-Hall. Englewood Cliffs, NJ.

Harnik, P. (2006). The excellent city park system: What makes it great and how to get there. The Human Metropolis: People and Nature in the 21st-Century City [Full Book], 47. http://dx.doi.org/10.2307/j.ctt5vk28x.12

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. Annual Review of Public Health, 35, 207–228. https://doi.org/10.1146/annurev-publhealth-032013-182443. http://dx.doi.org/10.1146/annurev-publhealth-032013-182443

Hehn, C., Heiland, S. and Hokema, D., 2015. Grüne Infrastruktur. Ein Gewinn für Landschaftsund Freiraumplanung. Landschaftsarchitekten, 2, pp.4-5.

Huang, L., Wu, J., & Yan, L. (2015). Defining and measuring urban sustainability: a review of indicators. Landscape Ecology, 30, 1175–1193. http://dx.doi.org/10.1007/s10980-015-0208-2

Hu, T., Chang, J., & Syrbe, R.-U. (2020). Green Infrastructure Planning in Germany and China: A comparative approach to green space policy and planning structure. Research in Urbanism Series, 6, 99–126.

Hussnain, M. Q., Anjum, G. A., Wakil, K., & Tharanga, P. (2014). Improving Efficiency in Data Collection for Urban Development Plans through Information and Communication Technology. International Conference on Town Planning and Urban Management (ICTPUM). Lahore.

Hoffmann, A., & Gruehn, D. (2010). Bedeutung von Freiräumen und Grünflächen in deutschen Groß-und Mittelstädten für den Wert von Grundstücken und Immobilien. TU, LLP.

Holling, C. S. (1973). Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4(1), 1–23. http://dx.doi.org/10.1146/annurev.es.04.110173.000245

Holling, C. S. (1996). Engineering resilience versus ecological resilience. Engineering within Ecological Constraints, 31(1996), 32.

Holling, C. S. (1986). The resilience of terrestrial ecosystems: local surprise and global change. Sustainable Development of the Biosphere, 14, 292–317.

Horwood, K., 2011. Green infrastructure: reconciling urban green space and regional economic development: lessons learnt from experience in England's north-west region. Local Environment, 16(10), pp.963-975. http://dx.doi.org/10.1080/13549839.2011.607157

Ifejika Speranza, C. (2010). Resilient adaptation to climate change in African agriculture (Issue 54). Studies.

Ignatieva, M., Stewart, G. H., & Meurk, C. (2011). Planning and design of ecological networks in urban areas. Landscape and Ecological Engineering, 7, 17–25. http://dx.doi.org/10.1007/s11355-010-0143-y

IPCC. (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability. In Climate Change 2014: Impacts, Adaptation and Vulnerability. https://doi.org/10.1017/cbo9781107415386

IPCC. (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation Special. In Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change (Vol. 9781107025). https://doi.org/10.1017/CBO9781139177245.009

Jacobs, C., Elbers, J., Brolsma, R., Hartogensis, O., Moors, E., Rodríguez-Carretero Márquez, M. T., & van Hove, B. (2015). Assessment of evaporative water loss from Dutch cities. Building and Environment, 83, 27–38. https://doi.org/10.1016/j.buildenv.2014.07.005

Jago-on, K. A. B., Kaneko, S., Fujikura, R., Fujiwara, A., Imai, T., Matsumoto, T., Zhang, J., Tanikawa, H., Tanaka, K., & Lee, B. (2009).

Urbanization and subsurface environmental issues: An attempt at DPSIR model application in Asian cities. Science of the Total Environment, 407(9), 3089–3104. http://dx.doi.org/10.1016/j.scitotenv.2008.08.004

James, P., Tzoulas, K., Adams, M. D., Barber, A., Box, J., Breuste, J., Elmqvist, T., Frith, M., Gordon, C., & Greening, K. L. (2009). Towards an integrated understanding of green space in the European built environment. Urban Forestry & Urban Greening, 8(2), 65–75. http://dx.doi.org/10.1016/j.ufug.2009.02.001

Jan, B., & Iqbal, M. (2008). Urbanization trend and urban population projections of Pakistan using weighted approach. In Sarhad Journal of Agriculture (Pakistan): Vol. v. 24.

Jongman, R. H. G., & Pungetti, G. (2004). Introduction: ecological networks and greenways. In Ecological networks and greenways; concept, desing, implementation (pp. 1–6). Cambridge University Press. http://dx.doi.org/10.1017/cbo9780511606762.003

Jordan, J. C. (2009). Rethinking Community Resilience to Climate Change: Does a Social Capital Lens Help? Development Studies Association (DSA) Annual Conference 2009: Contemporary Crises and New Opportunities.

Kambites, C. and Owen, S. (2006) 'Renewed prospects for green infrastructure planning in the UK', Planning Practice and Research, 21, pp. 483–496. doi: 10.1080/02697450601173413.

Kennedy, C., Cuddihy, J., & Engel-Yan, J. (2007). The changing metabolism of cities. Journal of Industrial Ecology, 11(2), 43–59. http://dx.doi.org/10.1162/jie.2007.1107

Kearns, A., Saward, R., Houlston, A., Rayner, J., & Viraswamy, H. (2014). Building urban resilience through green infrastructure pathways. Resilient Sustainable Cities: A Future, 52–65. http://dx.doi.org/10.4324/9780203593066-14

Khan, Sanaullah (5 August 2023). "2023 census results 'unanimously' approved at CCI meeting". DAWN. https://www.dawn.com/news/1768626/population-surpasses-240m-new-census-shows. (accessed on 08.08.2023).

Kardan, O., Gozdyra, P., Misic, B., Moola, F., Palmer, L. J., Paus, T., & Berman, M. G. (2015). Neighborhood greenspace and health in a large urban center. Scientific Reports, 5(1), 11610. https://doi.org/10.1038/srep11610

Khayyam, U. Floods: impacts on livelihood, economic status and poverty in the north-west region of Pakistan. Nat Hazards 102, 1033–1056 (2020). https://doi.org/10.1007/s11069-020-03944-7

Khayyam, U. (2016). What (not) Advances Effective Community-driven Development?: A Socio-economic & Politico-cultural Analysis of the Pashtun Ethnic Society of FATA, Pakistan. Universität Münster.

Khayyam, U., & Noureen, S. (2020). Assessing the adverse effects of flooding for the livelihood of the poor and the level of external response: A case study of Hazara Division, Pakistan. Environmental Science and Pollution Research, 27, 19638–19649. http://dx.doi.org/10.1007/s11356-020-08303-4

Khayyam, U., & Munir, R. (2022). Flood in mountainous communities of Pakistan: how does it shape the livelihood and economic status and government support? Environmental Science and Pollution Research, 1–20. http://dx.doi.org/10.1007/s11356-022-18709-x

Khayyam, U., & Waseem, S. (2021). Carbon emission as a result of forest land change in Islamabad, Pakistan. In Climate Change Science (pp. 41–57). Elsevier. http://dx.doi.org/10.1016/b978-0-12-823767-0.00003-3

Khayyam, U. (2016). What (not) Advances Effective Community-driven Development?: A Socio-economic & Politico-cultural Analysis of the Pashtun Ethnic Society of FATA, Pakistan. Universität Münster.

Kim, H. W., & Tran, T. (2018). An evaluation of local comprehensive plans toward sustainable green infrastructure in US. Sustainability, 10(11), 4143.

Kim, T.-B. (2010). Collaborative governance for sustainable development in urban planning in South Korea. University of Birmingham. http://dx.doi.org/10.3390/su10114143

Klein, R. J. T., Nicholls, R. J., & Thomalla, F. (2003). Resilience to natural hazards: How useful is this concept? Global Environmental Change Part B: Environmental Hazards, 5(1), 35–45. http://dx.doi.org/10.1016/j.hazards.2004.02.001

KPBOS. Khyber Paktunkhwa Bureau of Statistics. (2018). Available online: https://kpbos.gov.pk/ (accessed on 11.12.2020).

Lafortezza, R., Davies, C., Sanesi, G., & Konijnendijk, C. (2013). Green Infrastructure as a tool to support spatial planning in European urban regions. IForest - Biogeosciences and Forestry, 6(3), 102–108. https://doi.org/10.3832/ifor0723-006

Lafortezza, R., & Sanesi, G. (2019). Nature-based solutions: Settling the issue of sustainable urbanization. Environmental Research, 172, 394–398. http://dx.doi.org/10.1016/j.envres.2018.12.063

Landscape Institute. (2009). Green infrastructure: connected and multifunctional landscapes. Landscape Institute Position Statement. https://landscapewpstorage01.blob.core.windows.net/www-landscapeinstitute-org/2016/03/GreenInfrastructureLIPositionStatement2013.pdf

Leichenko, R. (2011). Climate change and urban resilience. Current Opinion in Environmental Sustainability, 3(3), 164–168. http://dx.doi.org/10.1016/j.cosust.2010.12.014

Little, C. E. (1995). Greenways for america. JHU Press.

Llausàs, A. and Roe, M., 2012. Green infrastructure planning: cross-national analysis between the North East of England (UK) and Catalonia (Spain). European planning studies, 20(4), pp.641-663. http://dx.doi.org/10.1080/09654313.2012.665032

Liu, W., Chen, W., & Peng, C. (2015). Influences of setting sizes and combination of green infrastructures on community's stormwater runoff reduction. Ecological Modelling, 318, 236–244. http://dx.doi.org/10.1016/j.ecolmodel.2014.11.007

Liu, X., Liu, H., Chen, J., Liu, T., & Deng, Z. (2018). Evaluating the sustainability of marine industrial parks based on the DPSIR framework. Journal of Cleaner Production, 188, 158–170. http://dx.doi.org/10.1016/j.jclepro.2018.03.271

Lu, F., & Li, Z. (2003). A model of ecosystem health and its application. Ecological Modelling, 170(1), 55–59. https://doi.org/10.1016/S0304-3800(03)00300-4

Luyet, V., Schlaepfer, R., Parlange, M. B., & Buttler, A. (2012). A framework to implement stakeholder participation in environmental projects. Journal of Environmental Management, 111, 213–219. http://dx.doi.org/10.1016/j.jenvman.2012.06.026

Mackrodt, U., & Helbrecht, I. (2013). Performative Bürgerbeteiligung als neue Form kooperativer Freiraumplanung. DisP-The Planning Review, 49(4), 14–24. http://dx.doi.org/10.1080/02513625.2013.892782

Mackrodt, U., & Helbrecht, I. (2013). Performative Bürgerbeteiligung als neue Form kooperativer Freiraumplanung. DisP-The Planning Review, 49(4), 14–24. http://dx.doi.org/10.1080/02513625.2013.892782

Mell, I. (2022). Examining the Role of Green Infrastructure as an Advocate for Regeneration. In Frontiers in Sustainable Cities (Vol. 4). https://www.frontiersin.org/articles/10.3389/frsc.2022.731975

Manyena, S. B. (2006). The concept of resilience revisited. Disasters, 30(4), 434–450. http://dx.doi.org/10.1111/j.0361-3666.2006.00331.x

Matthews, T., Lo, A. Y., & Byrne, J. A. (2015). Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. Landscape and Urban Planning, 138, 155–163. https://doi.org/https://doi.org/10.1016/j.landurbplan.2015.02.010

Mattijssen, T. J. M., Buijs, A. A. E., Elands, B. H. M., Arts, B. J. M., van Dam, R. I., & Donders, J. L. M. (2019). The transformative potential of active citizenship: Understanding changes in local governance practices. Sustainability, 11(20), 5781. http://dx.doi.org/10.3390/su11205781

Maier, C., Lindner, T., & Winkel, G. (2014). Stakeholders' perceptions of participation in forest policy: A case study from Baden-Württemberg. Land Use Policy, 39, 166–176. http://dx.doi.org/10.1016/j.landusepol.2014.02.018

Mazza, L., Bennett, G., Nocker, L. De, Gantioler, S., Margerison, L. L., Kaphengst, C. T., McConville, A., Rayment, M., Brink, P. ten, Tucker, G., & Diggelen, R. Van. (2011). Green Infrastructure Implementation and Efficiency. Final report for the European Commission, DG Environment on Contract ENV.B.2/SER/2010/0059.

McDonnell, M. J., Pickett, S. T. A., Groffman, P., Bohlen, P., Pouyat, R. V, Zipperer, W. C., Parmelee, R. W., Carreiro, M. M., & Medley, K. (2007). Ecosystem processes along an urban-to-rural gradient. In Urban Ecology. Springer.

McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. Biological Conservation, 127(3), 247–260. https://doi.org/10.1016/j.biocon.2005.09.005

McPherson, E. G., & Muchnick, J. (2005). Effects of street tree shade on asphalt concrete pavement performance. Journal of Arboriculture, 31(6), 303–310. http://dx.doi.org/10.48044/jauf.2005.039

MEA. Millennium ecosystem assessment (2005). Ecosystems and Human Well-Being. Synthesis. In World Health.

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. Landscape and Urban Planning, 147, 38–49. http://dx.doi.org/10.1016/j.landurbplan.2015.11.011

Mell, I. C. (2010). Green infrastructure: concepts, perceptions and its use in spatial planning. Newcastle University.

Mell, I. C., Henneberry, J., Hehl-Lange, S., & Keskin, B. (2013). Promoting urban greening: Valuing the development of green infrastructure investments in the urban core of Manchester, UK. Urban Forestry & Urban Greening, 12(3), 296–306. http://dx.doi.org/10.1016/j.ufug.2013.04.006

Mell, I. C. (2013). Can you tell a green field from a cold steel rail? Examining the "green" of Green Infrastructure development. Local Environment, 18(2), 152–166. http://dx.doi.org/10.1080/13549839.2012.719019

Mell, I. C. (2010). Green infrastructure: concepts, perceptions and its use in spatial planning. Newcastle University. https://theses.ncl.ac.uk/dspace/bitstream/10443/914/1/Mell10.pdf

Mell, I. (2015). Green infrastructure planning: policy and objectives. In Handbook on green infrastructure (pp. 105–123). Edward Elgar Publishing. http://dx.doi.org/10.4337/9781783474004.00013

Mell, I. C. (2017). Green infrastructure: reflections on past, present and future praxis. In Landscape research (Vol. 42, Issue 2, pp. 135–145). Taylor & Francis. http://dx.doi.org/10.1080/01426397.2016.1250875

Mell, I., Allin, S., Reimer, M., & Wilker, J. (2017). Strategic green infrastructure planning in Germany and the UK: a transnational evaluation of the evolution of urban greening policy and practice. International Planning Studies, 22(4), 333–349. https://doi.org/10.1080/13563475.2017.1291334.

Mentens, J., Raes, D., & Hermy, M. (2006). Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? Landscape and Urban Planning, 77(3), 217–226. https://doi.org/10.1016/j.landurbplan.2005.02.010

Mensah, C. A. (2014). Destruction of urban green spaces: A problem beyond urbanization in Kumasi city (Ghana). http://dx.doi.org/10.11648/j.ajep.20140301.11

Millennium Ecosystem Assessment. (2003). Ecosystem and human well-being: a framework eitfor assessment. World Resources Institute, Washington, DC.

Monteiro, R.; Ferreira, J.C. Green Infrastructure Planning as a Climate Change and Risk Adaptation Tool in Coastal Urban Areas. J. Coast. Res. 2020, 95, 889–893. http://dx.doi.org/10.2112/si95-173.1

Naeem, S., Cao, C., Fatima, K., Najmuddin, O., & Acharya, B. K. (2018). Landscape greening policies-based land use/land cover simulation for Beijing and Islamabad—An implication of sustainable urban ecosystems. Sustainability, 10(4), 1049. http://dx.doi.org/10.3390/su10041049

Nasir Iqbal. (2009). Supreme Court orders equal benefits for transvestites. https://www.dawn.com/news/477909/supreme-court-orders-equal-benefits-for-transvestites.

Naumann, S., Davis, M., Kaphengst, T., Pieterse, M., & Rayment, M. (2011). Design, implementation and cost elements of Green Infrastructure projects. Final Report, European Commission, Brussels, 138.

Naumann, S., Anzaldua, G., Berry, P., Burch, S., Davis, M., Frelih-Larsen, A., Gerdes, H., & Sanders, M. (2011). Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe. Final Report to the European Commission, DG Environment.

NDMA. October 19, 2022. "NDMA Floods (2022): Sitrep Report No.128." https://cms.ndma.gov.pk/storage/app/public/situation reports/October2022/QECa7rSLzWINuxZFHrHV.pdf.

National Disaster Management Authority of Pakistan (NDMA) (2012). National Disaster Management Plan. Islamabad: NDMA. Available at http://www.ndma.gov.pk/ex/Documents/ndmp.zip. http://dx.doi.org/10.1007/978-3-030-87745-3_300443

NDMA, 2010. National Disaster Management Authority, Islamabad, Pakistan. Annual Report 2010. Available at http://www.ndma.gov.pk.

NDMA, (2011). National Disaster Management Authority, Islamabad, Pakistan. http://www.ndma.gov.pk.

Niemeijer, D., & de Groot, R. S. (2008). A conceptual framework for selecting environmental indicator sets. Ecological Indicators, 8(1), 14–25. http://dx.doi.org/10.1016/j.ecolind.2006.11.012

Nizamani, A. A., & Shah, A. A. (2004). A review of forest policy trends for community participation in Pakistan. Policy Trend Report 2004, 28–34.

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. Urban For Urban Green 4: 115–123. http://dx.doi.org/10.1016/j.ufug.2006.01.007

o'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., & Nygaard, L. (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. Global Environmental Change, 14(4), 303–313. http://dx.doi.org/10.1016/j.gloenvcha.2004.01.001

OECD. (2001). Citizens as partners: Information, consultation and public participation in policy-making. Organisation for Economic Co-operation and Development, Paris. https://internationalbudget.org/wp-content/uploads/Citizens-as-Partners-OECD-Handbook.pdf. http://dx.doi.org/10.1787/9789264195578-en

OECD. (1993). Environmental indicators. A preliminary set. In Paris, France (Vol. 13, Issue 3). https://doi.org/10.1177/009155218501300304

Olafsson, A. S., & Pauleit, S. (2018). Green Surge Final Project Report. https://cordis.europa.eu/docs/results/603/603567/final1-green-surge-final-project-report-jan2018.pdf.

Pahl-Weber, E., & Henckel, D. (2008). The planning system and planning terms in Germany: A glossary (Issue 7). Studies in Spatial Development.

Pauleit, S., Ambrose-Oji, B., Andersson, E., Anton, B., Buijs, A., Haase, D., Elands, B., Hansen, R., Kowarik, I., & Kronenberg, J. (2019). Advancing urban green infrastructure in Europe: Outcomes and reflections from the GREEN SURGE project. Urban Forestry & Urban Greening, 40, 4–16. http://dx.doi.org/10.1016/j.ufug.2018.10.006

Pauleit, S., Hansen, R., Rall, E. L., Zölch, T., Andersson, E., Luz, A. C., Szaraz, L., Tosics, I., & Vierikko, K. (2017). Urban landscapes and green infrastructure. In Oxford research encyclopedia of environmental science. http://dx.doi.org/10.1093/acrefore/9780199389414.013.23

Pauleit, S., Liu, L., Ahern, J., & Kazmierczak, A. (2011). Multifunctional green infrastructure planning to promote ecological services in the city. http://dx.doi.org/10.1093/acprof:oso/9780199563562.003.0033

Pataki, D.E., Carreiro, M.M., Cherrier, J., Grulke, N.E., Jennings, V., Pincetl, S., Pouyat,R.V., Whitlow, T.H., Zipperer, W.C., 2011. Coupling biogeochemical cycles in urban environments: ecosystem services, green solutions, and misconceptions. Front. Ecol. http://dx.doi.org/10.1890/090220

Pakzad, P., Osmond, P., & Corkery, L. (2017). Developing Key Sustainability Indicators for Assessing Green Infrastructure Performance. Procedia Engineering. https://doi.org/10.1016/j.proeng.2017.04.174

Peterson, R. A. (1994). A Meta-analysis of Cronbach's Coefficient Alpha. Journal of Consumer Research. https://doi.org/10.1086/209405

Pörtner, H.-O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., Begum, R. A., Betts, R., Kerr, R. B., & Biesbroek, R. (2022). Climate change 2022: Impacts, adaptation and vulnerability. IPCC Geneva, Switzerland:

PBS. Pakistan Bureau of Statistics, population census 2023. Available online: https://www.pbs.gov.pk/content/announcement-results-7th-population-and-housing-census-2023-digital-census. (accessed on 08.08.2023).

Pretty, J., Peacock, J., Sellens, M., & Griffin, M. (2005). The mental and physical health outcomes of green exercise. International Journal of Environmental Health Research. http://dx.doi.org/10.1080/09603120500155963

Pickett, S. T. A., Burch, W. R., Dalton, S. E., Foresman, T. W., Grove, J. M., & Rowntree, R. (1997). A conceptual framework for the study of human ecosystems in urban areas. Urban Ecosystems. http://dx.doi.org/10.1023/a:1018531712889

Pintér, L., Hardi, P., Martinuzzi, A., & Hall, J. (2018). Bellagio STAMP: Principles for sustainability assessment and measurement. In Routledge handbook of sustainability indicators (pp. 21–41). Routledge. http://dx.doi.org/10.4324/9781315561103-2

Pugh, T. A. M., MacKenzie, A. R., Whyatt, J. D., & Hewitt, C. N. (2012). Effectiveness of green infrastructure for improvement of air quality in urban street canyons. Environmental Science & Technology. http://dx.doi.org/10.1021/es300826w

Rall, L., Niemela, J., Pauleit, S., Pintar, M., Lafortezza, R., Santos, A., & Železnikar, Š. (2015). A typology of urban green spaces, eco-system services provisioning services and demands. Report D3, 1.

Rayan, M., Gruehn, D., & Khayyam, U. (2021a). Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective. Urban Climate, 38, 100899. https://doi.org/https://doi.org/10.1016/j.uclim.2021.100899

Rayan, M., Gruehn, D., Khayyam, U., (2021b). Green infrastructure planning. A strategy to safeguard urban settlements in Pakistan. In: Jafari, M., Gruehn, D., Sinemillioglu, H., Kaiser, M. (Eds.), Planning in Germany and Iran. Responding Challenges of Climate Change through Intercultural Dialogue. Mensch und Buch Verlag. Berlin, pp. 197–220.

Rayan, M.; Khayyam, U.; Gruehn, D (2022). Local Perspectives on Green Resilient Settlements in Pakistan. In CIGOS 2021, Emerging Technologies and Applications for Green Infrastructure. Lecture Notes in Civil Engineering; Ha-Minh, C., Tang, A.M., Bui, T.Q., Vu, X.H.,Huynh, D.V.K., Eds.; Springer: Berlin/Heidelberg, Germany, 2022; Volume 203. [CrossRef]

Rayan, M.; Gruehn, D.; Khayyam, U (2022a). Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan. Sustainability 2022,14, 7966. https://doi.org/10.3390/su14137966.

Rayan, M.; Gruehn, D.; Khayyam, U (2022b). Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan. Int. J. Environ. Res. Public Health 2022, 19, 11844. https://doi.org/10.3390/ijerph191911844

Resilience, R. A. U. (2007). Research Prospectus.

Roe, M. and Mell, I., 2013. Negotiating value and priorities: evaluating the demands of green infrastructure development. Journal of Environmental Planning and Management, 56(5), pp.650-673. http://dx.doi.org/10.1080/09640568.2012.693454

Rolf, W. (2020). Peri-urban farmland included in green infrastructure strategies promotes transformation pathways towards sustainable urban development. Universität Potsdam. http://dx.doi.org/10.3097/lo.202196

Roggema, R. (2010). Adaptation to climate change: a spatial challenge. Springer. (Assessed 09-02-2021).

Rouse, D. C., & Bunster-Ossa, I. F. (2013). Green infrastructure: a landscape approach (Issue 571).

RVR – Regionalverband Ruhr (Eds.). (2016). Grüne Infrastruktur Ruhr. Essen: Regionalverband Ruhr. 83 pp.http://www.konzeptruhr.de/fileadmin/user_upload/metropoleruhr.de/Konzept_Ruhr/Veroeffe ntlichungen/WEBVERSION_Gruene_Infrastruktur_Ruhr_Dez16.pdf. (Accessed on 15.12.2022)

RVR. (2014). Trägerschaft für den Emscher Landschaftspark. Evaluierungsbericht 2014. Essen: Druckhaus. Cramer. https://www.rvr.ruhr/fileadmin/user_upload/01_RVR_Home/02_Themen/Umwelt_Oekologie/Emscher_Landschaftspark/PDFs/2014_Evaluierungsbericht_Emscher_Landschaftspark.pdf. Accessed 15. December.2022

Samara, T., & Tsitsoni, T. (2011). The effects of vegetation on reducing traffic noise from a city ring road. Noise Control Engineering Journal. http://dx.doi.org/10.3397/1.3528970

SEDAC. (2007). Socioeconomic Data and Applications Center -SEDAC compendium of environmental sustainability indicator collections. Columbia University.

Sekovski, I., Newton, A., & Dennison, W. C. (2012). Megacities in the coastal zone: Using a driver-pressure-state-impact-response framework to address complex environmental problems. Estuarine, Coastal and Shelf Science, 96, 48–59. http://dx.doi.org/10.1016/j.ecss.2011.07.011

Seto, K.C., Fragkias, M., Güneralp, B., Reilly, M.K., 2011. A meta-analysis of global urban land expansion. PloS one 6 (8), e23777.DOI:10.1371/journal.pone.0023777.

Segnestam, L., Aguilera Klink, F., Winograd, M., Farrow, A., Eade, J., Canter, L. W., Reid, W. V, McNeely, J. A., Tunstall, D. B., & Bryant, D. A. (2003). Indicators of environment and sustainable development: theories and practical experience (Issue P01 234). World Bank, Washington, DC (EUA).

Shen, L. Y., Jorge Ochoa, J., Shah, M. N., & Zhang, X. (2011). The application of urban sustainability indicators - A comparison between various practices. Habitat International. https://doi.org/10.1016/j.habitatint.2010.03.006

Shoup, L., & Ewing, R. (2010). The economic benefits of open space, recreation facilities and walkable community design. A Research Synthesis. Princeton, NJ, Active Living Research, a National Program of the Robert Wood Johnson Foundation.

Singh, K. (2007). Quantitative social research methods. Sage.

Shahid, N., Cao, C., Fatima, K., Najmuddin, O., & Acharya, B. K. (2018). Landscape greening policies-based land use/land cover simulation for Beijing and Islamabad—An implication of sustainable urban ecosystems. Sustainability, 10(4), 1049. http://dx.doi.org/10.3390/su10041049

Sturiale, L., & Scuderi, A. (2019). The role of green infrastructures in urban planning for climate change adaptation. Climate, 7(10), 119. http://dx.doi.org/10.3390/cli7100119

TEP. (2005). Advancing the delivery of green infrastructure: targeting issues in England's Northwest. The Environment Partnership.

Tzoulas, K., et al., 2007. Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. Landsc. Urban Plan. 81 (3), 167–178. https://doi.org/10.1016/j.landurbplan.2007.02.001.

UNDP-Pakistan. Development Advocate Pakistan. Sustain. Urbanization. 2018. Available online: https://www.undp.org/pakistan/publications/sustainable-urbanization (accessed on 16 August 2021).

UNDP-Pakistan. Development Advocate Pakistan, Population Growth: Implications for Human Development. 2019. Available online: https://www.pk.undp.org/content/pakistan/en/home/library/development_policy/dap-vol6-iss1-population-growth.html (accessed on 16.08.2021).

United Nations (UN), (2014). World Urbanization Prospects: The 2014 Revision, Highlights, Department of Economic and Social Affairs, Population Division, (ST/ESA/SER.A/352). http://dx.doi.org/10.7202/009001ar

UN. (2011). The 2011 Revision of World Urbanization Prospects. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. http://dx.doi.org/10.18356/cd4eece8-en. Available online: http://esa.un.org/unpd/wup/index.htm (accessed on 11.11.2021).

UN. (2019). World Urbanization Prospects:The 2018 Revision (Vol. 12). Department of Economics and Social Affair, Population Division, United Nation. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

UNDP-Pakistan. (2019). Development Advocate Pakistan, "Population Growth: Implications for Human Development" (Vol. 6, Issue 1). https://www.pk.undp.org/content/pakistan/en/home/library/development_policy/dap-vol6-iss1-population-growth.html (accessed on 16.08.2021).

UNDP-Pakistan. (2018). Development Advocate Pakistan, "Sustainable Urbanization" Available online: https://www.undp.org/pakistan/publications/sustainable-urbanization (accessed on 16 August 2021).

UNFPA (2008) State of world population 2007: unleashing the potential of urban growth, www.unfpa.org/swp/2007/english/chapter_3/index.html. (accessed on 06.06.2020].

UNFCCC. (2007). Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Bonn, Germany: United Nations Framework Convention on Climate Change. http://dx.doi.org/10.4324/9780203888469-65

UNFCCC. (2014). Background on the UNFCCC: The international response to climate change. United Nations Framework Convention on Climate Change: http://unfccc.int/essential_background/items/6031.php (accessed on 11.06. 2021).

UN Habitat. (2004). Urban indicator guidelines. Kenya.

UNISDR. (2012). How to make cities more resilient: a handbook for local government leaders. United Nations Geneva.

UN-SDG (2019). The Sustainable Development Goals Report: United Nations Department of Economic and Social Affairs. http://dx.doi.org/10.18356/55eb9109-en. Available online: https://www.un-ilibrary.org/content/books/9789210478878/read (accessed on 06.12.2021).

UN-OCHA. Pakistan Flood Relief and Early Recovery Response plan; United Nations Office for the Coordination of Humanitarian Affairs: New York, NY, USA, 2010.

USEPA. (2010). Green infrastructure case studies: municipal policies for managing stormwater with green infrastructure. EPA (USA) Washington, DC.

Van Renterghem, T., Botteldooren, D., & Verheyen, K. (2014). Road traffic noise shielding by vegetation belts of limited depth. Journal of Sound and Vibration. http://dx.doi.org/10.1016/j.jsv.2012.01.006

Von Haaren, C., & Reich, M. (2006). The German way to greenways and habitat networks. Landscape and Urban Planning, 76(1–4), 7–22. http://dx.doi.org/10.1016/j.landurbplan.2004.09.041

Von Haaren, C., Galler, C., & Ott, S. (2008). Landscape planning. The basis of sustainable landscape development. Bundesamt Für Naturschutz/Federal Agency for Nature Conservation, Gebr. Klingenberg Buchkunst Leipzig GmbH, 51.

Wakil, K., Hussnain, M. Q., Yusuf, A., & Abdul Jabbar, J. (2016). Project Report: Scenario Planning based Participatory Urban Growth Management Plans Using ICT. Islamabad. Available online: https://think-asia.org/handle/11540/7573 (accessed on 11.06.2022).

Waseem, S., & Khayyam, U. (2019). Loss of vegetative cover and increased land surface temperature: A case study of Islamabad, Pakistan. Journal of Cleaner Production, 234, 972–983. http://dx.doi.org/10.1016/j.jclepro.2019.06.228

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. Ecology and Society, 9(2). http://dx.doi.org/10.5751/es-00650-090205

Walker, B., & Salt, D. (2012). Resilience practice: building capacity to absorb disturbance and maintain function. Island press. http://dx.doi.org/10.5822/978-1-61091-231-0

Weber, T., Sloan, A., & Wolf, J. (2006). Maryland's Green Infrastructure Assessment: Development of a comprehensive approach to land conservation. Landscape and Urban Planning. http://dx.doi.org/10.1016/j.landurbplan.2005.02.002

Weber, T. C., & Allen, W. L. (2010). Beyond on-site mitigation: An integrated, multi-scale approach to environmental mitigation and stewardship for transportation projects. Landscape and Urban Planning. http://dx.doi.org/10.1016/j.landurbplan.2010.04.003

Weilenmann, M. F., Vasic, A. M., Stettler, P., & Novak, P. (2005). Influence of mobile air-conditioning on vehicle emissions and fuel consumption: A model approach for modern gasoline cars used in Europe. Environmental science & technology, 39(24), 9601-9610. http://dx.doi.org/10.1021/es050190j

Weldon, S., Bailey, C., & O'Brien, L. (2007). New pathways to health and well-being: Summary of research to understand and overcome barriers to accessing woodland. Edinburgh: Forestry Commission Scotland.

Westphal, L. M. (2003). Urban greening and social benefits: a study of empowerment outcomes. Arboriculture & Urban Forestry, 29(3), 137. http://dx.doi.org/10.48044/jauf.2003.017

Williamson, K. S. (2003). Growing with green infrastructure. Heritage Conservancy Doylestown.

Wilker, J., Rusche, K., & Rymsa-Fitschen, C. (2016). Improving participation in green infrastructure planning. Planning Practice & Research, 31(3), 229–249. http://dx.doi.org/10.1080/02697459.2016.1158065

Wilkinson, C. (2012). Social-ecological resilience: Insights and issues for planning theory. Planning Theory, 11(2), 148–169. http://dx.doi.org/10.1177/1473095211426274

Wise, S., Braden, J., Ghalayini, D., Grant, J., Kloss, C., MacMullan, E., Morse, S., Montalto, F., Nees, D., & Nowak, D. (2010). Integrating valuation methods to recognize green infrastructure's multiple benefits. In Low impact development 2010: Redefining water in the city (pp. 1123–1143). http://dx.doi.org/10.1061/41099(367)98

Wong, T. H. F., & Brown, R. R. (2009). The water sensitive city: Principles for practice. Water Science and Technology, 60(3), 673–682. https://doi.org/10.2166/wst.2009.436

Wong, C. P., Jiang, B., Kinzig, A. P., Lee, K. N., & Ouyang, Z. (2015). Linking ecosystem characteristics to final ecosystem services for public policy. Ecology Letters, 18(1), 108–118. http://dx.doi.org/10.1111/ele.12389

World Bank. (1996). The World Bank Participation Sourcebook. World Bank,Washington. http://dx.doi.org/10.1596/0-8213-3558-8. Available online: https://documents1.worldbank.org/curated/en/289471468741587739/pdf/multi-page.pdf. (accessed on 11.06.2021).

World Bank. (2008). Global city indicator programme report. Canada: World Bank.

Wright, H. (2011). Understanding green infrastructure: the development of a contested concept in England. Local Environment, 16(10), 1003–1019. http://dx.doi.org/10.1080/13549839.2011.631993

Wu, J., & Wu, T. (2012). Sustainability indicators and indices: an overview. Handbook of Sustainability Management, 65–86. http://dx.doi.org/10.1142/9789814354820_0004

Yang, J., Yu, Q., & Gong, P. (2008). Quantifying air pollution removal by green roofs in Chicago. Atmospheric Environment, 42(31), 7266–7273. http://dx.doi.org/10.1016/j.atmosenv.2008.07.003

Yin, R. K. (2003). Case study research design and methods third edition. Applied Social Research Methods Series, 5.

Yin, R. K. (2009). Case study research: Design and methods (Vol. 5). sage.

Zhang, K., Wen, Z., Du, B., & Song, G. (2008). A multiple-indicators approach to monitoring urban sustainable development. Ecology, Planning, and Management of Urban Forests: International Perspectives, 35–52. http://dx.doi.org/10.1007/978-0-387-71425-7_4

Zhang, K., He, X., & Wen, Z. (2003). Study of indicators of urban environmentally sustainable development in China. International Journal of Sustainable Development, 6(2), 170–182. http://dx.doi.org/10.1504/ijsd.2003.004213

Appendix

Publications

Appendix

A	*Article:* Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective
B	*Article*: Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan
C	*Article*: Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan
D	Structured questionnaire for native experts and households (HHs) community survey.

Article A

Key facts and author contributions

Reference	Rayan, M., Gruehn, D., & Khayyam, U. (2021a). Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective. *Urban Climate*, 38, 100899. https://doi.org/https://doi.org/10.1016/j.uclim.2021.100899
Contributions	MR: 100% (character count: ca. 46,252)
Review	Double-blind peer review
Publication	Submitted: 05 March 2021 Accepted: 20 Jun 2021 Published: 29 Jun 2021

Signature:

_________________________ ____03.01.2024_______

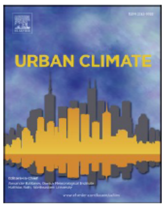
Muhammad Rayan Date

Urban Climate 38 (2021) 100899

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim



Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective

Muhammad Rayan [a,*], Dietwald Gruehn [a], Umer Khayyam [b]

[a] *School of Spatial Planning, Chair of Landscape Ecology and Landscape Planning (LLP), TU Dortmund University, Germany*
[b] *Department of Development Studies, School of Social Sciences and Humanities (S3H), National University of Sciences and Technology (NUST), Islamabad, Pakistan*

A R T I C L E I N F O

Keywords:
Urban green infrastructure (UGI)
Urban resilience
Urban eco-system
Sustainable UGI indicators
Relative Index (RI) analysis

A B S T R A C T

Over the recent years, urban green infrastructure (UGI) modelling has emerged as an adaptation strategy to enhance cities' resilience against ever-rising environmental hazards. The UGI improves urban eco-system functions to protect human health and wellbeing, both locally and globally. Pakistan lacks inclusive and resilient land-use planning policies as well as frameworks to protect its inhabitants, and ecosystems from the rising climatic hazards. So, this research aims to determine and assemble sustainable UGI planning indicators based on local stakeholder's perspectives. It is to develop a comprehensive and integrative indicator-based framework model to build climate-resilient urban regions in Pakistan's northwest parts. The in-depth online expert's survey is administered through 172 questionnaires themed around UGI, urban resilience and climate change adaptation. The data is analysed by using Relative Importance Index (RII) and Interquartile Range Technique (IQR). The finding shows potential twenty-two (primary and secondary) sustainable UGI indicators, classified into three main categories; Extremely Important (*E*-Imp); Important (Imp) and Moderately important (M-Imp) levels. Subsequently, a set of vital green elements that achieved (RII value ≥ 0.76) were identified that upgraded and strengthened each UGI indicator's quality. Additionally, it helps to reinforce an intricate connection among climate resilience strategies, green spaces, ecosystem functions, and human health/wellbeing in the study region. The UGI model facilitates policy planning and decision-making process for resilient land use planning and urban sustainability.

1. Introduction

It remains imperative to build environmental sustainability in times of unprecedented urban growth. Also, the vital aspects are climate variability and sudden change patterns of land cover due to anthropogenic activities that have transformed the urban outlook under threats like flooding, drought, urban heat island effect, intensified energy demands, and carbon emissions (Desa, 2014, 2019). In response, global societies have developed several theoretical frameworks and instrumental approaches instead of building urban sustainability. Yet, any scientific and policy indicators are limited to assist in-validating a margin between essential and inessential indicators. Alternatively, developing and grounding Green Infrastructure Indicators (GI) remains essential and crucial for urban

* Corresponding author.
E-mail addresses: muhammad.rayan@tu-dortmund.de (M. Rayan), dietwald.gruehn@tu-dortmund.de (D. Gruehn), dr.umer@s3h.nust.edu.pk (U. Khayyam).

https://doi.org/10.1016/j.uclim.2021.100899
Received 5 March 2021; Received in revised form 18 June 2021; Accepted 20 June 2021
Available online 29 June 2021

regions. Urban Green Infrastructure (UGI)[1] is recognized as a cost-effective and nature-based infrastructure solution for enhancing urban sustainability. It also helps in achieving resilience against climate change (CC) in the upset urban regions (Tzoulas et al., 2007). UGI strengthens the resilience of the natural systems to cope with climatic hazards at an altered intensity at multiple levels. Besides that UGI is revamping the existing present ideas of urban green space planning (Davies et al., 2005). It also improves the interlinkage of green space networks with the community's welfare, biodiversity, and stormwater management. Due to the broadness of scale, UGI can be utilized to enhance the health of the urban eco-system (Weber and Allen, 2010), in flood-affected countries like Pakistan.

The last two decades recorded and testified that most major cities of Pakistan (e.g., Islamabad, Peshawar, Lahore, Karachi, etc.) are faced with a declining trend of green spaces. To blame are: inadequate landscape and greening policies (LGP) and lack of awareness resulting in the transformation of agricultural land to urban infrastructure development (Naeem et al., 2018). At the back end lies population explosion and uncontrolled migration to urban centres in the wake of better socio-economic and livelihood opportunities.

At the national level in Pakistan, 39.22% of inhabits (out of 207.7 million) are dwelled in urban areas (PBS, 2018) . This unprecedented concentration has evolved multidisciplinary climatic challenges, majorly the urban flooding. The increasing number of flood events has started endangering the safety of human health, natural resources as well as urban ecosystems. It is because, Pakistan is ranked the 8th most vulnerable country to natural disasters in the world, followed by Thailand and Nepal, according to the Germanwatch long-term climate risk index (CRI) [2] (Eckstein et al., 2020). This is mainly the result of the non-availability of resources and poor management and planning practices (Ahsan, 2018), ending up in multi-hazards, which has extended (direct and indirect) damages to the urban system. Further to blame are inappropriate planning guidelines and frameworks for developing and managing activities within the green spaces. If the present planning situation persists, it will trigger many more natural disaster events of various scales and effects in the country, including the north-western parts of the country, more severely.

The North-West region/Khyber Pakhtunkhwa (KP) province of Pakistan faces more severe impacts of urban flooding (Atta-ur-Rahman and Khan, 2013). The region lies at the core of in-daunting natural disasters i.e., urban flooding. It is linked to the area's unique geophysical location in the Himalayas, Hindukush, and Karakoram ranges. Major rivers of Pakistan e.g., Swat Kabul, Kunhar and Panjkora, etc. arise from these steep and high mountains, which increase the catchment area vulnerability towards urban flooding (Khayyam and Noureen, 2020) (Fig. 1). To address all these interconnected causes and effects of flooding, an eco-friendly policy and strategy concerning resilient land use planning are required, considering urban green infrastructure (UGI) and climate change (CC) themes holistically.

It will be naive to say that no research studies had been performed on such topics, specifically in Pakistan. Sofar researches found that improving the spatial technologies adoption in the planning process, and the development of land use maps is the most recent one (Hussnain et al., 2014; Wakil et al., 2016). But, these are at the earlier research stages, besides such proposed interventions require considerable time and financial resources to develop an efficient and systematic data collection mechanism Whereas, in contrast, many studies on green infrastructure planning, as a nature-based adaptation and mitigation tool to climate change were found in the developed countries like, Netherland, Germany and the UK (Demuzere et al., 2014; Lafortezza et al., 2013; Matthews et al., 2015; Mell et al., 2017; Monteiro and Ferreira, 2020).

So, the need of the time is to develop a sustainable composite urban green infrastructure (UGI), indicator-based framework model. Only such a model can help to provide land use planning policies and strategies for smart resilient, and sponge cities. This will increase the percentage of innovative mixed-use urban green spaces helping to minimize surface runoff and enrich the infiltration capacity. This would also help recharge the aquifers efficiently (15%- 64%) compared to grey infrastructure. It is, therefore, indispensable to plan green spaces infrastructure in a way that should supplement the present grey infrastructure and enhance the urban resilience of KP against climate variation. This planning technique has the potential to promote and encourage nature-based infrastructure solutions to naturally minimize the urban flooding effects (Gill et al., 2007). Thus, broad-based planning instruments can contribute to protecting, restoring, and advance the socio-economic and ecological well-being of KP.

Thus, to identify and rank the significance level of each UGI indicator and its interlinkage with multiple green elements, this research study will be a pioneering step to develop a sustainable composite indicator-based framework model. According to the local environment, this model will encompass a set of core UGI indicators and green elements. Such a model will assist in building resilient urban regions that have the capacity to protect the KP region against natural disasters or flooding.

The research study tries to answer the following research questions:

I. Which vital key green elements improve the resilience of a UGI indicator?
II. How to identify and rank the degree of importance of each UGI indicator in terms of the applicability and scale in building an eco-friendly urban environment?
III. How to determine the importance level of each potential green element in regards to the specific UGI indicator?

[1] The growing intensity of UGI planning has made the term to be defined more explicitly as 'the network of open spaces, waterways, gardens, woodlands, green corridors, street trees and open countryside that brings many social, economic and environmental benefits to local people and communities' (TEP, 2005). An alternate version of UGI is "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions sustains clean air and water and provides a wide array of benefits to people and wildlife" (Benedict and McMahon, 2006).

[2] The German Global Climate Risk Index is a study based upon reliable and complete set of data available on the impacts of climate-related hazards, observed by all the countries worldwide. Furthermore, the low income countries should understand the index as a sign of warning in order to be well prepared for extreme weather and climate events in the future. www.germanwatch.org/en/cri

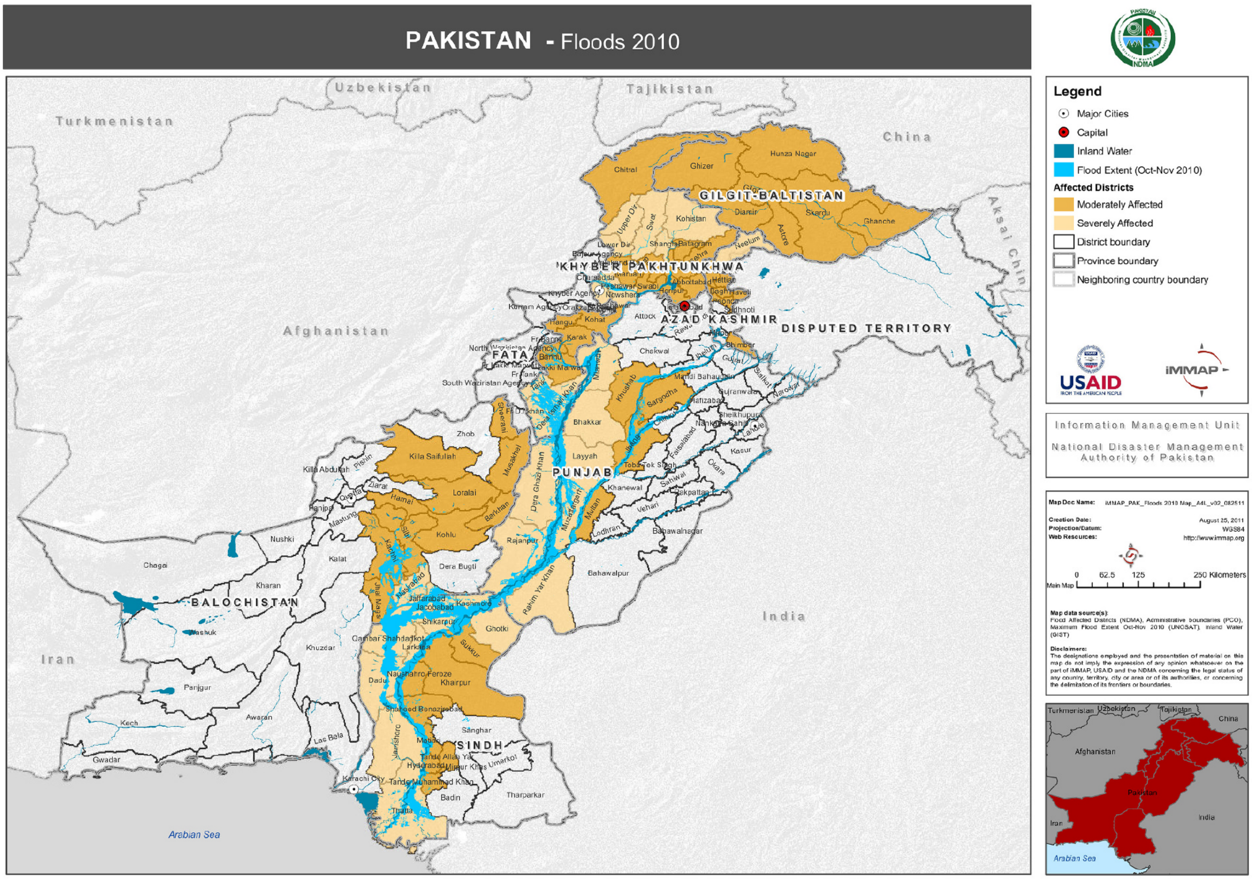


Fig 1. Flood affected urban centres.
Sources: Pak-NDMA (2011)

2. Research methodology

2.1. Deployed frameworks

The proposed UGI conceptual framework developed by (Rayan et al., 2021) was based on Driver-Pressure-State-Impact-Response (DPSIR) framework. The model conceptualizes a relationship among GI elements and anthropogenic activities. It is to reduce environmental stress, upsurges ecosystem functions, and human wellbeing at both individual and community levels (see Figure A.1). The second conceptual framework/model was evolved by (Tzoulas et al., 2007) that inserted three more fundamental elements like, GI elements, eco-system function aspects, and climate resilience strategies, as shown in (Figure B.1). This provides resilience against Anthropocentrism activities and helps to minimize continuous pressure on the ecology of the region. Urban green spaces typologies and ecosystem health model are revised by the author developed from (Ahern, 2007; Davies et al., 2006; USEPA, 2010; Gill et al., 2007) and (Lu and Li, 2003), relates to the quantity, quality, and variability of eco-system functions. The strong correlations between the said four systems are evident (Rayan et al., 2021). Additionally, semi-structured meetings were conducted in Pakistan with experts regarding the potential role of green growth development as an element of an ecofriendly environment- that has evolved nine themes Table 1. Blending both models and concepts in a consolidated framework helps identify and select the initial set of ten ecological, six socio-cultural, and six economic (primary and secondary) potential UGI indicators and ten GI elements and technologies. This would enhance and strengthen the resilience of the urban land use planning in coping with gradually climate-changing like heat island effect; urban flooding; drought in Pakistan.

The proposed indicators were quantitative, which were analysed on responses of the local actors towards urban Green infrastructure (UGI) indicators. The examination aimed to determine the relative importance index (RII) of each indicator in terms of the applicability and scale regarding specific green elements for an eco-friendly environment. This will validate and verify a set of most significant ecological, socio-cultural, and UGI planning indicators and their relationship with each particular green element. This allows us to strengthen the urban climate resilience and will benefit cities specifically at the community scale. It is managing urban flooding risk, decreasing the effects of Urban Heat Island (UHI); reduce building power consumption, and upgrading coastal resiliency.

Table 1
List of concepts, evolved from the local expert's meetings.

Mitigation to climate change	Adaptation to climate change	Water management
Green space networks	Ecosystem functions and services	Wildlife and Biodiversity
Urban resilience	Organic food production	Energy-efficient building
Social cohesion /unity	A green economy	

Source: Author's.

This study formulates an inclusive and composite indicator-based model, which provides an opportunity to enhance the outdoor natural atmosphere and proposed innovative natural avenues for climate change adaptation in KP province. The study will be seen as a first and pioneer step to put the research in its relevant local context of Peshawar and Mardan division within the north-western parts of KP province.

2.2. Sampling size and sampling technique

In total 212 respondents participated in the study, out of which 172[3] questionnaires (with 95% and margin of error ± 5%) were scrutinized and included in the analysis, as per (Cochran, 1977). Initially, a pre-test was carried out with two local government officials, three academicians, and two practitioners to examine the suitability, inclusiveness, and precision of the survey questionnaires as it helps to refine the final questionnaire tool (Munn and Drever, 1990). Some minor revisions were made based on the inputs provided by the participants to make the survey design more appropriate and time-efficient (Appendix C).

In the final survey, maximum variability was ensured ($p = .5$), despite the lack of data on experts, which provides the exact numbers of local stakeholders in the relevant fields (Cochran, 1977). The results were then generalized over the total study population as suggested by (Baruch, 1999) and (Babbie, 1973). The questionnaire was based on open-ended and closed-ended questions with answers registered on the Likert scale[4] of Sections A-C (Fig. 2). The questions revolved around UGI indicators and green elements in the relevance of local context, suggested by (Likert, 1932; Bucci, 2003; Singh, 2007).

Purposive sampling was deployed in the classification of experts, which helps to categorize the stakeholders into multiple classes such as policymakers; practitioners (architects, planners, ecologists, and sociologists, etc.); academicians, and students, as illustrated by Table 2. Within the purposive sampling, the snowball technique was employed to identify specific actors. Each respondent further recommended another local expert with appropriate knowledge and expertise in the relevant field to gather relevant information, as accepted (Singh, 2007).

2.3. Targeted stakeholder

The targeted stakeholders were stakeholders having subject knowledge from diverse fields; decision-makers, academicians, practitioners, and students involved in planning and policymaking for sustainable urban development in Pakistan (Table 2). The study has targeted individuals from diversified, age, education, gender, expertise, professional experience, etc. groups (Table D.1). The demographic profile confirmed 46% as female and 54% as male. The majority of respondents were from Lahore (capital of Punjab province), Peshawar (capital of Khyber Pakhtunkhwa province), and Islamabad (Capital of Pakistan), considered as major urbanized cities of Pakistan. Regarding the background of the participant, the greater majority are, architects which are 69 (40.1%) of the respondent; urban planners are 34 (19.8%); infrastructure experts are 19 (11%); Landscape experts are 16 (9.3%), and climate change/ ecologist experts are 14 (8.1%) of the respondents.

This signifies almost all stakeholders from eight sectors participated. In the context to the respondent's expertise, as illustrated in Appendix D, 30.8% have less than five years of professional experience; 37.2% have five to ten years of hands-on experience; 20.9% have eleven to fifteen five experience and 11.0% have more than fifteen years of practical experience. This shows high standard quality data are collected.

Furthermore, the URL links of survey questionnaires were also mailed to the state representative institutes and non-state actors at national and provincial levels, such as the Pakistan Council of Architecture And Town Planners (PCATP); Ministry of Planning Development & Special Initiatives (PC); Ministry of Climate Change (MOCC); Environmental Protection Agency (Pak-EPA); Ministry of

[3] The rest questionnaires were excluded as mandatory questions were not answered.

[4] Section A: aimed at verifying the participant's profile, knowledge, and experience. The category of 'trans' as a third gender was included as officially recognized by government of Pakistan. Section B: encompassed four questions, explained in (Annex 2). Which verifying and validating the local stakeholder perspective on the proposed possibilities and definitions of the UGI, climate change, climate change adaptation, and urban resilience. Section C: are classified into the three subsections (ecological, socio-cultural, and economic), and each section includes multiple questions with the aim of rating and identifying the importance level of specific sustainable UGI indicator and its interrelationship with multiple green elements. Potential UGI indicators and elements were developed by the author in his preceding research studies. This resulted in selecting the most vital green elements that enhanced the quality standard of a particular UGI indicator and build resilient urban regions against natural hazards like flooding.

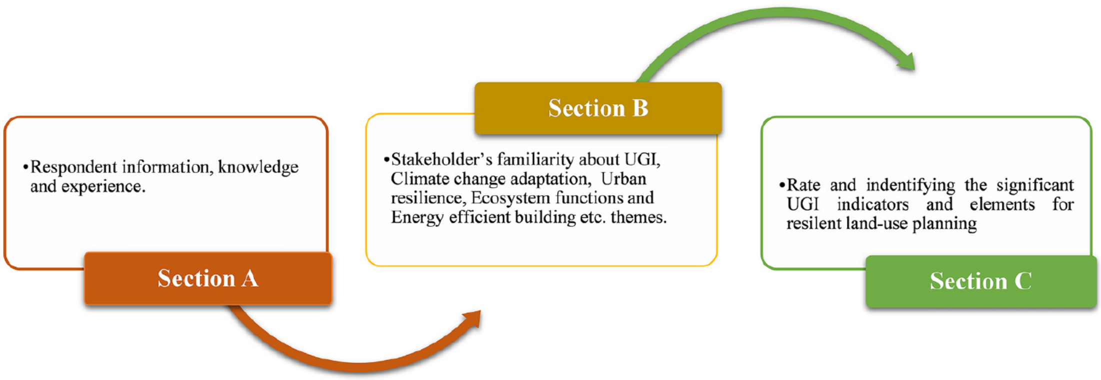


Fig. 2. Hierarchical sections of an In-depth questionnaire survey.
(Source: Author's)

Table 2
List of Stakeholders/Sampling groups.

NO	Stakeholders
1	Government Official (Policy/ Decision-makers)
2	Planners
3	Architects
4	Environmentalists
6	Economists
7	Academicians
8	University Students
9	Non-state actors e.g. (ADB & GIZ-Pakistan)

Source: Author's

Housing and Works; Forestry, Environment and Wildlife Department, Government of Khyber Pakhtunkhwa (KP); Urban Policy Unit (UPU), Planning and Development (P&D), KP province, and the non-state actors e.g. Asian development bank (ADB), Pakistan and Deutsche Gesellschaft für Internationale Zusammenarbeit, (GIZ) GmbH, Pakistan.

2.4. *Data analysis*

The acknowledged feedbacks were examined using both "Statistical Package for the Social Sciences" (SPSS) and Microsoft Excel software. Questions based coding systems were adopted for section B and C, which helps to segregate the stakeholder responses easily and strengthen the results reliability.

Two Likert scales were utilized to get the participant feedback, section-b utilizes a 5-point Likert scale, and a 9-point Likert scale was applied in section-c. Based upon the expert's survey questionnaire content, data analysis was distributed into three following components i.e.

- Section A: demographic analysis;
- Section B: identifying the definition, knowledge, and familiarity of stakeholders about UGI, urban resilience, climate change, and climate change adaptation themes;
- Section C: determining the relative importance index (RII) analysis of the UGI indicators and green space elements.

The relative index (RI) analysis technique was utilized, which helps in determining and calculating the comparative significance of each UGI indicator and its relationship with various vital green space elements related to the local environment. This methodology is considered as the best strategy for such forms of ordinal scale surveys (Chinyio et al., 1998; Adetunji, 2006; Braimah and Ndekugri, 2009).

To calculate the relative importance index, the following equation was employed Eqn I.

$$RII = \Sigma W/(N^*A) \tag{I}$$

[w = weightage assign by each participant on a Likert scale (one to five or one to nine), N = total no of the sample size, and A = highest weight on a scale].

Based on a relative index (results) significance level of each UGI indicator was determined. Moreover, it illustrated the ranking order of UGI indicators as per their importance. In order to determine a rational number of key sustainable UGI indicators and elements from the RII results, two different methodologies were adopted. First; relative Index values (RIV) were transformed into the Nine-point important scale (Table 3). This recognizes the importance level of each UGI indicator and ranks them accordingly. For this reason, important scale criteria were adopted (Chinyio et al., 1998; Akadiri, 2011) on adding four more levels to accomplish the variation in the degree of importance among the specified sustainable UGI indicators.

Secondly, to determine the importance level and the correlation of green space elements with the respective potential UGI indicator, developed by the author in his earlier research study (Rayan et al., 2021). An interquartile range technique (IQR) is applied to establish the cut-off point[5] in the relative importance index values (RIV) of green elements. IQR is an effective technique that determines the difference between the median of the first quartile (Q1) and third quartile (Q3) of the RII data set (Beattie et al., 2004; Monette et al., 2013; Wan et al., 2014; Luo et al., 2016). This enables us to establish more manageable and key green elements that perform an imperative instrument in strengthening and improving the quality of a specific sustainable indicator. This leads to developing a comprehensive sustainable UGI indicator base model for building a resilient urban region in the north-western region of Pakistan.

3. Results and findings

3.1. Section B: Stakeholder's familiarity with urban green infrastructure, urban resilience, and climate change and adaptation themes

Section B of the survey questionnaire represent the local expert's familiarity they had with the multiple themes such as urban green infrastructure (UGI); urban resilience; climate change (CC) and climate change adaptation. To understand their perspective, four questions have been asked (Appendix E).

Fig. 3 clarifies the respondent's level of agreement for the suggested possibilities; illustrates what climate change means (CC) to them. The most approved options by the experts are one, and the dissatisfied option is five, with an agreed share of 85.1%, and 10.3%. Likewise, around ¾ of the respondents have experienced an increase in extreme weather events (e.g. Storms, droughts, and heavy precipitation) that have disturbed eco-friendly urban environment.

The results further examined climate change adaptation essence in a native context. The overall outcome represents that option one; had achieved a higher agreement percentage (74.7%) compare to option eight, which accomplished a lower percentage (2.3%) from the local actors, as illustrated in (Fig. 4).

The trends describe statistically foremost independent variables, contribute towards enhancing adaptive capacity and reducing the vulnerability towards climate change, i.e., urban flooding, and promote sustainable development in Pakistan.

Further results explored the level of awareness on urban resilience. More than three-fourths of the respondents endorsed that option one is more effective compared to the last option. Also, in other proposed descriptions, the confidence level varies, between 40% to 50%. This reflects a strong tendency to accentuate the resilience of the city.

The statistical investigation also portrays the expert's knowledge level on urban resilience. Moreover, it provides an insightful review of local stakeholders towards the safe and green resilience approaches for sustainable human settlements, as illustrated by Fig. 5.

It is worth mentioning that three-quarters (75.9%) of respondents acknowledge option 2 compared to option 8. This elucidates what urban green infrastructure (UGI) means to local stakeholders. In contrast, options 1, 3, and 14 also received more than half a degree of a confidence vote from the participants, reflects the level of satisfaction for the potential alternatives as summarised in Fig. 6. All these four possibilities can be perceived as an influential gauge that defines urban green Infrastructure (UGI) as illustrated below.

Option 2: Enhances the natural ecological processes and sustain the natural resource.

Option 3: Enhanced and maintained the level of biodiversity.

Option 1: Promote networks connectivity and mobility among the urban green spaces.

Option14: Reconnecting people with the landscape through innovative design by developing mixed-use spaces.

that service entire populations.

The above results show core key stakeholder has been involved at the local level in defining the aforementioned imperative themes.

[5] In this analysis, 0.76 value was considered as the cut-off point, that helps to identify the vital Green infrastructure elements for each sustainable green growth planning indicator. This contributes a significant role in upgrading and strengthening the resilience of the city system against the constantly rising climatic hazards in Pakistan.

Table 3
Nine-point important scale.

Extremely-Unimportant	(*E*-UNIMP)	(0 ≤ RI < 0.2)
Moderately-Unimportant	(M-UNIMP)	(0.2 ≤ RI < 0.3)
Slightly-Unimportant	(S-UNIMP)	(0.3 ≤ RI < 0.4)
Unimportant	(UNIMP)	(0.4 ≤ RI < 0.5)
Low	(L)	(0.5 ≤ RI < 0.6)
Slightly-Important	(S-IMP)	(0.6 ≤ RI < 0.7)
Moderately-Important	(M-IMP)	(0.7 ≤ RI < 0.8)
Important	(IMP)	(0.8 ≤ RI < 0.9)
Extremely-Important	(E-IMP)	(0.9 ≤RI ≤ 1)

Source: Author's.

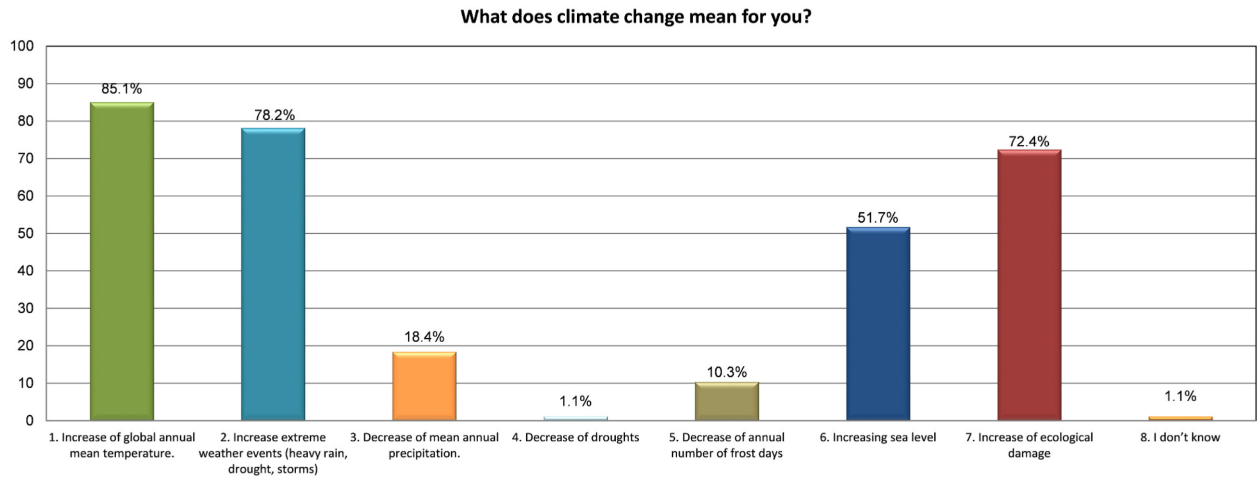


Fig. 3. Defining climate change (CC).
Source: Author's.

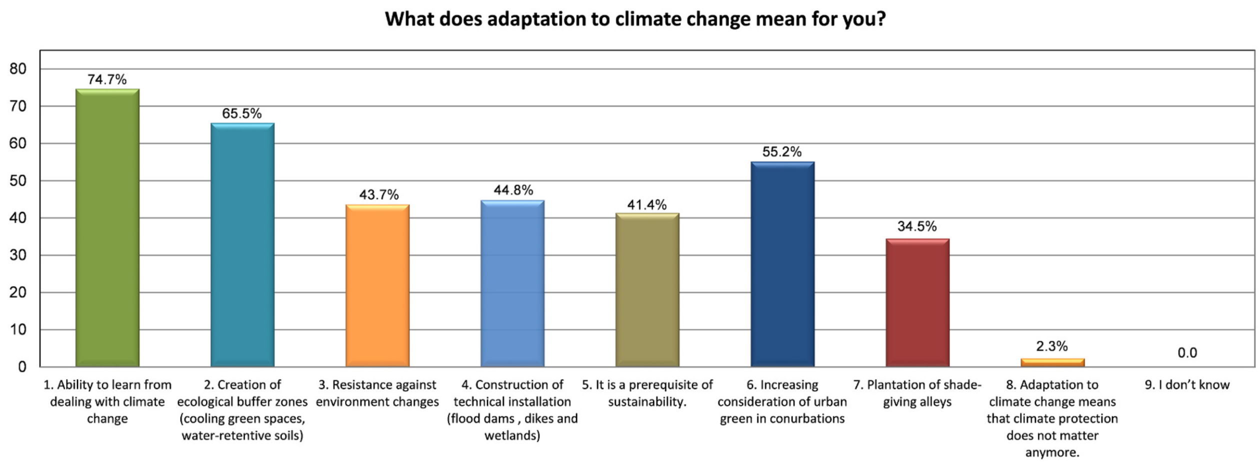


Fig. 4. Describing adaptation to climate change (CC).
Source: Author's.

It plays an essential role in verifying several optimal approaches to holistic UGI and climate change adaptation concepts. This may bring about the desire results in managing the natural hazards effectively at grassroot levels. Furthermore, this examination helps in developing a comprehensive framework, which would assist in defining appropriate sustainable UGI indicators and elements. Such an effort would contribute to managing urban ecosystems; enhance environmental, recreational, and human activities. Along with, minimize the forthcoming impacts of climate variations in the northwest urban region of Khyber Pakhtunkhwa, Pakistan.

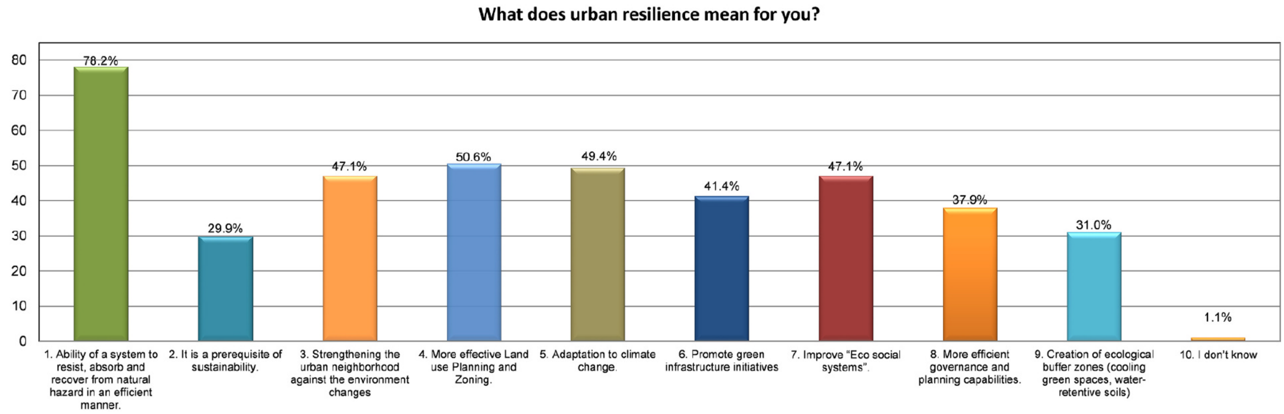


Fig. 5. Determining Urban resilience.
Source: Author's.

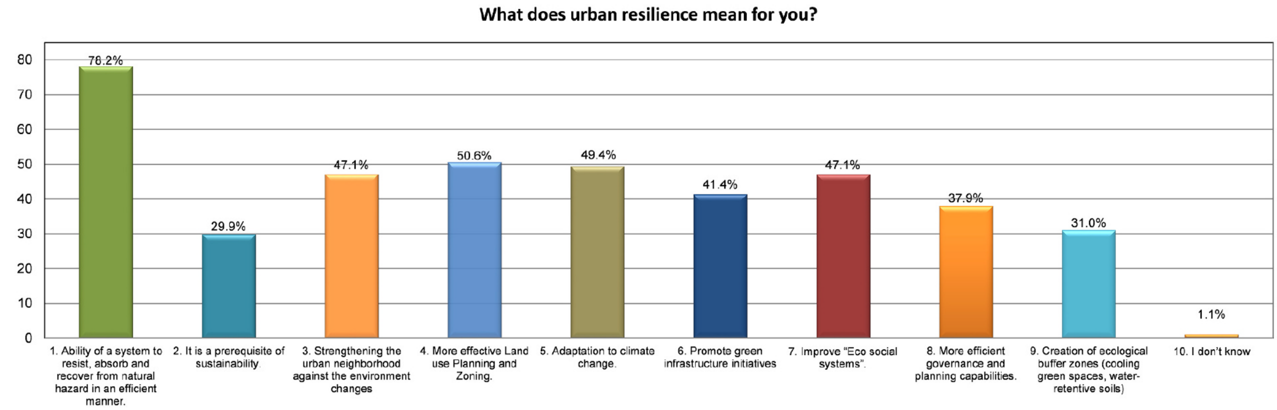


Fig. 6. Elucidating Urban Green Infrastructure (UGI). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
Source: Author's

Table 7
Cronbach's alpha reliability.

Criteria	Cronbach's alpha
Ecological	0.97600
Socio-cultural	0.93855
Economic	0.90279

Source: Author's calculated using survey data.

3.2. Section C: Analysis to measure the relative importance level of UGI indicators, and identify the essential key UGI elements for each sustainable indicator

At this level, exploratory analyses are clustered into two groups; the first set of analyses investigated the importance level of each UGI indicator, classified into three subcategories of sustainability. In the second level, key green elements are determined, which

Table 6
An example of RII calculation for, optimizing stormwater management indicator.

RII = Σ W / (N * A)……… (I)
W = weightage assigns to each indicator by the participants on a 9-point Likert scale.
N = Total no of the sample
A = Represents the highest weight on a Likert scale.

RII = (9*92) + (8*31) + (7*16) + (6*13) + (5*8) + (−4*3) + (−3*3) + (−2*2) + (−1*2) / (172*9) = 0.837

Source: Author's.

Table 7
Relative Importance Index (RII) value of each UGI indicator.

Ecological	Urban Green infrastructure Indicators	Respondents (N)	Weighted total	Relative Importance index (RII) RII = Σ W / (N*A)….. (i)	Cut-off point. Interquartile range technique (IQR)	Selected UGI Indicators (RII ≥ 0.85)	Ranking	Importance level
	1. Optimize storm water management							
	Increasing pervious surfaces.	172	1296	0.837	0.82	no	10	IMP
	Reducing, storing and biological-treating storm water runoff.	172	1250	0.807	0.82	no	13	IMP
	2. Reduction in urban heat island effects.							
	Increased percentage of green surface.	172	1398	0.903	0.82	yes	4	*E*-IMP
	Applying evaporative materials on roof, wall and ground surfaces.	172	1145	0.740	0.82	no	20	M-IMP
	3. Air quality improvement (e.g. pollutant removal, alter the wind flow).							
	Implementing green impermeable screen in a street canyon and planting high concentration of green trees.	172	1238	0.800	0.82	no	15	IMP
	4. Noise quality improvement							
	Applying green sound barrier for limited and higher noise reductions (i.e. for limited noise; thick hedges with a small piece of grassland can be provided and higher noise; broad-leaved deciduous trees, thick layers of bamboo can be provided).	172	1230	0.795	0.82	no	16	M-IMP
	5. Reduced carbon emission (e.g. avoided greenhouse gas emission through cooling).							
	Planting higher concentration of tree as shading and evaporating material for hardscape.	172	1400	0.904	0.82	yes	3	*E*-IMP
	6. Improve energy efficiency in buildings.							
	Optimize green energy saving techniques.	172	1448	0.935	0.82	yes	1	E-IMP
	7. Enhanced soil quality and erosion.							
	Intensification of permeable surfaces and optimizing soil stability.	172	1339	0.865	0.82	yes	6	IMP
	8. Enhanced and protect Urban Biodiversity.							
	Promote the connectivity and mobility between urban green spaces.	172	1301	0.840	0.82	no	8	IMP
Socio-cultural	1. Food production (e.g. urban agriculture; kitchen gardens; and community gardens).	172	1273	0.822	0.82	no	11	IMP

(*continued on next page*)

Table 7 (*continued*)

Ecological	Urban Green infrastructure Indicators	Respondents (N)	Weighted total	Relative Importance index (RII) RII = Σ W / (N*A)….. (i)	Cut-off point. Interquartile range technique (IQR)	Selected UGI Indicators (RII ≥ 0.85)	Ranking	Importance level
	2. Improving social well-being. Optimizing the opportunities for recreation, social interaction and enhanced attractiveness of city.	172	1299	0.839	0.82	no	9	IMP
	Enhanced attractiveness of city (diverse landscape features).	172	1205	0.778	0.82	no	17	M-IMP
	3. Improving physical and mental well-being (i.e. Visual and physical access to green space has a Positive relation with stress reduction and anxiety).	172	1347	0.870	0.82	yes	5	IMP
	4. Provision of outdoor sites for education and research.	172	1180	0.762	0.82	no	19	M-IMP
	5. Improve accessibility and connectivity to encourage cycling and walking opportunities.	172	1134	0.733	0.82	no	21	M-IMP
Economic indicators	1. Amplified property values.	172	1092	0.705	0.82	no	22	M-IMP
	2. Save healthcare cost.	172	1269	0.820	0.82	no	12	IMP
	3. Reduce energy consumption (e.g. cooling and heating demands).	172	1328	0.858	0.82	yes	7	IMP
	4. Reduce the risk of flood damages.	172	1424	0.920	0.82	yes	2	E-IMP
	5. Reducing private car use by increasing walking and cycling (e.g. shifting travel mode).	172	1248	0.806	0.82	no	14	IMP
	6. Value of air pollutant removal / avoidance.	172	1186	0.766	0.82	no	18	M-IMP

Source: Author's.

perform an essential tool in enhancing the relationship and quality standard of a particular UGI sustainable indicator against climate variability.

The Cronbach's alpha (α) reliability experiment was executed to examine the internal consistency of survey data sets as reflected in Table 7. The alpha (α) value for Ecological; Socio-cultural and Economic criteria were greater than (α = 0.7), an acceptable threshold of reliability (Cortina, 1993; Peterson, 1994; Hair et al., 1998).

3.2.1. *Determine the importance level of each potential UGI indicators*

The first phase of the study employs the Relative Importance Index (RII) methodology. This helps to evaluate the significance level, also determine the collective level of agreement among the local stakeholders for each respective UGI indicator (Table 7: and D.1:). The potential sustainable UGI indicators were ranked according to their weights calculated by using the RII eq. A sample of RII calculation for optimizing the stormwater management indicator is elucidated in below Table 6. Afterwards, the nine-point scale criteria (Table 3) were applied to the RII values to categorize the UGI indicator into multiple importance levels. This leads to accomplishing variance in the significance scales. (See Table 7.)

Table 8a
: Relative Importance Index (RII) value of each UGI Elements and technology.

Categories	Urban Green infrastructure Indicators	Relative Importance index (RII) of UGI Elements and technology RII = Σ W / (N * A)...............................(i)									
		Community Garden	Botanical Garden	Urban park	Forest	Green streets & alleys	Rain garden & Bio-wale	Green & Permeable parking lot	Wetland	Green roof & Green wall	Horticultural
Ecological	1. Optimize storm water management.										
	Increasing pervious surfaces	0.71	0.73	0.83	0.92	0.83	0.91	0.73	0.90	0.74	0.72
	Reducing, storing and biological-treating storm water runoff.	0.65	0.70	0.68	0.85	0.80	0.93	0.73	0.95	0.71	0.68
	2. Reduction in urban heat island effects (e.g. Increased percentage of green surface and applying evaporative materials on roof, wall and ground surfaces).	0.74	0.75	0.87	0.94	0.87	0.75	0.62	0.71	0.84	0.91
	3. Air quality improvement (e.g. pollutant removal, alter the wind flow).										
	Implementing green impermeable screen in a street canyon and planting higher concentration of green trees	0.66	0.67	0.71	0.93	0.85	0.48	0.61	0.77	0.81	0.72
	4. Noise quality improvement.										
	Applying green sound barrier for limited and higher noise reductions (i.e. for limited noise; thick hedges with a small piece of grassland can be provided and higher noise; broadleaved deciduous trees, thick layers of bamboo can be provided).	0.72	0.74	0.85	0.94	0.88	0.51	0.71	0.75	0.88	0.68
	5. Reduced carbon emission (e.g. avoided greenhouse gas emission through cooling).										
	Planting higher concentration of tree as shading and evaporating material for hardscape.	0.73	0.75	0.84	0.95	0.87	0.57	0.71	0.75	0.88	0.72
	6. Improve energy efficiency in buildings.										
	Optimize green energy saving techniques.	0.54	0.53	0.59	0.61	0.60	0.51	0.54	0.53	0.94	0.55
	7. Enhanced soil quality and erosion.										
	Intensification of permeable surfaces and optimizing soil stability.	0.78	0.75	0.81	0.93	0.80	0.74	0.70	0.84	0.68	0.74
	8. Enhanced and protect Urban Biodiversity.										
	Promote the connectivity and mobility between urban green spaces	0.73	0.85	0.84	0.92	0.81	0.61	0.68	0.84	0.79	0.76

(*continued on next page*)

Table 8a (*continued*)

Categories	Urban Green infrastructure Indicators	Relative Importance index (RII) of UGI Elements and technology RII = Σ W / (N * A)................................(i)									
		Community Garden	Botanical Garden	Urban park	Forest	Green streets & alleys	Rain garden & Bio-wale	Green & Permeable parking lot	Wetland	Green roof & Green wall	Horticultural
Socio-cultural	1. Food production (e.g. urban agriculture; kitchen gardens; and community gardens).	0.89	0.66	0.66	0.73	0.60	0.39	0.47	0.56	0.74	0.91
	2. Improving social well-being.										
	Optimizing the opportunities for recreation, social interaction and enhanced attractiveness of city.	0.75	0.86	0.92	0.89	0.89	0.62	0.72	0.84	0.86	0.74
	Enhanced attractiveness of city (diverse landscape features).	0.87	0.75	0.88	0.74	0.80	0.70	0.71	0.77	0.90	0.69
	3. Improving physical and mental well-being (i.e. visual and physical access to green space has a positive relation with stress reduction and anxiety).	0.93	0.79	0.88	0.92	0.79	0.55	0.69	0.84	0.71	0.74
	4. Provision of outdoor sites for education and research.	0.85	0.91	0.80	0.93	0.73	0.70	0.64	0.88	0.81	0.88
	5. Improve accessibility and connectivity to encourage cycling and walking opportunities.	0.74	0.74	0.86	0.87	0.93	0.42	0.65	0.80	0.60	0.67
Economic indicators	1. Amplified property values.	0.85	0.86	0.93	0.71	0.80	0.70	0.72	0.66	0.93	0.72
	2. Save healthcare cost.	0.91	0.78	0.87	0.92	0.84	0.57	0.67	0.73	0.71	0.81
	3. Reduce energy consumption (e.g. Cooling and heating demands).	0.73	0.73	0.83	0.87	0.79	0.72	0.73	0.75	0.93	0.73
	4. Reduce the risk of flood damages.	0.70	0.69	0.80	0.97	0.84	0.91	0.73	0.92	0.65	0.66
	5. Reducing private car use by increasing walking and cycling (e.g. shifting travel mode).	0.72	0.79	0.82	0.84	0.94	0.46	0.61	0.79	0.30	0.51
	6. Value of air pollutant removal / avoidance.	0.73	0.79	0.88	0.96	0.91	0.60	0.68	0.82	0.91	0.73

Source: Author's

Table 8b
: Key UGI indicators and Green elements.

Categories	Urban Green infrastructure Indicators	Interquartile range technique (IQR)		Cut-off point.	Selected No of UGI elements (RII ≥ 0.76)	Selected Green elements
		IQR = (Q3-Q1) (Median)	Mean (IQR)			
Ecological	1. Optimize storm water management .					
	Increasing pervious surfaces	0.79	0.76	0.76	5	Rain Garden; Wetland; Forest; Green streets; Urban parks.
	Reducing, storing and biological-treating storm water runoff.	0.72	0.76	0.76	4	Rain Garden; Wetland; Forest; Green streets
	2. Reduction in urban heat island effects (e.g. Increased percentage of green surface and applying evaporative materials on roof, wall and ground surfaces).	0.79	0.76	0.76	5	Green roofs and wall; Forest; Green streets; Urban parks.
	3. Air quality improvement (e.g. pollutant removal, alter the wind flow)					
	Implementing green impermeable screen in a street canyon and planting higher concentration of green trees.	0.72	0.76	0.76	4	Wetland; Green roof & Green wall
	4. Noise quality improvement					
	Applying green sound barrier for limited and higher noise reductions (i.e. for limited noise; thick hedges with a small piece of grassland can be provided and higher noise; broadleaved deciduous trees, thick layers of bamboo can be provided).	0.75	0.76	0.76	4	Forest; Urban parks; Green streets & alleys; Green roof & Green wall.
	3. Air quality improvement (e.g. pollutant removal, alter the wind flow)					
	Planting higher concentration of tree as shading and evaporating material for hardscape.	0.75	0.76	0.76	4	Forest; Urban parks; Green streets & alleys; Green roof & Green wall.
	6. Improve energy efficiency in buildings.					
	Optimize green energy saving techniques.	0.54	0.76	0.76	1	Green roof & Green wall.
	7. Enhanced soil quality and erosion.					
	Intensification of permeable surfaces and optimizing soil stability.	0.77	0.76	0.76	5	Forest; Urban parks; Green streets & alleys; Wetland
	8. Enhanced and protect Urban Biodiversity.					
	Promote the connectivity and mobility between urban green spaces.	0.80	0.76	0.76	6	Botanical Garden; Forest; Urban parks; Green streets & alleys; Wetland; Green roof & Green wall; Horticultural
Socio-cultural		0.66	0.76	0.76	2	Community Garden; Horticultural

(*continued on next page*)

Table 8b (*continued*)

Categories	Urban Green infrastructure Indicators	Interquartile range technique (IQR)		Cut-off point.	Selected No of UGI elements (RII ≥ 0.76)	Selected Green elements
		IQR = (Q3-Q1) (Median)	Mean (IQR)			
	1. Food production (e.g. urban agriculture; kitchen gardens; and community gardens).					
	2. Improving social well-being. Optimizing the opportunities for recreation, social interaction and enhanced attractiveness of city.	0.85	0.76	0.76	6	Botanical Garden; Forest; Urban parks; Green streets & alleys; Wetland; Green roof & Green wall.
	Enhanced attractiveness of city (diverse landscape features)	0.76	0.76	0.76	5	Community Garden; Urban parks; Green streets & alleys; Wetland; Green roof & Green wall.
	3. Improving physical and mental well-being (i. e. Visual and physical access to green space has a positive relation with stress reduction and anxiety).	0.79	0.76	0.76	6	Community Garden; Botanical Garden; Forest; Urban parks; Green streets & alleys; Wetland;
	4. Provision of outdoor sites for education and research.	0.83	0.76	0.76	7	Community Garden; Botanical Garden; Forest; Urban parks; Wetland; Green roof & Green wall; Horticultural
	5. Improve accessibility and connectivity to encourage cycling and walking opportunities.	0.74	0.76	0.76	4	Forest; Urban parks; Green streets & alleys; Wetland
Economic indicators	1. Amplified property values.	0.76	0.76	0.76	5	Community Garden; Botanical Garden; Urban parks; Green streets & alleys; Green roof & Green wall
	2. Save healthcare cost.	0.80	0.76	0.76	6	Community Garden; Botanical Garden; Urban parks; Forest; Green streets & alleys; Horticultural
	3. Reduce energy consumption (e.g. cooling and heating demands).	0.74	0.76	0.76	4	Forest; Urban parks; Green streets & alleys; Green roof & Green wall.
	4. Reduce the risk of flood damages.	0.76	0.76	0.76	5	Forest; Urban parks; Green streets & alleys; Rain garden & Bio- swale; Wetland.
	5. Reducing private car use by increasing walking and cycling (e.g. shifting travel mode).	0.75	0.76	0.76	5	Botanical Garden; Forest; Urban parks; Green streets & alleys; Wetland.
	6. Value of air pollutant removal / avoidance.	0.80	0.76	0.76	6	Botanical Garden; Forest; Urban parks; Green streets & alleys; Wetland; Green roof & Green wall.

Source: Author's.

All UGI indicators lie in the categories of extremely important (E-Imp) or essential (Imp), or moderately important (M-Imp). As listed in the table as mentioned above 7, four UGI indicators had achieved an extremely important (E-Imp) level with an RII value between 0.935 and 0.903. Eleven indicators had accomplished an important (Imp) level with an RII value between 0.874 and 0.800, and seven indicators had obtained a moderately important (M-Imp) level with an RII value between 0.795 and 0.707 range (Table 7).

Overall, the outcome establishes that the category of ecological indicators collects a higher acceptance level from the local stakeholders than the other two categories. The majority of ecological indicators fall into extremely Important (E-Imp) or Important (Imp) levels. This represents the significance of sustainable UGI indicators in building a resilient and eco-friendly urban environment in Pakistan. The most highly vulnerable country to climatic hazards like, e.g. urban flooding, drought, etc. (Eckstein et al., 2018).

3.2.2. *(a) Identifying the relative importance level of each potential green elements in regards to the specific sustainable UGI indicators*

The second phase of analysis identifies the vital elements that help to enhance and strengthen the quality of sustainable UGI indicators, mandated to build a safe and green resilient urban region against climate change in KP province. Based on the experts' perspective, the RII values were calculated. The empirical results portray, most of the green elements are rated above their mid-point (Table 8a). This signifies, actors give greater consideration to UGI elements in strengthening the standard and resilience of specific sustainable UGI indicators in the face of anticipated climate change impacts.

Based on the below empirical evidence, it can be stated that not every urban green space element had an excellent functional linkage with the respective UGI indicator. To reach an optimum result, a manageable number of green elements are selected for each UGI indicator from the list of RII values; helped to reinforce the correlation between green growth planning indicators and elements (Table 8b). This correlation not only supports the policy formulation but also ensures the effectiveness of implementation for resilient land use planning. Moreover, it enhances the decision maker's perception and the capacity to identify and rectify the mistakes in coping with the gradually climate-changing.

3.2.3. *(b) Determining the vital key green space elements*

Table 8b presents the vital green space elements and their correlation with a specific sustainable UGI indicator. An Interquartile Range (IQR) technique is applied to determine the cut-off point in the Relative Importance Index (RII) data set. As the IQR value varies between 0.54 and 0.85, an average IQR data set was taken to define a specific cut-off point value of 0.76 (Table 8b). This helps to identify the significant green elements for respective sustainable green growth planning indicators, taken into account for the inclusive UGI indicator-based framework model.

Moreover, the most important finding of this study is the patterns of variation observed on the final list of selected vital green elements (Table 8b). This implies that not every individual green element performs an essential role in the robustness of the quality standard of respective UGI indicators against climate variability in the urban setting. This has led to an inclusive and cohesive UGI model that contributes to strengthening the intricate connection between climate resilience strategies, green spaces, ecosystems functions and ensuring human health and wellbeing.

Thus, to conclude, the ultimate aim of this examination is to accomplish a high level of agreement and attention from the local stakeholders towards the sustainable UGI indicator base framework for green growth planning, which may ultimately lead to a well-balanced relationship between anthropocentrism and eco-centrism activities in KP region.

4. Discussion

This study is an effort towards developing an inclusive, sustainable green growth planning indicator-based framework, which provides an opportunity to reconnect the local inhabitants with the innovative mixed-use green spaces. The interaction of human nature explores how to use nature-based infrastructure solutions, which, in turn, enables us to reduce vulnerability to climatic hazards and promote an eco-friendly environment through the window of urban green infrastructure (UGI). Global studies also endorse that the need the time is to synthesize UGI and resilience concepts into the planning process and develop resilient land use planning strategies, which ultimately lead to environmental sustainability (Foster et al., 2011). This planning technique fosters ecosystem resilience, biodiversity conversation and minimizes naturally the environmental stress resulting from anthropogenic activities in the urban interface of K·P province, Pakistan.

This region lies at the centre of in-daunting climatic challenges due to its adverse geographical location, inadequacy landscape and greening policies (LGP) for resilient land-use planning, and weakness in the planning authorities' law enforcement. This results in constant pressure on the urban land-cover of KP province, as a consequence of which, a dramatic decline is observed in the green space structure's quantity and quality (Shahid et al., 2018).

Further, in the discussion, this study found that a multidisciplinary expert-based participatory approach empowers and encourages the local actors to actively engage in the planning and decision-making process at all levels. It is recognized as the best tool to manage and promote community stewardship for urban green spaces more effectively at the grassroots level (Harnik, 2006). In relation, to the participatory approach in landscape and greening infrastructure policies, many developing countries like Pakistan still lack the institutionalization of the participatory approach in the policy and legal framework of the country (Ashfaque and Awan, 2015). This research shows the effective contribution of local stakeholder's in determining essential UGS elements for each respective sustainable UGI indicator. The methodology used to assess every UGS element against the individual UGI indicator: In order to accomplish a strong level of agreement among the local actors towards sustainable green growth planning indicators and elements. A broad pattern of variation observed, in particular in the selected key green elements, illustrates the impacts on the UGI indicators, which could show up a strong link between essential green elements and indicators. This ultimately leads to achieving an eco-friendly and climate resilience environment at the city and federal level.

Moreover, in view of the proceeding discussion, a significant relationship was established between each key green element and UGI indicator, whereas some green space element does not considerably improve the resilience of a specific UGI indicator. It is established that a distinctive quality characterizes every individual green element, contribute a positive role in improving the efficiency and effectiveness of UGI indicators, and help to adapt and mitigate the effects of climate change. The performance of UGS elements depends on two main factors; specific configuration and the spatial context on which it can be examined (Ahern, 2007). This simply means UGS elements can perform multiple functions, depending on the culture and context of the region. This empirical contribution helps to define a diverse taxonomy of UGS elements for the respective sustainable UGI indicators, which can contribute an essential value to urban climatic resilience at multiple scales of the KP region.

The cohabitation of key green elements and UGI indicators may lead to developing a sustainable UGI indicator-based framework model, which builds a new cultural paradigm that supports green growth development in the KP region. Ideally, this framework could be utilized in other provinces of Pakistan with similar characteristics.

5. Conclusion and policy implication

The study has presented an explicit methodology for developing a sustainable UGI indicator-based framework model, according to the local context. Such a scientific framework portrays the interrelationship of UGS elements with respective composite core UGI indicators and deepens local stakeholders' and decision-maker's understanding of the role of green space infrastructure planning in the mitigation and adaptation to climate-related disasters like e.g. urban flooding. Moreover, it improves the process of collaborations among the actors and relevant government institutions; that help to develop natural-based climate adaptation strategies, depending on the native condition. These strategies can lead a way to meet the goals of building climate-resilient cities in the KP region.

The empirical finding also shows: the rapid increase in climate change (CC) and the non-effective programming and structuring of institutions to cope with the climatic hazards is a significant setback in the landscape and greening policies (LGP) for resilient land-use planning of the KP region. Moreover, experience in coping with resilient land-use planning or simply climatic resilience through urban green space infrastructure is limited to the required extent. UGS infrastructure results from a proper effective planning system, while in developing countries like Pakistan, the planning system is undue influence; distorted the planning process and results. To bridge this planning gap, scientific knowledge and hands-on experience in the field of UGS infrastructure initiatives should be provided to the decision-makers. This result to identify the significance of UGS infrastructure in reshaping the land-use planning of urban regions; leads to achieving a resilient city-state.

In conclusion, these findings highlight the role of stakeholders in developing a sustainable UGI indicator-based framework, meeting the standards of a resilient city, and the role of stakeholders in developing a sustainable UGI indicator-based framework, meeting the standards of a resilient city through LGP policymaking and implementation. This will help in the development of green resilient cities not only specific to KP province, but also for the entire country.

5.1. *Policy implications*

The research findings recognized an increase in urban flooding in the study area, owing to a loss of urban green space structure' quantity and quality.

Hence, the study recommends several key policies and strategies to build a resilient urban region in coping with gradually climate-changing like urban flooding.

- A proactive approach of the decision-makers towards the long-term sustainable urban landscape and greening policies and strategies for resilient land use planning.
- Increasing knowledge and awareness among all local stakeholders and authorities to better understand urban greens space (UGS) infrastructure planning, a sustainable and cost-efficient climate change adaptation towards resilient cities. UGS should be integrated with the existing grey infrastructure to improve urban sustainability and achieve stability to address both presents and forthcoming flood risks.
- The natural-based green initiatives require intensive administrative support and encouragement at various levels, ranging from grass-root to local regional and national levels for the optimal result.
- In a flood-born area, the government should plan multiple vital UGS infrastructure elements like e.g. rain gardens, bioswales, infiltration trenches, green alleys, and green roofs, etc., that not only minimize the surface runoff but enriches the infiltration and storage capacity more efficiently.

- A need for developing an Inclusive and cohesive mapping of existing urban green spaces (UGS) at three different planning levels: local; regional; national. This would help to identify and develop a standardized classification of green space elements across all spatial levels. Such an effort would contribute to enhancing UGS potential, which ultimately may lead to overcoming the high risk of flooding in urban areas.
- In high vulnerable flood plains areas, the need for governments is to relocate the local inhabitants to safer zones and re-convert the development land into multiple green buffer zones that encompass different green measures like, e.g. wetlands, artificial dikes, and water-absorbent forest landscapes, etc. The Dutch and German case studies are good examples of GI measures implementation, sustainable tools for reducing risks of urban flooding, and climate variation.

6. Further research

This work is part of an in-progress research study aimed to develop a UGI indicator-based framework model, which assists in defining the landscape and greening policies (LGP) and strategies for resilient land-use planning. It can be seen as a pioneering step to put the research in its relevant local urban context of the KP region. The empirical study proposes a comprehensive and integrative framework with a set of twenty-two (primary and secondary) sustainable UGI indicators and vital urban green space elements (UGS) elements for each particular green growth planning indicator, grounded on the survey data analysis.

In the forthcoming research, the practicability of a composite UGI framework will also be examined by an in-depth community survey at the district level. The sampling will be done in three different districts of KP province, i.e. Peshawar, Mardan, and Charsadda. Based upon their local perspective and experience, weights will be allocated to the potential UGS elements in terms of applicability in specified sustainable UGI indicators. This will portray the satisfaction level of local inhabitants regarding the identified vital UGS elements and their correlation with the respective potential UGI indicator. It also presents how familiar the local community is with multiple concepts like urban green Infrastructure (UGI); urban resilience; and climate change and adaptation.

In addition, the important area of study is to foster community participation, which is not being practised in the country as a whole. So, research findings can endorse and encourage the participatory planning approach for building a climate-resilient urban region through policymaking and implementation of green infrastructure strategies.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Consent to publish

The authors declare their consent to publish this study once finally accepted, both in soft and hard as copyright of the publisher.

Authors contributions

All authors whose names appear in the manuscript have contributed at all stage of this study, including the preparation of this manuscript.

Availability of data and materials

All data generated or analysed during this study are included in this article.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Muhammad Rayan reports financial support was provided by DAAD - Deutscher Akademischer Austauschdienst. Muhammad Rayan reports a relationship with DAAD - Deutscher Akademischer Austauschdienst that includes: funding grants.

Acknowledgements

The author would like to acknowledge the financial grant made available through the DAAD - Deutscher Akademischer Austauschdienst to support this research, Ref: Funding programme/-ID: Forschungsstipendien - Promotionen in Deutschland, 2018/19 (57381412).

Appendix A. Development of conceptual base frameworks

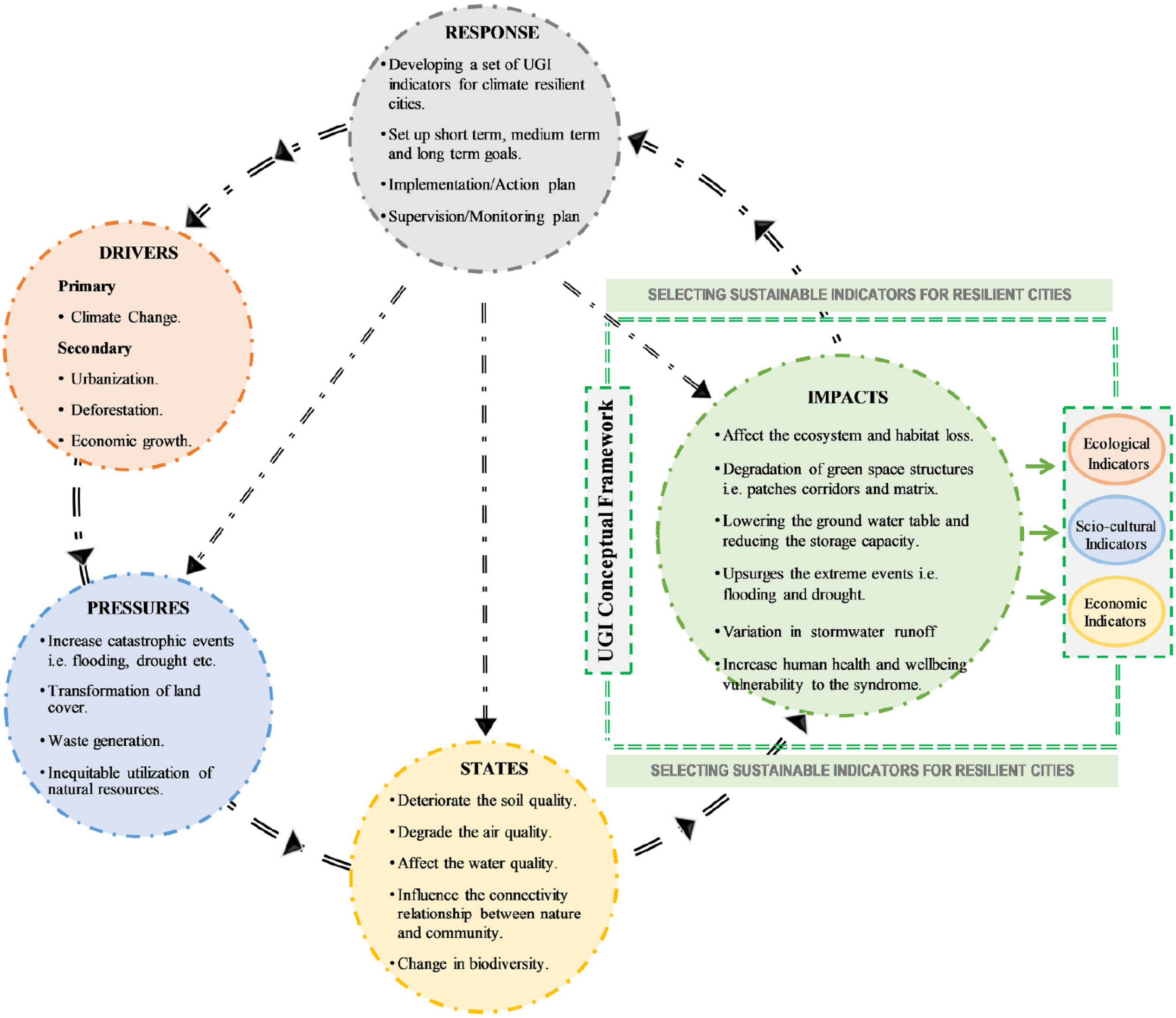


Fig. A.1. Relationship among the anthropogenic activities and Urban GI for resilient cities. (Source: Rayan et al. (2021).

Appendix B

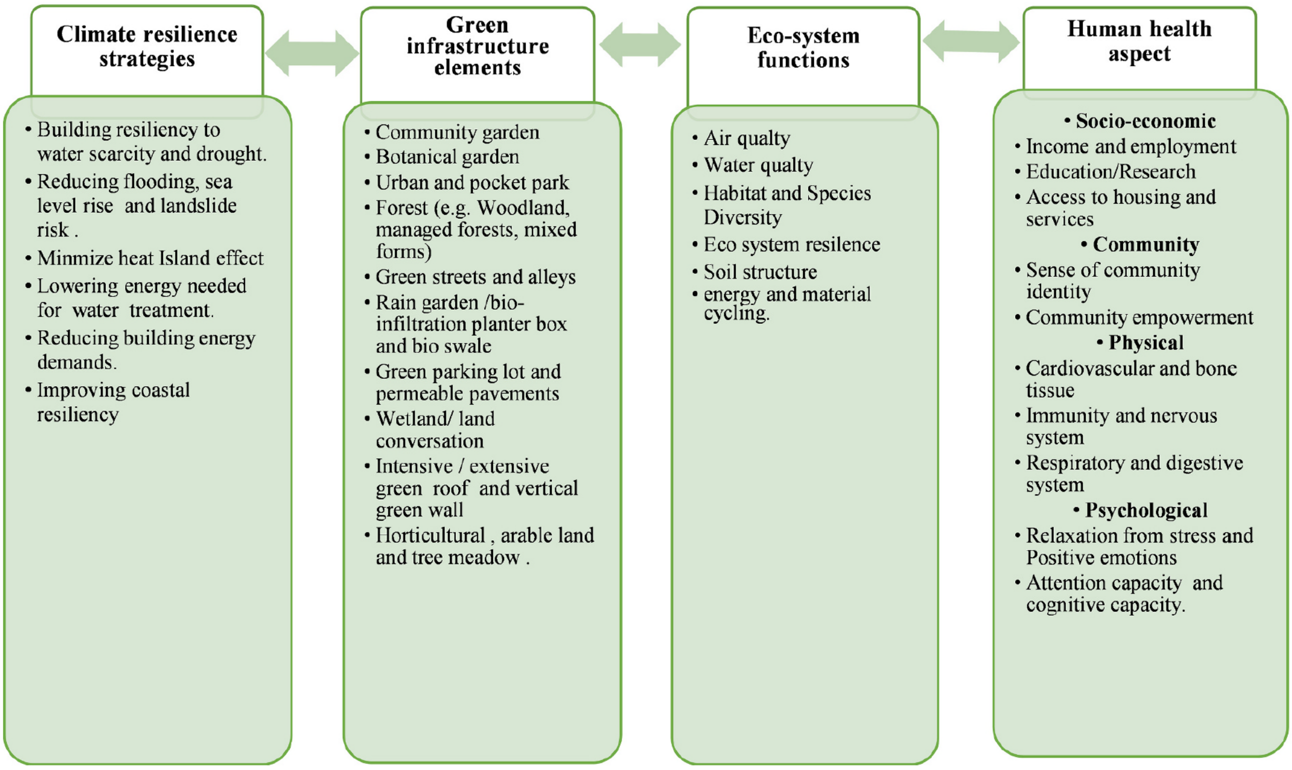


Fig. B.1. Conceptual base model: climate resilience strategies, eco-system, human wellbeing, and GI elements.
(Source: Rayan et al. (2021)).

Appendix C

Based on the inputs provided by the participants in the pilot survey, some minor revisions were made, aimed to make the survey design more appropriate and time-efficient

- Section A: In the participant profile, a diverse category had also been incorporated into the question of gender class. In Pakistan, the government officially recognized "trans" as the third gender (Nasir Iqbal, 2009; Guramani, 2018a, 2018b).
- In section b three-point Likert scale was updated into a five-point, and in Section C five-point Likert scale was transformed into a nine-point, aimed to achieve more variability among the respondent inputs and precision in the results.
- To mitigate the ambiguity among the participant's feedback, certain queries of section c were also re-phrased.

Appendix D

Table D.1
Demographic analysis of local Stakeholder/ respondents.

`Demographics	Frequency	Percent
Gender		
Male	93	54.1
Female	79	45.9
Diverse	0	0
Education		
Primary education and below	0	0
Secondary education	0	0
Higher Secondary education	0	0

(continued on next page)

Table D.1 (*continued*)

`Demographics	Frequency	Percent
Tertiary/Higher education	160	93
Other	12	7
Location		
Lahore	30	17.4
Hyderabad, Sindth	6	3.5
Karachi	14	8.1
Peshawar	39	22.7
Islamabad	27	15.7
Charsaddaa	4	2.3
Sheikhupura	2	1.2
Swabi	4	2.3
Abbottabad	16	9.3
Gilgit	5	2.9
Thana Malakand	1	0.6
Gujranwala	2	1.2
Mardan	6	3.5
Nowshera	2	1.2
taxila	4	2.3
Rawalpindi	10	5.8
Stakeholders expertise		
Building /Architecture	69	40.1
Infrastructure	19	11
Landscape planning	16	9.3
Urban planning	34	19.8
Horticulture/Arboriculture	3	1.7
Climate change / Ecology	14	8.1
Economy	5	2.9
Sociology	6	3.5
Other	6	3.5
Professional Experience		
Less than five years	53	30.8
Five to ten years	64	37.2
Ten to fifteen years	36	20.9
More than fifteen years	19	11

Source: Author`s calculated using survey data

Appendix E

Verifying and validating the local stakeholder perspective on the proposed possibilities and definitions of the Urban Green Infrastructure (UGI); climate change; climate change adaptation; urban resilience themes.

The following four questions have appeared in section B of the online expert questionnaire.

- What does climate change mean for you?
- What does adaptation to climate change mean for you?
- What does urban resilience mean for you?
- What does green infrastructure mean for you?

References

Adetunji, Israel O., 2006. Sustainable Construction: A Web-Based Performance Assessment Tool. Loughborough University. Thesis. https://hdl.handle.net/2134/2302.

Ahern, J., 2007. Green infrastructure for cities: the spatial dimension. In. In: Cities of the Future: Towards Integrated Sustainable Water and Landscape Management. IWA Publishing, Citeseer.

Ahsan, Ahmad, 2018. Urban flood risk management in Pakistan. Islamabad: Daily Times. Retrieved 04.12.2020 from. https://dailytimes.com.pk/280433/urban-flood-risk-management-in-pakistan/.

Akadiri, O.P., 2011. Development of a Multi-Criteria Approach for the Selection of Sustainable Materials for Building Projects. University of Wolverhampton.

Ashfaque, R., Awan, M., 2015. Final Report-Policy and Legal Reform Study (GEF-Protected Areas Management Project). Ministry of Environment, Government of Pakistan.

Atta-ur-Rahman, Khan, A.N., 2013. Analysis of 2010-flood causes, nature and magnitude in the Khyber Pakhtunkhwa, Pakistan. Nat. Hazards 66 (2), 887–904. https://doi.org/10.1007/s11069-012-0528-3.

Babbie, E.R., 1973. Survey Research Methods (Wadsworth Pub).

Baruch, Y., 1999. Response rate in academic studies-A comparative analysis. Hum. Relat. 52 (4), 421–438. https://doi.org/10.1177/001872679905200401. SAGE Publications Ltd.

Beattie, A., et al., 2004. Future career pathways in nursing and midwifery. A Delphi survey of nurses and midwives in South West England. NT Research. SAGE Publications. https://doi.org/10.1177/136140960400900505.
Benedict, M.A., McMahon, E.T., 2006. Green Infrastructure: Linking Landscapes and Communities. Island Press, Washington, DC, Urban Land.
Braimah, N., Ndekugri, I., 2009. 'Consultants' perceptions on construction delay analysis methodologies'. J. Constr. Eng. Manage-ASCE. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000096.
Bucci, H.P., 2003. The value of Likert scales in measuring attitudes of onlinelearners [online]. Available at: http://www.hkadesigns.co.uk/websites/msc/reme/likert.
Chinyio, E.A., Olomolaiye, P.O., Corbett, P., 1998. Quantification of construction clients' needs through paired comparisons. J. Manag. Eng. 87–92. https://doi.org/10.1061/%28ASCE%290742-597X%281998%2914%3A1%2887%29.
Cochran, W.G., 1977. Sampling Techniques, 3rd edition. John Wiley & Sons, New York.
Cortina, J.M., 1993. What is coefficient alpha? An examination of theory and applications. J. Appl. Psycho. US: Am. Psychol. Assoc. https://doi.org/10.1037/0021-9010.78.1.98.
Davies, C., et al., 2005. 'Green Infrastructure and the City Regions', Discussion Paper. NECF, Dunston.
Davies, C., et al., 2006. Green Infrastructure Planning Guide. Final Report, Project.
Demuzere, M., et al., 2014. Mitigating and adapting to climate change: multi-functional and multi-scale assessment of green urban infrastructure. J. Environ. Manag. 146, 107–115. https://doi.org/10.1016/j.jenvman.2014.07.025.
Desa, U.N., 2014. World Urbanization Prospects, the 2011 Revision. Population Division, Department of Economic and Social Affairs, United Nations Secretariat.
Desa, U.N., 2019. World urbanization prospects 2018: highlights (ST/ESA/SER. A/421).
Eckstein, J., et al., 2018. From Climatological to Small-Scale Applications: Simulating Water Isotopologues with ICON-ART-Iso (Version 2.3). Geoscientific Model Development.
Eckstein, D., Künzel, V., Schäfer, L., 2020. Global climate risk index 2021. Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000–2019. Available at: http://germanwatch.org/en/download/8551.pdf.
Foster, et al., 2011. The value of green infrastructure for urban climate adaptation. Center Clean Air Policy 750 (1), 1–52.
Gill, S.E., et al., 2007. Adapting cities for climate change: the role of the green infrastructure. Built Environ. 33 (1) https://doi.org/10.2148/benv.33.1.115.
Guramani, N., 2018a. National Assembly passes bill seeking protection of transgender rights. In: DAWN. Available at: https://www.dawn.com/news/1406400.
Guramani, N., 2018b. Senate unanimously approves bill empowering transgenders to determine their own identity. In: DAWN. Available at: https://www.dawn.com/news/1393766.
Hair, J.F., et al., 1998. Multivariate Data Analysis, 5th edPrentice-Hall. Englewood Cliffs, NJ.
Harnik, P., 2006. 'The excellent city park system: What makes it great and how to get there', The Human Metropolis: People and Nature in the 21st-Century City [full book], 47.
Hussnain, M.Q., et al., 2014. 'Improving Efficiency in Data Collection for Urban Development Plans through Information and Communication Technology', in International Conference on Town Planning and Urban Management (ICTPUM) (Lahore).
Iqbal, Nasir, 2009. Supreme Court Orders Equal Benefits for Transvestites. Available at: https://www.dawn.com/news/477909/supreme-court-orders-equal-benefits-for-transvestites.
Khayyam, U., Noureen, S., 2020. Assessing the adverse effects of flooding for the livelihood of the poor and the level of external response: a case study of Hazara division, Pakistan. Environ. Sci. Pollut. Res. 27 (16), 19638–19649.
Lafortezza, R., et al., 2013. 'Green infrastructure as a tool to support spatial planning in European urban regions', iForest - biogeosciences and forestry. SISEF - Italian Soc. Silvicult. Forest Ecol. 6 (3), 102–108. https://doi.org/10.3832/ifor0723-006.
Likert, R., 1932. A technique for the measurement of attitudes. Arch. Psychol. 22 140, 55.
Lu, F., Li, Z., 2003. A model of ecosystem health and its application. Ecol. Model. 170 (1), 55–59. https://doi.org/10.1016/S0304-3800(03)00300-4.
Luo, D., et al., 2016. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. https://doi.org/10.1177/0962280216669183.
Matthews, T., Lo, A.Y., Byrne, J.A., 2015. Reconceptualizing green infrastructure for climate change adaptation: barriers to adoption and drivers for uptake by spatial planners. Landsc. Urban Plan. 138, 155–163. https://doi.org/10.1016/j.landurbplan.2015.02.010.
Mell, I., et al., 2017. Strategic green infrastructure planning in Germany and the UK: a transnational evaluation of the evolution of urban greening policy and practice. Int. Plan. Stud. 22 (4), 333–349. https://doi.org/10.1080/13563475.2017.1291334. Routledge.
Monette, D.R., Sullivan, T.J., DeJong, C.R., 2013. Applied Social Research: A Tool for the Human Services. Nelson Education.
Monteiro, R., Ferreira, J.C., 2020. Green infrastructure planning as a climate change and risk adaptation tool in coastal urban areas. J. Coast. Res. 95 (sp1), 889–893. https://doi.org/10.2112/SI95-173.1.
Munn, P., Drever, E., 1990. Using Questionnaires in Small-Scale Research. A Teachers' Guide. Scottish Council for Research in Education, 15 St. John Street, Edinburgh, EH8 8JR, Scotland, United Kingdom.
Naeem, S., et al., 2018. Landscape greening policies-based land use/land cover simulation for Beijing and Islamabad-an implication of sustainable urban ecosystems. Sustainability. 10 (4), 1049. Multidisciplinary Digital Publishing Institute.
Pak-NDMA, 2011. National Disaster Management Authority, Islamabad, Pakistan. http://www.ndma.gov.pk.
PBS, 2018. Pakistan Bureau of Statistics, Urban Demographic. Available at: http://www.pbs.gov.pk/.
Peterson, R.A., 1994. A meta-analysis of Cronbach's coefficient alpha. J. Consum. Res. https://doi.org/10.1086/209405.
Rayan, M., Gruehn, D., Khayyam, U., 2021. Green infrastructure planning. A strategy to safeguard urban settlements in Pakistan. In: Jafari, M., Gruehn, D., Sinemillioglu, H., Kaiser, M. (Eds.), Planning in Germany and Iran. Responding Challenges of Climate Change through Intercultural Dialogue. Mensch und Buch Verlag. Berlin, pp. 197–220.
Shahid, N., Chunxiang, C., Khunsa, F., Omaid, N., Bipin, K.A., et al., 2018. Landscape greening policies-based land use/land cover simulation for Beijing and Islamabad—An implication of sustainable urban ecosystems. Sustainability 10 (4), 1049. Multidisciplinary Digital Publishing Institute.
Singh, K., 2007. Quantitative Social Research Methods. Sage.
TEP, 2005. Advancing the Delivery of Green Infrastructure: Targeting Issues in England's NorthWest (The Environment Partnership).
Tzoulas, K., et al., 2007. Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. Landsc. Urban Plan. 81 (3), 167–178. https://doi.org/10.1016/j.landurbplan.2007.02.001.
USEPA, 2010. Green infrastructure case studies: municipal policies for managing stormwater with green infrastructure'. In: EPA (USA) Washington, DC.
Wakil, K., Hussnain, M.Q., Yusuf, A., Abdul Jabbar, J., 2016. Project Report: Scenario Planning based Participatory Urban Growth Management Plans using ICT. Islamabad. Available at: https://think-asia.org/handle/11540/7573.
Wan, X., et al., 2014. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med. Res. Methodol. https://doi.org/10.1186/1471-2288-14-135.
Weber, T.C., Allen, W.L., 2010. Beyond on-site mitigation: An integrated, multi-scale approach to environmental mitigation and stewardship for transportation projects', Landscape and Urban Planning. Elsevier.

Article B

Key facts and author contributions

Reference	Rayan, M.; Gruehn, D.; Khayyam, U (2022b). Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan. *Int. J. Environ. Res. Public Health* 2022, 19, 11844. https://doi.org/10.3390/ijerph191911844
Contributions	MR: 100% (character count: ca. 55, 078)
Review	Double-blind peer review
Publication	Submitted: 11 August 2022 Accepted: 7 September 2022 Published: 20 September 2022

Signature:

_________________________ 03.03.2024

Muhammad Rayan Date

International Journal of
Environmental Research and Public Health

MDPI

Article

Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan

Muhammad Rayan [1,*], Dietwald Gruehn [1] and Umer Khayyam [2]

[1] Research Group Landscape Ecology and Landscape Planning (LLP), Department of Spatial Planning, TU Dortmund University, 44227 Dortmund, Germany

[2] Department of Development Studies, School of Social Sciences and Humanities (S^3H), National University of Sciences and Technology (NUST), Islamabad 44000, Pakistan

* Correspondence: muhammad.rayan@tu-dortmund.de

Abstract: Rising vulnerability of the urban green infrastructure (UGI) is grabbing global attention, for which inclusive urban landscape and greening policies (ULGP) and frameworks are crucial to support green growth. As such, this research intends to explore the local community's perspective to assemble sustainable UGI indicators for vital taxonomy of the urban green space (UGS) elements, aiming to develop a multi-functional and sustainable UGI-indicator-based framework that is eco-friendly and supports green-resilient cities in Khyber Pakhtunkhwa (KP) province, Pakistan. An in-depth household survey was executed in three KP districts: Charsadda, Peshawar, and Mardan, placing self-administered 192 questionnaires while covering themes around climate change adaptation, urban resilience, and UGI. Relative importance index (RII) and the interquartile range (IQR) methods were set up for data analysis that revealed excellent reliability ($\alpha > 0.88$) and internal consistency. The results confirmed community-based UGI indicators with a focus on promoting green-energy-saving strategies as e-imp (level 9, RII = 0.915), while other (ten) UGI indicators as important (RII = 0.811–0.894) and (eleven) as moderately important (RII = 0.738–0.792). These UGI indicators were found to be enhanced by UGS elements (RII $\geq$ 0.70). These findings provide a foundation for urban policy change and the development of a sustainable UGI framework to build an eco-regional paradigm for greener growth.

Keywords: climate change; adaptation; urban green infrastructure; community participation; KP, Pakistan

check for updates

Citation: Rayan, M.; Gruehn, D.; Khayyam, U. Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan. *Int. J. Environ. Res. Public Health* **2022**, *19*, 11844. https://doi.org/10.3390/ijerph191911844

Academic Editor: Paul B. Tchounwou

Received: 11 August 2022
Accepted: 7 September 2022
Published: 20 September 2022

1. Introduction

Urbanization leads to the shrinkage of urban green spaces, which directly contributes to extreme climatic hazards such as flooding, drought, urban heat island effect, etc. These hazards then further result in the degradation of ecosystem functions (ESF) and the loss of biodiversity and affect human health/well-being [1–5]. The experts anticipate that the climate change observed today and in the foreseeable future will be influenced by the variability of anthropogenic forcing [6]. If we cannot limit global climate change, there will be far-reaching repercussions on nature and society [7]. The global vulnerability of cities to climate-related hazards and stresses is expected to increase due to an increased built-up footprint compared to the population growth rates. According to research, it is estimated that the urban population will grow by 72% from 2000 to 2030, while the built-up area of cities (with 100,000 residents) will grow by 175 percent [8]. The incremental trend of the world population and anthropogenic activities has changed the land cover and contributed to the greying of the natural landscape. These harmful impacts of urbanization and the corresponding high pressure on the natural environment, at an unprecedented rate, are badly hampering urban growth in the major cities of Pakistan. In Pakistan, the urbanization rate is amplified from 32.98% (year 2000) to 36.91% (2019), with further projections to reach 50% by 2025 [9]. This upsurge is transforming the local attitude towards green spaces; thus, urban centers receiving less consideration become unsafe [10] and evolve multidisciplinary climatic challenges. Amongst other challenges, 'urban flooding' remains the most threatening climatic hazard with the power to endanger human safety and frighten natural resources and ecosystems. Furthermore, jeopardizing the socio-economic fabric of urban (flood-affected) inhabitants stays common.

These issues call for urban green infrastructure (UGI) (UGI planning is defined as "a network composed of open spaces, waterways, gardens, forests, green corridors, trees on streets, and open spaces, bringing many social, Economic and ecological benefits" [11]. Another UGI version exists as "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions sustains clean air and water and provides a wide array of benefits to people and wildlife" [12]) to enhance urban sustainability [13]. UGI is perceived as a nature-based and cost-effective solution to achieve resilience in the land use planning process to mitigate the ever-rising climate uncertainties [14,15], a revamp of all existent contemporary ideas concerning green space planning [16,17], an approach to enrich the health of the ecosystem, minimizes the surface-water runoff, improves water infiltration rate [18] and a cost-effective strategy to mitigate urban floods. Thus, UGI planning is already testified and declared important in countries such as Germany, the UK, and the Netherlands, where it is encouraged to promote innovative nature-based green solutions for climate change mitigation and adaptation [19–22]. Hence, it is confirmed that planning instruments (such as UGI) play an imperative role in minimizing the urban flooding effects, thereby enhancing the socio-ecological well-being of any region. Based on its strengths, this nature-based green (NBGI) approach stands as an applicable instrument for sustainable climate-risk management (SCRM) in cities [23], yet importantly, in bitterly climate-affected countries such as Pakistan.

1.1. Establishing a Niche: Climate Change Impacts

Pakistani urban areas pose multifaceted climatic encounters [24]. The consistent urban flooding events observed in recent years are putting lives and livelihoods at stake [25]. It is these growing incidences of floods, strong monsoon circulation, surface temperature rises, etc., that are making the country highly vulnerable and positing it (as per the climate risk index-CRI) (CRI is research that is centered on a comprehensive and accurate database of climate hazard effects observed in all countries in the world. In addition, low-income countries need to utilize the index as a warning signal to equip themself completely for future catastrophic disasters. www.germanwatch.org/en/cri, (accessed on 11 June 2021)) the eighth most vulnerable country to climate hazards [26]. Therefore, the disastrous impacts on ecosystems, biodiversity, agriculture, human settlements, human health, etc., are profound with different levels of adaptability [27,28]. Such devastating disasters for a country such as Pakistan (an agrarian economy) directly hamper the agricultural sector, which contributes 21.9% of GDP and employs 45% of local labor [29,30]. These disturbing lives and livelihoods remain prominent in the major/mega cities, which is further linked to massive and unplanned settlements at the expense of decreasing forest cover [4,31]. Other factors contributing to this issue are high population density, building of new colonies or expansion of physical infrastructure, etc., that are removing the green cover and urban green-spaces and rising air pollution [32,33]. These aforementioned problems prevail due to non-existent UGI planning in the existing urban plans and policies of the country, where such effective strategies are perceived only as a luxury urban activity. It is mainly associated with beautification (though not an essential urban amenity) to influence urban resilience against climatic hazards [10,34,35].

The whole alarming situation is linked to the regional non-resilient outlook toward unbalanced and reactive urban planning policies [36] that leads to unplanned settlements–further enlarging the environmental issue in the country [37]. Aside from the planning deficiencies (as outlined above), other contributing factors are inadequate ULGP, weak laws and enforcement, un-due influence, lack of scientific knowledge, lack of awareness, non-existence of PP is recognized as the effective tool to promote community stewardship in the planning and decision-making process to bolster nature-based-green infrastructure (NBGI) initiatives in land-use planning; effectively tackling socio-environmental problems at grassroots levels [38–42] approach, etc., all contributing to the transformation of green-spaces into urban functions/activities [10,35,43]. This exerts constant pressure on land cover, so deterioration of UGS elements. These issues declare Pakistani mega cities highly vulnerable to natural calamities, with no exception of the northwest territories of KP [44].

At a national level in Pakistan, KP province suffered predominantly from consistent flooding events in the last decade [25], which marks this area as highly vulnerable and risky to in-daunting events, accounting for massive economic and human losses [22,36,45] Generally, these damages are linked to region geographic position and topographical features. The area lies on the bank of Swat Kabul, Kunhar, and Panjkora rivers' basin that originates from the high mountains of Hindukush, Himalayas, and Karakoram ranges. Being at water banks, it enhances the catchment area's vulnerabilities to urban flooding (Figure 1). In addition, the issue also stresses the built environment service, which leads to the over-exploitation of natural green barriers [10], thereby endangering the urban ESF and human health/well-being in urban settlements [46–48]. Therefore, tackling the underlying causes and destructive effects of climate change in this region requires an immediate effort to examine the nexus between the UGI and climate-resilience notions to be incorporated (holistically) in the land-use planning process [26–29]. It is to develop a rich, multi-functional/inclusive/sustainable UGI-indicator-based (framework) model structured according to the local built environment. Such a model should be grounded on the (native) community perspective or the PP process—that further leads to strengthening the climate-resilient strategies, green spaces (GS), ecosystem functions (ESF), and human well-being in catchment areas.

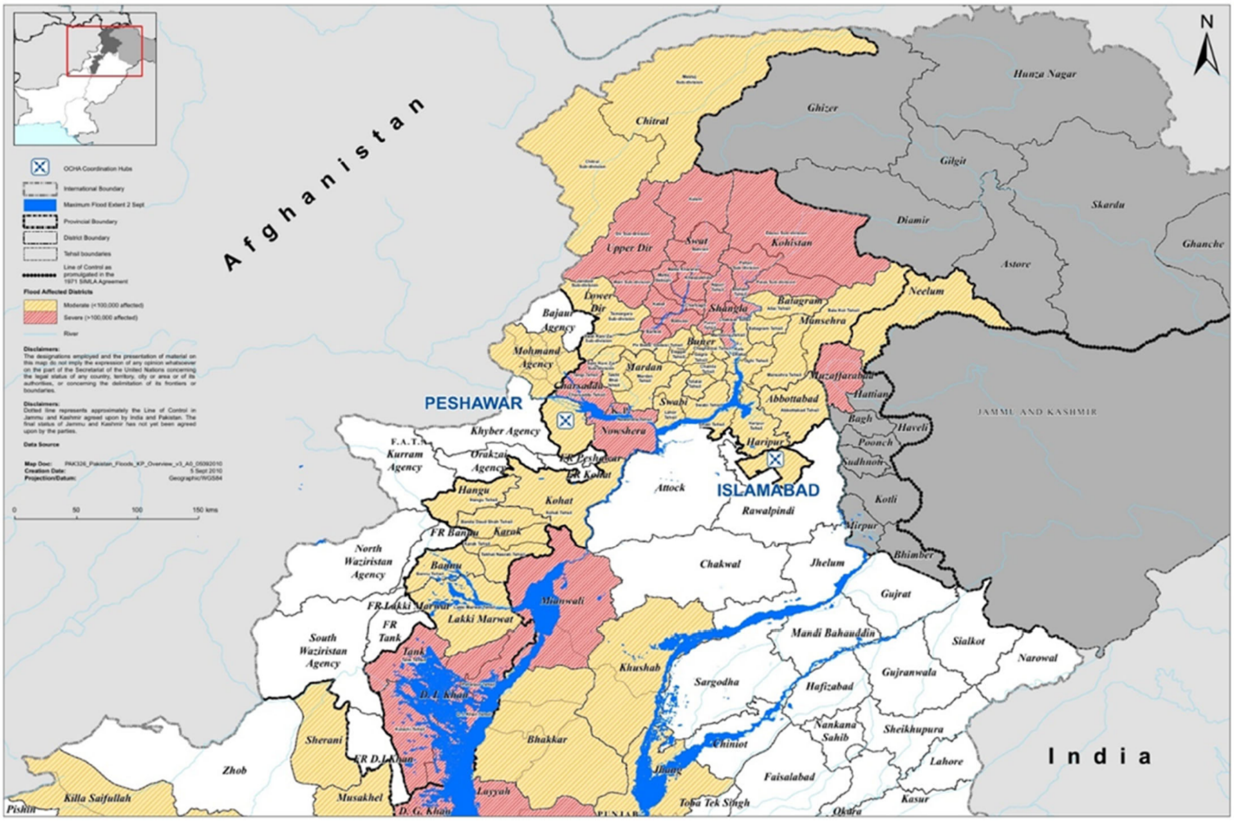


Figure 1. Flood-affected districts of KP province. Map Source: [24].

1.2. PP for UGI and UGS

PP (as an effective tool) can facilitate community stewardship in the planning and decision-making process, though so far less considered within the Pakistan planning context [11,12,30–34,49,50]. Consequently, PP deems more effective in understanding the complexity of interactions among the ecosystems and humans [38,51,52]. Hence, PP facilitates in drawing 'human-nature' studies/concepts for not only finding nature-based green infrastructure (NBGI) solutions [53] but, in turn, enabling human societies to enhance their adaptative capacity and build resilience against (ever-rising) environmental hazards, e.g., urban flooding [44,45]. To further add, a (bottom-up) PP approach help for a successful transition to green action plans (GAP) [38].

It is established that there is a dearth of research studies in Pakistan towards developing theoretical and empirical foundations for UGI planning and implementation, which is a prerequisite for an eco-friendly and climate resilience environment in the country (in general) and in KP (in particular). Though planning authorities in Pakistan adopt spatial technologies in-order to develop land-use maps of major urban districts, these interventions are still in their infancy [54,55] and usually require more time and financial resources [34,56], especially in the non-collaborative and unilateralism environment (with undue influence) that Pakistan possesses [43,49].

Hence, to bridge this gap, this (novel) research study intends to develop a rich body of multi-functional conceptual UGI-indicator-based framework/model, which can be grounded upon "Triple Bottom Line" (TBL) (The triple bottom line (TBL) refers to sustainability's environmental, socio-cultural, and economic dimensions. It is the most commonly accepted model used in most urban sustainability applications [46,47,57]) sustainability and adapted to the local context. Such a potential framework encompasses a set of core sustainable UGI indicators and vital taxonomy of UGS elements. To bottom-up oriented framework/model testify and validate the margin between essential and inessential potential UGI indicators and green space elements. Here, the local community evaluates the significance of the sustainable UGI indicators and their relationship with multiple UGS elements, according to the native built-in environment. It is because (i) the effectiveness of UGS structures (usually) depends on the spatial contextual factors (socio-cultural and economic) of any region where they are examined [15,50,58–60] and (ii) not all the UGS elements had an excellent functional linkage to improve the resilience of respective sustainable UGI indicators while coping with the gradual climate change.

In this sense, this research study is inception that breeds the PP approach to develop an inclusive, sustainable UGI-indicator-based framework to build green and resilient cities in the KP province. It is also imperative that this UGI model, developed through this study, can be adapted to the native spatial environment-will provide a proactive and long-term way for ULGP and guidelines for CC mitigation/adaptation. This may lead to a well-balanced relationship between anthropocentrism and eco-centrism activities for KP and beyond. Moreover, such a framework will lead to encouraging innovative green grass-root initiatives, with the mandate to build a new eco-cultural paradigm to enhance the adaptive capacity in sustained human settlements. This will inevitably open up a new domain of study to gradually probe more deeply into innovative community PP approaches when planning nature-based green adaptation techniques for climate change adaptation.

1.3. Study Aim and Research Questions

This research study aims to analyze the community perspective (through the bottom-up PP approach) to gauge the locals' insightful view regarding UGI-indicator-based framework/model. It is to obtain a greater consensus among the local community to find a relationship between sustainable UGI indicators and (potential) taxonomy of UGS elements, as per the native built environment. This then leads to validating the sustainable UGI framework/model, which fits best in the local socio-economic and cultural context. Such an effort would contribute to enhancing green-spaces, besides alleviating vulnerability towards climate hazards. They also improve regional socio-ecological resilience.

It also builds climate-resilient cities in KP territory under a community participation approach–promoting a sense of community ownership. Therefore, the study intends to find answers to the following three research questions:

i. What is the level of the local community's understanding of Climate Change and UGI?
ii. Which essential UGS elements strengthen the resilience of (sustainable) UGI indicators?
iii. What type of UGI-indicator-based model contributes to building a green climate-resilient city-state?

2. Research Methodology

This research has adopted the UGI (conceptual base) framework model developed by the author [48], grounded on two conceptual frameworks: (i) Driver pressure state impact response (DPSIR) framework that aims to conceptualize the relationship between UGI elements and anthropogenic activities to build climate-resilient cities and (ii) incorporation of the model, proposed by [14], which is further enhanced by inserting three additional components, (a) climate resilience strategies, (b) eco-system function—ESF and then (c) the UGI elements as suggested by [15,17,59,61], but revised to build a strong correlation among them [48] (for details, see Appendix A: Figures A1 and A2). Additionally, semi-structured discussions with multi-stakeholder (planning experts and community) in Pakistan were conducted regarding the potential role of NBGI initiatives' in promoting an eco-friendly and climate-resilient environment, resulting in nine cross-cutting themes [34] (see Appendix B: Table A1).

The consolidated integration of both models and concepts intends to build a cohesive, sustainable UGI framework. This framework is perceived to enhance urban resilience against (ever-rising) environmental hazards and (simultaneously) minimize the degradation of the urban ecosystem health. These conceptual models and new cross-cutting themes (an innovation of this study) are regarding the potential role of UGS infrastructure in addressing SCRM. This, in-tern, assists in determining the (potential twenty-two, some placed under main headings) UGI indicators that were classified into three main sustainability categories (i.e., ecological, socio-cultural, economical). It was conducted along with the ten (community garden (CG); botanical garden (BG); urban park (UP); forest (FO); green streets (GR); rain garden and bio-swale (RG); green and permeable parking area (GPA); wetland (WL); green roof and green wall (GRW); and horticulture (HO)) vital UGS (quantitative) elements to accomplish the research questions. Of course, there could be other indicators, such as institutional and political. However, that is out of the scope of this research and can be considered in future research. The potential UGI indicators and green elements are mainly quantitative, and the relative importance index (RII) and interquartile range (IQR) analysis technique employed applied to calculate the relative significance of each sustainable UGI indicator, as well as the UGS elements, as analyzed by the local community (within the real-life context). This method is recognized best approach for ordinal-scale surveys [62–65].

2.1. Study Area, Sampling Technique, and Survey Design

Multi-stage sampling technique is used. Firstly, selection of the municipalities (Tehsil) (Based on the higher population, the municipalities (Tehsil) in each district are selected (Table 1)) in each study district (Peshawar, Mardan, and Charsadda) (Table 1), and secondly; the selection of sub-municipalities (Union Council-UC) in each tehsil in the KP province, which is based on population census datasets [66]. (For determining the UC, this research integrated the interquartile range (IQR) technique with criteria 1. IQR is an efficient method for determining cut-off points [64,67–70]; based on population census datasets [66] and above the cut-off point (mid-point), all UCs were selected for the field survey (Figure 2). This methodology was adopted as there is no official list of the residential houses affected by climatic uncertainty within UCs exist. Moreover, each municipality has a minimum of 20 and a maximum of 37 sub-municipalities (called Union Councils-UCs). So, the most floods affected, time (cost) efficient areas, and safer strategies (in time of COVID-19 pandemic) were selected for study purposes). Thirdly: the flood-affected Households (HHs) were consulted in the community survey (Table 2 and Figure 2) executed in the case study area from October 2020 to mid-December 2020.

Table 1. Population census of three districts of KP province.

District	Tehsil	Town	Population	Geographic Data	Climate	Precipitation (mm) (1999–2018)
Mardan	Mardan Tehsil		1,403,394	34.2883° N, 72.1890° E	Humid subtropical	400.3
	Katlang Tehsil		343,144	34.3521° N, 72.0764° E		
	Takht Bhai Tehsil		626,523	34.3314° N, 71.9046° E		
Charsadda	Charsadda Tehsil		804,194	34.2165° N, 71.7148° E		
	Shabqadar Tehsil		383,765	34.2186° N, 71.5546° E		
	Tangi Tehsil		428,239	34.3040° N, 71.6555° E		
Peshawar	Peshawar Tehsil ([71])	Town 1	759,595	33.9437° N, 71.6199° E		546.075
		Town 2	547,807			
		Town 3	821,059			
		Town 4	435,940			
		Peshawar cant.	70,741			

Source: Authors' compilation from the KP Bureau of Statistics (2018) [66], KP Local Government [71] and Pakistan Metrological department (2019) [72].

Table 2. Sampling size for the community survey.

District	Tehsil *(Selection Grounded on a High Urban Population)*	Tehsil Population	Union Council Population *(Selection Grounded on a High Urban Population with the Integration of the Interquartile Range Technique (IQR)*	Total No of Sample Population (with 95 CI and + 5 MoE)	Average HH Size No *(Source: KP Bureau of Statistics)*	No of HHs Sample 399.6/6.2 399.5/7 339.7/5.6
Mardan	Mardan	1,403,394	411,148	399.6	6.2	64
Charsadda	Charsadda	804,194	350,483	399.5	7	57
Peshawar	Town3	821,059	575,409	399.7	5.6	71

Source: Authors' own elaboration, compilation the [66].

In total, 192 HHs [with 95%confidence level (CI), ±5% margin of error (MoE)] in which 64 HHs belong to Mardan, 57 HHs to Charsadda, and 71 HHs from Peshawar tehsils. A total of 1198.8 sample population (community) were consulted to study the subject trends, as per Cochran (1977) (Table 2), succeeded over from pilot testing to check the independence of various indicators and necessary modification in the questionnaire, as per the inputs (from local govt. officials, two expert consultants, three academicians, and three community members), which were conducted to check its feasibility, inclusiveness, and precision. This approach helped to do prior minor amendments (see Appendix C) questions' appropriateness and time efficiency [73,74]. In general, the acknowledgment level remained acceptable for generalizing the results over the whole study sample population [75,76].

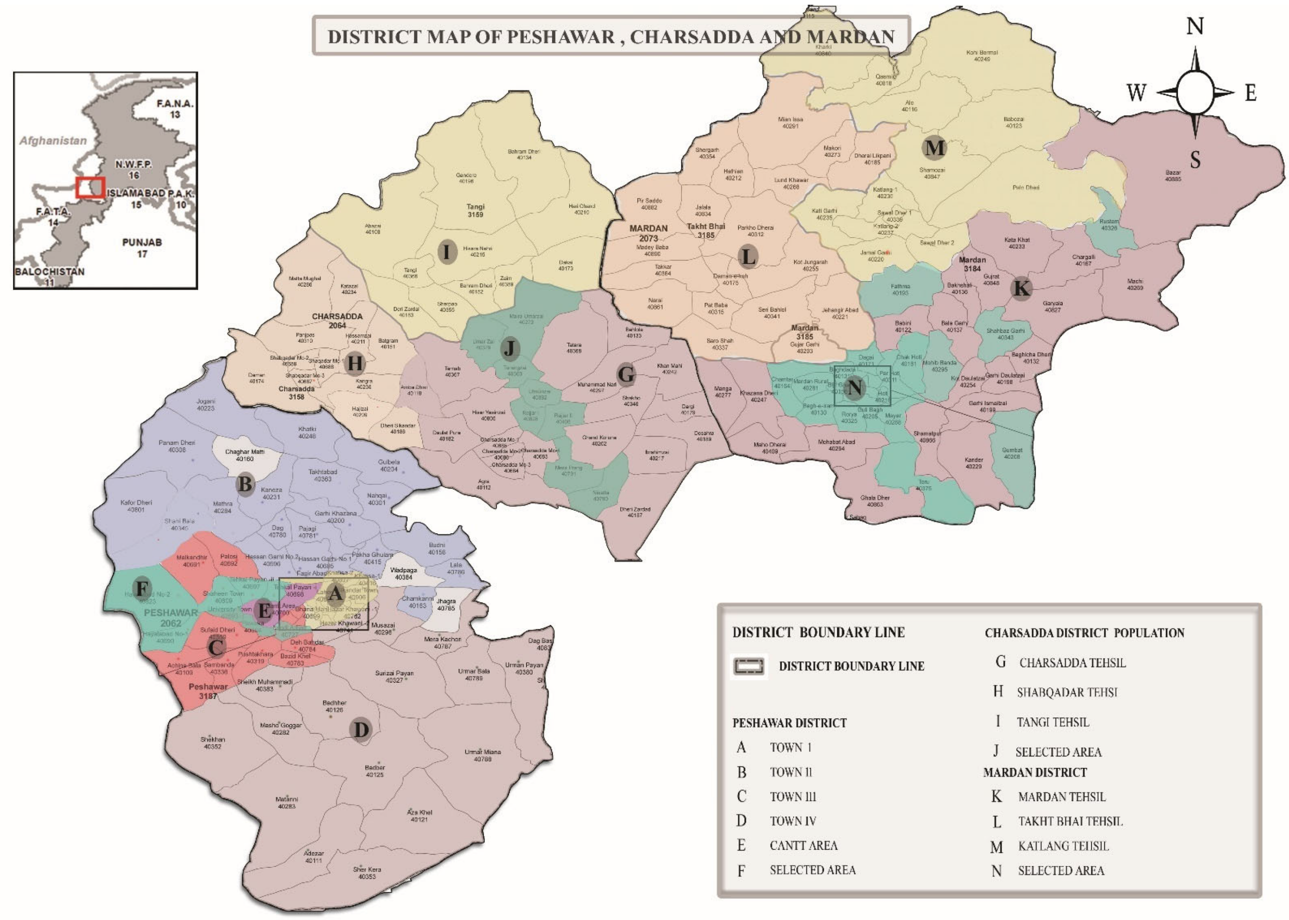


Figure 2. District, tehsil, and union council map of Mardan, Charsadda, and Peshawar. Source: Authors' compilation from [24,66].

The community-based empirical study employed the snowball technique in the case study to identify specific HHs, which served as a reference benchmark, selecting every fourth HH from the reference point as an HHs sample to obtain field data. This methodology was deployed since no official lists of flood-affected residential houses exist within UCs. To collect the study data, a structured survey questionnaire was designed with three Sections A–C. ("Section A was labelled as the demographic information, aiming to validate the respondent profile, knowledge, and location. The diverse category "trans" has been included as a third gender since the state approved it. Part B comprehends 4 questionnaires designed to verify the native community's views on the potential definitions of climate change (CC), adaptation to CC, urban resilience, and UGI, as explained in Appendix D; Part C was divided into three sub-parts (environmental, socio-cultural, and economic), each comprising several queries to define and determine the significance of each UGS element and its relationship with sustainable UGI indicators. The Potential UGI indicators and UGS elements were developed by the authors in preceding research studies" [48]. "This process resulted in selecting the vital taxonomy of the UGS elements that enhanced the quality standard and health of respective UGI indicators and would build the urban interface in the KP region that is resilient against constantly rising environmental threats such as urban flooding" [34]), which consist of closed and open-ended questions (Figure 3). A Likert-scale approach was adopted [77–79] to register the participants' responses so that the native community perspective of (potential and sustainable) UGI indicators and their relationship with multiple vital taxonomy green elements in the local urban environment can be easily explored.

The demographic characteristic affirmed 65.6% as male, 22.4% as female, 12% preferred not to mention their gender, and no participant was from the third-gender category; this option was provided as the government of Pakistan officially recognizes "trans" as a third gender [80–82]. The participation percentage of Masculine is high compared to feminine participation because most of the KP region's households are mainly male-headed [66]. Moreover, the other reasons behind this relatively low no are (i) the female HHs are very low, and the majority of HH are male-headed in the area; (ii) local social and cultural norms are challenging to gain access to females; (iii) society does not allow outsider males (authors) to directly interact with females in their areas—yet this study tried to include the maximum possible female as HH heads through volunteer enumerators understanding the local culture and knowledge of the study.

Regarding the participants' educational background, 73.4% had tertiary/higher education levels, 19.3% were intermediate, and 7.3% had secondary education (Table 3). The study also signifies nearly all representatives from the major four age groups had participated in the survey that shows the engagement of community individuals from all age groups. The age group with the highest frequency was 30–40 years (43.8%), followed by 34.4% in the age bracket of 20–30 years (The socio-demographics presented here only project all segments of the society, across all age groups, gender categories, and income and education levels were duly consulted. Their separate relationship for the study variables was neither intended to be covered nor they have influenced the broader findings of this study) (Table 3). The participants came from an array of socioeconomic backgrounds.

Table 3. Socio-demographic analysis.

Socio-Demographics	Total Participants	Ratio
Gender-specific		
Male	126	65.6
Female	43	22.4
Diverse (the government of Pakistan recognizes the identification of "trans" as a third gender [80–82])	0	0
Prefer not to say	23	12
Location		
Charsadda	56	29.1
Mardan	46	24
Peshawar	67	34.9
Not mention	23	12
Literacy		
No education to elementary	0	0
Secondary education (SSC)	14	7.3
Intermediate	37	19.3
Higher education	141	73.4
Other (informal)	5	2.6
Age		
15–20 years	0	0
20–30 years	66	34.4
30–40 years	84	43.8
40–50 years	42	21.9
50–60 years	14	7.3

Source: Authors' calculation, using field data.

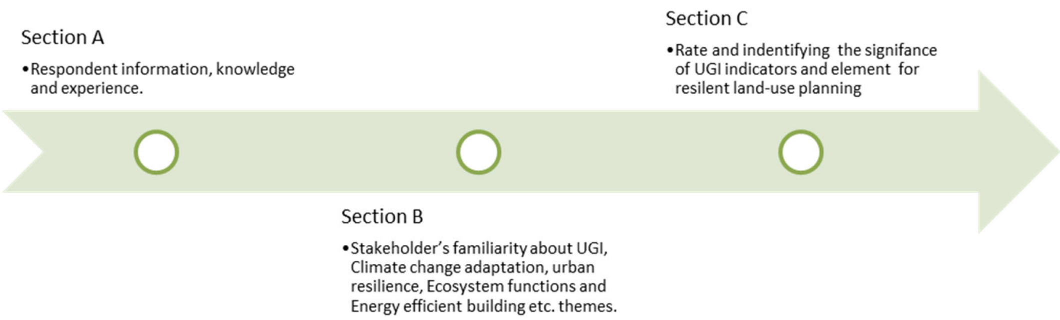


Figure 3. Community HH survey strategy. Source: [34].

2.2. Data Analysis and Survey Reliability

Data were examined through Microsoft Excel. Sections B and C (as of Figure 3) of the survey questionnaire used a question-based coding algorithm to segregate and examine the community responses. Cronbach's alpha (α) was executed, and α-values (>0.7) confirmed data reliability (Figure 4).

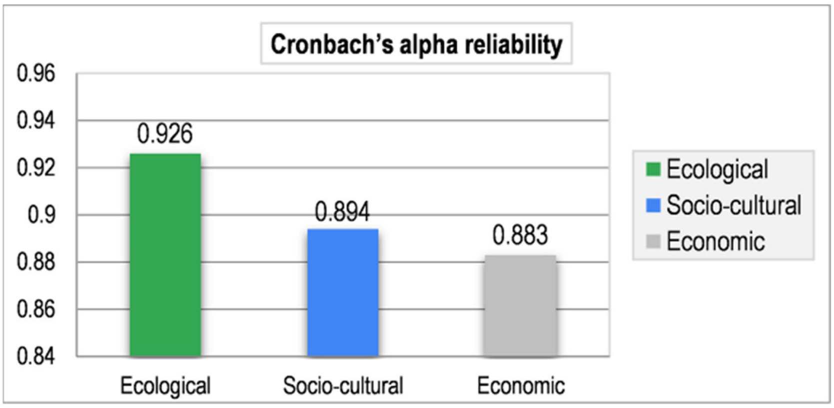


Figure 4. Cronbach's alpha reliability. Source: Authors' calculation using field data.

As the proposed UGI indicators and UGS elements are quantitative, therefore the relative importance index (RII) technique was employed to examine community responses to build a composite (potential) UGI framework/model. It is to determine community satisfaction of UGS elements and UGI indicators, according to the local built-in environment, as executed in similar research studies for ordinal-scale surveys [62–65,83].

Based upon RII (outcomes), the importance level of each UGI indicator and UGS element was calculated. To ensure a rational quantity of UGI indicators and vital UGS elements (for respective UGI indicators from RII), two interrelated strategies were introduced: (a) adaptation importance scale criterion, as proposed by Chinyio (1998) [62] and Akadiri (2011) [83], yet inserting 'four new levels', so accounting for (in-total) nine-point importance levels [34] (Table 4). The scale ranges from "extremely unimportant" to "extremely important", utilizing both Positive and negative weights (Table 5). The values substituted into formula 1 (Table 5) are from Table 6. It is to find variance in the significance levels amongst the UGI indicators and UGs elements because not all the GS elements positively enhanced the efficacy of the sustainable UGI indicators.

Table 4. Criterion of 9-point scale.

1	Extremely unimportant	(e-unimp)	$(0 \leq RI < 0.2)$
2	Moderately unimportant	(m-unimp)	$(0.2 \leq RI < 0.3)$
3	Slightly unimportant	(s-unimp)	$(0.3 \leq RI < 0.4)$
4	Unimportant	(unimp)	$(0.4 \leq RI < 0.5)$
5	Low	(l)	$(0.5 \leq RI < 0.6)$
6	Slightly important	(s-imp)	$(0.6 \leq RI < 0.7)$
7	Moderately important	(m-imp)	$(0.7 \leq RI < 0.8)$
8	Important	(imp)	$(0.8 \leq RI < 0.9)$
9	Extremely important	(e-imp)	$(0.9 \leq RI \leq 1)$

Source: [34].

Table 5. Equation (1) A sample estimating the RII value of increasing pervious surfaces to optimize the stormwater management indicator.

$RII = \Sigma W/(N \times A) \ldots$ (1)

W = Likert scale weights: assigned by participants to each indicator (1 to 9).

N = Total number of samples

A = The highest value on a Likert scale.

$RII = (9 \times 93) + (8 \times 42) + (7 \times 21) + (6 \times 18) + (5 \times 8) + (-4 \times 3) + (-3 \times 3) + (-2 \times 2) + (-1 \times 2)/(192 \times 9) = 0.834$

(as rated by a community member)

Source: Authors' calculation using field survey data.

The second methodology was the adaptation of the Interquartile Range (IQR) technique to identify a specific cut-off point in the RII Values (RIV) of UGS elements. The IQR is a viable and effective technique to determine the difference between the median of the lower (Q3) and upper (Q1) quartile of the RII data set [64,68–70]. It also enables the identification of a vital (manageable) number of UGS elements for the respective UGI indicators according to the native spatial environment. The value of 0.70 is considered a cut-off point, which assists in determining the key UGS elements for each specific UGI indicator. This enhances the urban system's ability to withstand climate threats of anthropogenic changes. The cut-off-point (RI = 0.7) is based on the Likert scale (Table 4), ranging from Moderately important to Extremely important. The cut-off point ((RI < 0.7) implies that not all the individual UGS elements had an excellent functional connection with the (respective) UGI indicators to fight climate change in the study areas.

Table 6. RII value of sustainable UGI indicators.

Categories	Urban Green Infrastructure Indicators	Particpants (n)	Overall Weight	Relative Index RII = ΣW/(N × A)	Cut-Off Point. Interquartile Range Technique (IQR)	Approved UGI Indicators (RII ≥ 0.80)	Rank Order Based on RII Value	Level of Signifance (9-Point Scale Criterion)
Ecological	**"Optimize storm water management"**							
	i. "Increasing pervious surfaces"	192	1441	0.834	0.80	yes	9	8
	ii. "Minimize, retain and organically purified rainwater runoff".	192	1364	0.789	0.80	no	14	7
	"Decreasing the impact of urban heat islands"							
	iii. "Enhanced the quantity of the green spaces".	192	1517	0.878	0.80	yes	3	8
	iv. "Use of evaporative materials on the roofs, walls and floors".	192	1287	0.745	0.80	no	19	7
	"Enhancing air quality (e.g., extracting impurities)".							
	v. "Growing more green trees and installing a green barrier in a roadway".	192	1339	0.775	0.80	no	16	7
	"Enhancing noise quality".							
	vi. "Use a green sonic wall to reduce the minimum and maximum noise pollution. (i.e., thick hedges could be provided with a small meadow for minimum noise and for maximum noise reduction wide layers of bamboo and deciduous trees could be provided)".	192	1347	0.780	0.80	no	15	7
	"Lower emissions of carbon (e.g., elimination of greenhouse gas emissions through greenery)"							
	vii. "Grow greater density of trees as shading and evaporating fabric for the paved surfaces".	192	1513	0.876	0.80	yes	4	8
	"Enhancing building energy performance".							
	viii. "Promote green energy-saving strategies".	192	1581	0.915	0.80	yes	1	9
	"Improved soil fertility and degradation condition".							
	ix. "Increase previous areas and plant trees to enhance soil stabilization".	192	1473	0.852	0.80	yes	6	8
	"Improved and safeguard urban ecology".							
	x. "Improve and strengthen the urban green network connectivity".	190	1430	0.836	0.80	yes	8	8

Table 6. *Cont.*

Categories	Urban Green Infrastructure Indicators	Particpants (n)	Overall Weight	Relative Index RII = ΣW/(N × A)	Cut-Off Point. Interquartile Range Technique (IQR)	Approved UGI Indicators (RII ≥ 0.80)	Rank Order Based on RII Value	Level of Signifance (9-Point Scale Criterion)
Socio-cultural	**i. "Agri-production (e.g., home gardening; urban farming; and community farming)".**	192	1411	0.817	0.80	yes	10	8
	"Enhancing social wellness".							
	ii. "Optimizing the recreation, and socialization activities".	192	1402	0.811	0.80	yes	11	8
	iii. "Improved city's appeal (through various green elements)".	192	1275	0.738	0.80	no	21	7
	iv. "Enhancing the mental and physical health (e.g., visual and physical exposure to open green areas has a beneficial effect on stress and anxiety reduction)".	192	1509	0.873	0.80	yes	5	8
	v. "Provide ecological areas for research & education".	192	1304	0.755	0.80	no	18	7
	vi. "Enhance connectivity of green areas to promote walking & biking opportunities".	192	1287	0.745	0.80	no	19	7
Economic indicators	**i. "Enhanced the value of property".**	192	1244	0.720	0.80	no	22	7
	ii. "Minimize healthcare expense".	192	1369	0.792	0.80	no	13	7
	iii. "Decrease energy use (e.g., heating & cooling requirements)".	192	1448	0.838	0.80	yes	7	8
	iv. "Minimize the risk of flood disasters".	192	1544	0.894	0.80	yes	2	8
	v. "Decreasing the utilization of private cars by encouraging walking and biking opportunities (i.e., changing modes of transportation)".	192	1377	0.797	0.80	no	12	7
	vi. "Value of eliminating of air pollutants".	192	1331	0.770	0.80	no	17	7

Source: Authors' calculation using field survey data. Significance level keys: 1—extremely unimportant; 2—moderately unimportant; 3—slightly unimportant; 4—unimportant; 5—low; 6—slightly important; 7—moderately important; 8—important; 9—extremely important.

3. Results and Findings

The results of the community-based (bottom-up) empirical field study were elucidated, firstly, the answer to RQ1: community's understanding of climate change, adaptation to climate change, urban resilience, and urban green infrastructure themes. The next sections tackle (RQ2 and RQ3), determining key UGS elements that strengthen sustainable UGI indicators, thereby contributing to a (probable) UGI framework/model. The attempt to develop an essential resilience against the environmental challenges in the native built-in context.

3.1. Section A: Understanding the Local Perspective

The results represented that options one, two, six, and seven are more effective than other options, which achieve a lower percentage. The statistical investigation represents that more than three-fourths of the community believe that an increase in the global annual mean temperature poses severe weather events such as rising sea levels and, thereupon, damages the ecological health of both the urban as well as rural areas (Figure 5). This leads to endangering human health/well-being safety and destruction to urban eco-system functions in the study districts. Further results about "adaptation to climate change" in the native/local context found that options: one, two, three, four, and seven remained extremely important–receiving more than 75% Satisfaction Approval Vote (SAV) (Figure 6). This set of five important variables helps to outline the imperative concept of "adaptation to climate change (CC)" in an indigenous context, besides contributing to strengthening local adaptive capacity. They also assist in building resilience towards environmental hazards (i.e., urban flooding).

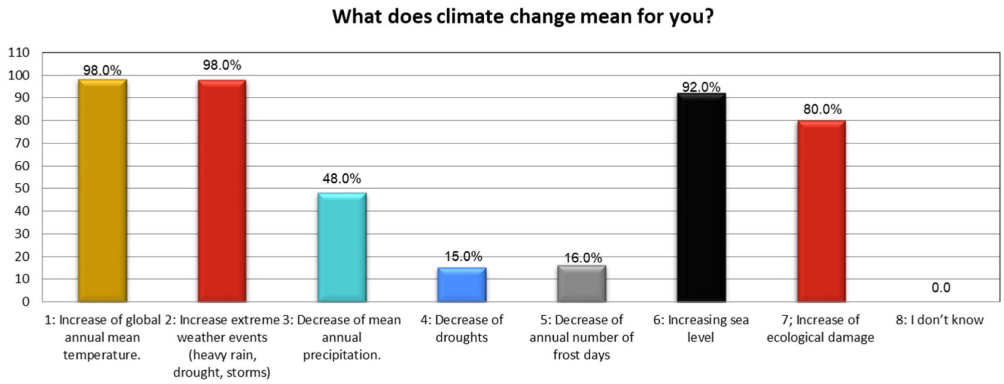


Figure 5. Defining climate change (CC). Source: Authors' calculation using field data.

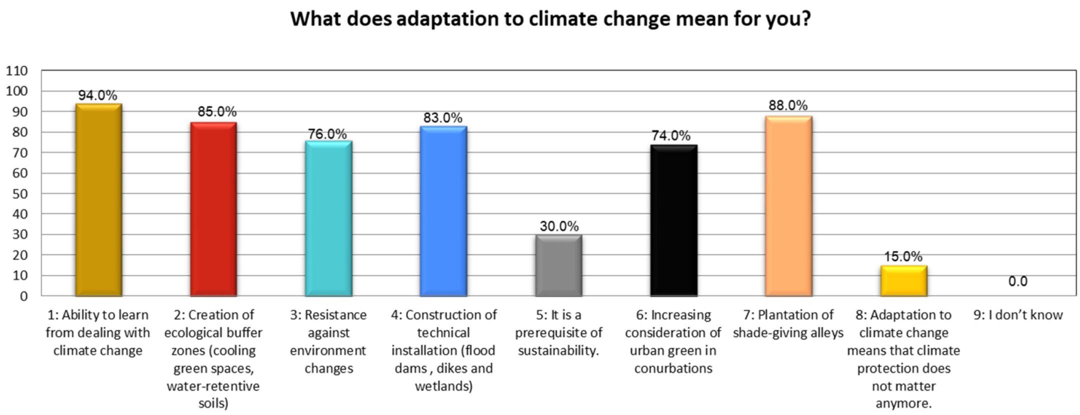


Figure 6. Defining climate change adaptation. Source: Authors' calculation using field data.

Furthermore, the results emphasize that the local community acknowledged 3/4 of the potential options that are perceived as influential in gauging/defining urban resilience in the local context. The statistical result shows that options: one, three, four, five, six, and eight are more effective as they received >75% SAV than options two, seven, and nine (SAV < 50%) (Figure 7). This illustrated participants' understanding and level of confidence in the potential alternatives, which may lead to green-growth approaches and a sustainable urban environment in KP. The results further elucidate the perception of the native respondents on the potential possibilities of UGI, so it is worth noting that option 2 is extremely significant compared to option 14, which received 81% and 23% confidence votes from the participants. Besides that, the community also endorses options: 1, 3, 4, 7, 8, 9, 12, and 13, though the confidence level varies between 60% and 70% (Figure 8). This certifies all the nine potential possibilities were viewed as a key standard to define UGI at the grass-root level in the study areas.

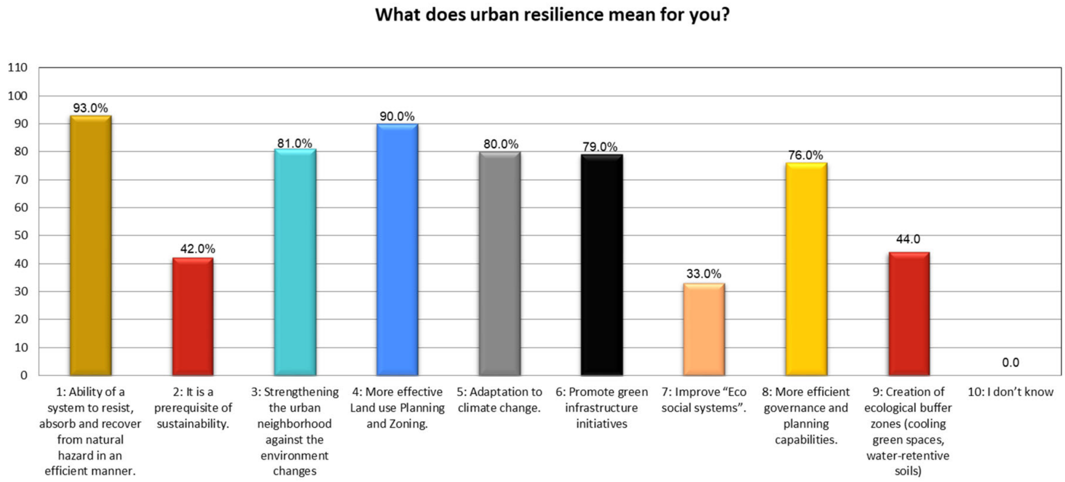


Figure 7. Defining urban resilience. Source: Authors' calculation using field data.

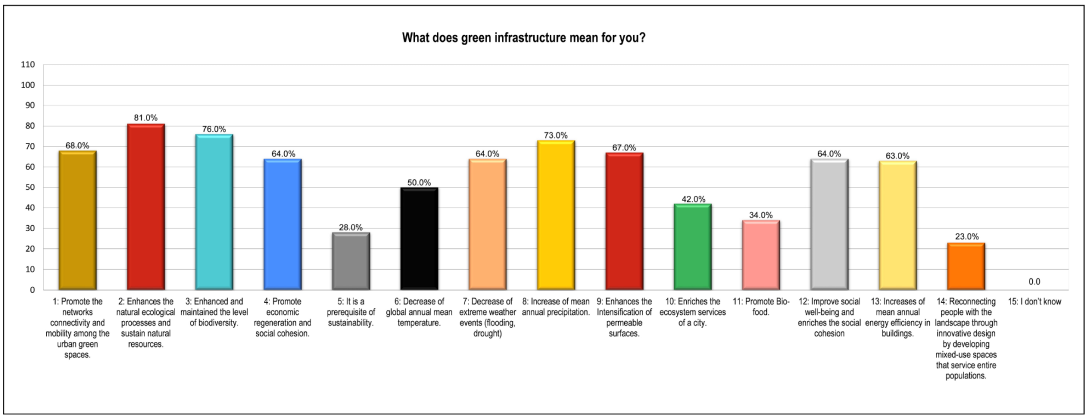


Figure 8. Elucidating urban green infrastructure (UGI). Source: Authors' calculation using field data.

The results so far illustrate the community's perspective and level of confidence in each potential possibility. This endorses multiple optimal approaches that can help to define the imperative themes such as climate change and adaptation, urban resilience, and UGI. Furthermore, such efforts enhance the inhabitant's knowledge, beliefs, attitudes, and preferences regarding the potential role of NBGI in times of climate change. These investigations have the potential to contribute to the development of a sustainable UGI framework so as to build a green and climate-resilient city-state at the local, regional, and national levels in Pakistan.

The first part of the results concludes that most of the local community believes that its the increase in the global annual mean temperature that is resulting in severe weather events (e.g., storms, droughts, heavy precipitation, and sea-level rise) and disturbing the ecological system of the region. These situations are leading to risking human health and well-being, besides damaging urban green-space structures (quantity and quality), affecting ESF, and loss of biodiversity at all spatial levels. Therefore, the local inhabitants highlighted the need to create green buffer zones (such as wetlands, water-absorbent forest landscapes, etc.), construction of walls (at coasts), and more multi-scale plantations; only then can we ensure and enhance the adaptative capacity of the urban systems against the anticipated environmental challenges and recover from the natural calamities. There is a dire need to learn from the day-to-day experiences to deal with climate change, besides community-level adaptation to climate change. Additionally, there is a need for effective spatial land use and zoning plans to foster the rational use of urban land to develop various urban functions sustainably. This enables the transformation of the KP regions into eco-friendly and green climate-resilient city-state.

3.2. Section B: RII of Sustainable Indicators and UGS Elements for UGI Indicators

The empirical results of this section constitute answers to the study's RQ2 and RQ3. Hence, this section is grouped into two sets to (i) investigation of key UGS elements that fortify the significance of each (sustainable) UGI indicator, as categorized in the TBL; (ii) identifying key UGS that play a fundamental function in enhancing the quality of UGI indicators ultimately contributes to a (probable) UGI framework/model that has the strength of encountering climatic hazards in urban settings.

3.2.1. Determine the RII of Sustainable UGI Indicators

The potential UGI indicators were categorized according to their weights by using the RII formula. An example of the RII calculation is explained in Table 5 (the values substituted into the formula are from Table 6). Then, the RII technique was deployed to gauge the significance of all sustainable UGI indicators as per local community perspectives (Table 6). The below empirical evidence showed that all the UGI sustainable indicators were divided into three groups: moderately important (m-imp), important (imp), and extremely important (e-imp). One UGI indicator (promoting green energy-saving strategies) had achieved the (e-imp) level 9 with an agreed share of 0.915 RII values. Along with this, ten UGI indicators (imp) and eleven indicators (m-imp) were recognized with an RII value ranging from 0.811 to 0.894 and from 0.738 to 0.792, respectively (Table 6). None of the values was found between 1 and 6, i.e., from extremely unimportant to slightly important. Overall, the result has established that most of the UGI indicators fall into the categories of important (imp) and moderately important (m-imp), whereas only one ecological indicator belongs to the extremely important group. This portrays the indicator's importance and distinctive quality based on the insightful review of the local community towards each UGI indicator. Such an effort would contribute to promoting sustainable green growth and, therefore, adds to building climate-resilient cities.

It is also important to note that if this research outcome is compared with the author's previous (top-down) local planning expert studies [34,51], it illustrates that the importance levels assigned by planning experts to potential sustainable UGI indicators vary. For example, in the expert study, the ecological indicators received a higher acceptance level than the other two categories, but vice versa in the community-based empirical study.

3.2.2. (a) RII Values of UGS Elements with Regards to UGI Indicators

The results have further determined UGS elements that improve the quality of each UGI indicator in making cities inclusive, eco-friendly, and resilient against environmental change. RII data set ranged between 0.37 to 0.95 values (Table 7). This reflects that, while dealing with climate-related disasters, not all the UGS elements assist positively in enhancing the efficacy of the UGI indicator. Only the UGS elements with an RII > 0.70 (Table 8) have the potential to enhance the efficacy of the UGI indicators against anticipated environmental challenges in the local urban context. These correlations enable to build of an inclusive and sustainable UGI indicator framework, besides supporting the formulation of green-growth strategies in land-use planning. Additionally, highlighting such vital taxonomy of green-space elements can improve the native community's understanding of NBGI for climate change mitigation/adaptation. Thus, the community-based green strategies can help to build an eco-sustainable and climate-resilient environment in the urban interface of the KP province and beyond.

3.2.3. (b) Identifying the Key UGS Elements

The finding further confirmed a functional linkage of each green element with the sustainable indicator, based on IQR values (0.60–0.76) with a cut-point of 0.70 (Table 8). These results highlighted important UGS elements for each UGI indicator, conditioned to local environments and community understanding. Overall, the outcome represents a pattern of variance, which signifies that each potential UGS element is characterized by a distinctive quality, and it does not improve the functional linkage and health of every UGI indicator. It is probably due to regional spatial context. Yet, the determined key green elements (Table 8) that perform a pivotal role in strengthening the resilience of respective UGI indicators also help to mitigate/adapt against the climatic variabilities in the urban settings.

It is also established that the city/urban appeal can be improved through various taxonomy of mixed-use green-spaces. It can be achieved more explicitly through the recommended UGS categories CG: "community garden"; BG: "botanical garden"; UP: "urban park"; FO: "forest"; RG: "rain garden and bio-swale"; WL: "wetland"; GRW: "green roofs and walls" and HO: "horticultural" [34]. Similarly, the study further propels the community's recommended green measures should be considered to plan risk-reducing contingencies against floods and heat island effects. Such bottom-up green initiatives promote community stewardship in green space planning, improve cities' ecological resilience, and benefit dwellers in times of climate emergencies. These measures need immediate attention by the concerned stakeholders for the mitigative measure, followed by other inclusion of additional UGS elements in the landscape greening policies and planning for adaptive measures. All in all, the findings contribute to achieving an agreement on establishing a sustainable and inclusive UGI framework backed by the community's understanding/importance. This may lead to building a new regional paradigm, which would encourage green growth infrastructure, not only in KP province but also in other regions having the same features.

It is worth mentioning that if this research outcome is compared with the native experts studied [34], it exemplifies both the native multi-stakeholder's viewpoints on understanding the functional interlinkage between taxonomy of UGS elements and UGI indicators in the native built environment vary in some optimal possibilities. However, in most cases, the collective level of agreement overlapped/agreed. This reflects the knowledge, awareness, and perspective of native experts [34,51] and the community toward the natural green landscape-based (NBLB) approach, a sustainable, cost-efficient, and innovative climate change adaptation/mitigation approach for green cities. Additionally, the overall research studies represent a strong tendency to accentuate the holistic and effective multi-stakeholder participatory planning (MSPP) approach in the decision-making process for designing and implementing NBLG initiatives that naturally alleviate the high risk of environmental hazards in the northwest urban region of Khyber Pakhtunkhwa, Pakistan.

Table 7. RII values for each urban green space (UGS) element.

Categories	Urban Green Infrastructure Indicators	Relative Index (RII) of UGS Elements RII = ΣW/(N × A)									
		Community Garden	Botanical Garden	Urban Park	Forest	Green Streets	Rain Garden & Bio-swale	Green & Permeable Parking Area	Wetland	Green Roof & Green Wall	Horticultural
Ecological	**"Optimize storm water management".**										
	i. "Increasing pervious surfaces".	0.71	0.72	0.75	0.88	0.63	0.76	0.6	0.81	0.56	0.59
	ii. "Minimize, retain and organically-purified rainwater runoff".	0.66	0.69	0.65	0.82	0.81	0.91	0.71	0.92	0.7	0.65
	"Decreasing the impact of urban heat islands".										
	iii. "Enhanced the quantity of the green spaces".	0.7	0.73	0.75	0.9	0.67	0.48	0.4	0.6	0.65	0.58
	iv. "Use of evaporative materials on the roofs, walls and floors".	0.65	0.69	0.76	0.86	0.63	0.91	0.82	0.94	0.73	0.53
	"Enhancing air quality (e.g., extracting impurities)".										
	v. "Growing more green trees and installing a green barrier in a roadway".	0.72	0.73	0.79	0.84	0.74	0.55	0.58	0.65	0.71	0.63
	"Enhancing noise quality".										
	vi. "Use a green sonic wall to reduce the minimum and maximum noise pollution. (i.e., thick hedges could be provided with a small meadow for minimum noise and for maximum noise reduction wide layers of bamboo and deciduous trees could be provided)".	0.69	0.69	0.74	0.91	0.69	0.42	0.37	0.6	0.64	0.61
	"Lower emissions of carbon (e.g., elimination of greenhouse gas emissions through greenery)"										
	vii. "Grow greater density of trees as shading and evaporating fabric for the paved surfaces".	0.73	0.76	0.76	0.91	0.72	0.41	0.41	0.63	0.67	0.65
	"Enhancing building energy performance".										
	viii. "Promote green energy-saving strategies".	0.63	0.57	0.64	0.68	0.64	0.38	0.34	0.51	0.87	0.55
	"Improved soil fertility and degradation condition".										
	ix. "Increase previous areas and plant trees to enhance soil stabilization".	0.73	0.77	0.74	0.89	0.66	0.63	0.53	0.70	0.60	0.70
	"Improved and safeguard urban ecology".										
	x. "Improve and strengthen the urban green network connectivity".	0.71	0.79	0.75	0.93	0.65	0.42	0.44	0.70	0.68	0.70

Table 7. *Cont.*

Categories	Urban Green Infrastructure Indicators	Relative Index (RII) of UGS Elements RII = ΣW/(N × A)									
		Community Garden	Botanical Garden	Urban Park	Forest	Green Streets	Rain Garden & Bio-swale	Green & Permeable Parking Area	Wetland	Green Roof & Green Wall	Horticultural
Socio-cultural	i. "Agri-production (e.g., home gardening; urban farming; and community farming)".	0.87	0.66	0.61	0.76	0.53	0.35	0.30	0.45	0.61	0.82
	"Enhancing social wellness"										
	ii. "Optimizing the recreation, and socialization activities".	0.78	0.81	0.81	0.82	0.75	0.41	0.30	0.68	0.71	0.69
	iii. "Improved city's appeal (through various green elements)".	0.75	0.78	0.82	0.85	0.79	0.70	0.69	0.77	0.75	0.74
	iv. "Enhancing the mental and physical health (e.g., visual and physical exposure to open green areas has a beneficial effect on stress and anxiety reduction)".	0.79	0.74	0.81	0.89	0.75	0.39	0.38	0.75	0.69	0.61
	v. "Provide ecological areas for research & education".	0.72	0.79	0.68	0.85	0.67	0.45	0.42	0.74	0.72	0.76
	vi. "Enhance connectivity of green areas to promote walking & biking opportunities".	0.69	0.76	0.83	0.89	0.78	0.35	0.35	0.71	0.55	0.58
Economic indicators	i. "Enhanced the value of property".	0.74	0.74	0.85	0.63	0.74	0.51	0.52	0.56	0.82	0.70
	ii. "Minimize healthcare expense".	0.82	0.77	0.80	0.88	0.73	0.42	0.34	0.67	0.70	0.68
	iii. "Decrease energy use (e.g., heating & cooling requirements)".	0.69	0.68	0.75	0.75	0.66	0.45	0.33	0.55	0.90	0.61
	iv. "Minimize the risk of flood disasters".	0.70	0.72	0.74	0.95	0.71	0.73	0.64	0.86	0.61	0.60
	v. "Decreasing the utilization of private cars by encouraging walking and biking opportunities (i.e., changing modes of transportation)".	0.66	0.73	0.80	0.84	0.79	0.42	0.44	0.71	0.53	0.53
	vi. "Value of eliminating of air pollutants".	0.72	0.78	0.79	0.92	0.75	0.43	0.45	0.64	0.76	0.69

Source: Authors' calculation using field survey data.

Table 8. Key Urban Green Space (UGS) elements.

Categories	Urban Green Infrastructure Indicators	Interquartile Range (IQR) Methdology				Cut-Off Point.	Approved Number of UGS Elements (RII ≥ 0.70)	Approved Urban Green Space (UGS) Elements
		Q1	Q3	IQR = (Q3-Q1) (Median)	Mean			
Ecological	**"Optimize storm water management".**							
	i. "Increasing pervious surfaces".	0.61	0.76	0.72	0.70	0.70	6	CG; BG; UP; FO; RG; WL
	ii. "Minimize, retain and organically-purified rainwater runoff".	0.67	0.82	0.71	0.70	0.70	6	FO; GS; RG; GPA; WL; GRW.
	"Decreasing the impact of urban heat islands".							
	iii. "Enhanced the quantity of the green spaces".	0.59	0.72	0.66	0.70	0.70	4	CG; BG; UP; FO.
	iv. "Use of evaporative materials on the roofs, walls and floors".	0.66	0.85	0.75	0.70	0.70	6	UP;FO;RG:GPA;WL; GRW
	"Enhancing air quality (e.g., extracting impurities)".							
	v. "Growing more green trees and installing a green barrier in a roadway".	0.60	0.69	0.67	0.70	0.70	6	CG; BG; UP; FO; GS; GRW.
	"Enhancing noise quality".							
	vi. "Use a green sonic wall to reduce the minimum and maximum noise pollution. (i.e., thick hedges could be provided with a small meadow for minimum noise and for maximum noise reduction wide layers of bamboo and deciduous trees could be provided)".	0.64	0.75	0.70	0.70	0.70	2	FO; UP.
	"Lower emissions of carbon (e.g., elimination of greenhouse gas emissions through greenery)"							
	vii. "Grow greater density of trees as shading and evaporating fabric for the paved surfaces".	0.64	0.75	0.70	0.70	0.70	5	CG; BG; UP; FO; GS.
	"Enhancing building energy performance".							
	viii. "Promote green energy-saving strategies".	0.52	0.64	0.60	0.70	0.70	1	GRW
	"Improved soil fertility and degradation condition".							
	ix. "Increase previous areas and plant trees to enhance soil stabilization".	0.64	0.74	0.70	0.70	0.70	6	CG; BG; UP; FO; WL; HO.
	"Improved and safeguard urban ecology".							
	x. "Improve and strengthen the urban green network connectivity".	0.66	0.74	0.70	0.70	0.70	6	CG; BG; UP; FO; WL; HO.

Table 8. *Cont.*

Categories	Urban Green Infrastructure Indicators	Interquartile Range (IQR) Methdology				Cut-Off Point.	Approved Number of UGS Elements (RII ≥ 0.70)	Approved Urban Green Space (UGS) Elements
		Q1	Q3	IQR = (Q3-Q1) (Median)	Mean			
Socio-cultural	**i. "Agri-production (e.g., home gardening; urban farming; and community farming)".**	0.47	0.74	0.61	0.70	0.70	3	CP; FO; HO.
	"Enhancing social wellness"							
	ii. "Optimizing the recreation, and socialization activities".	0.68	0.80	0.73	0.70	0.70	6	CG; BG; UP; FO; GS; GRW
	iii. "Improved city's appeal (through various green elements)".	0.74	0.79	0.76	0.70	0.70	9	CG; BG; UP; FO; GS; RG; GRW; WL; HO.
	iv. "Enhancing the mental and physical health (e.g., visual and physical exposure to open green areas has a beneficial effect on stress and anxiety reduction)".	0.63	0.78	0.75	0.70	0.70	6	CG; BG; UP; FO; GR; WL
	v. "Provide ecological areas for research & education".	0.67	0.76	0.72	0.70	0.70	6	CG; BG; FO; WL; GRW; HO
	vi. "Enhance connectivity of green areas to promote walking & biking opportunities".	0.56	0.78	0.70	0.70	0.70	5	BG; FO; UP; GS; WL.
Economic indicators	**i. "Enhanced the value of property".**	0.58	0.74	0.72	0.70	0.70	6	CG; BG; UP; GS; GRW; HO.
	ii. "Minimize healthcare expense".	0.67	0.79	0.72	0.70	0.70	6	CG; BG; UP; FO; GS; GRW.
	iii. "Decrease energy use (e.g., heating & cooling requirements)".	0.57	0.74	0.67	0.70	0.70	3	FO; UP; GRWl.
	iv. "Minimize the risk of flood disasters".	0.66	0.74	0.72	0.70	0.70	7	CG; BG; UP; FO; GS; RG; WL.
	v. "Decreasing the utilization of private cars by encouraging walking and biking opportunities (i.e., changing modes of transportation)".	0.53	0.78	0.69	0.70	0.70	5	BG; FO; UP; GS; WL.
	vi. "Value of eliminating of air pollutants".	0.65	0.78	0.74	0.70	0.70	6	CG; BG; UP; FO; GS; GRW.

Source: Authors' calculation using field survey data Keys: CG: "community garden"; BG: "botanical garden"; UP: "urban park"; FO: "forest"; GS: "green streets"; RG: "rain garden and bio-swale"; GPA: "green permeable parking area"; WL: "wetland"; GRW: "green roofs and walls".

4. Discussion

This research contributes to building up an inclusive and sustainable UGI framework, thereby connecting the local community (and their perspective) with the multi-functional urban green areas. Such an ecological interaction between humans and nature helps to understand NBGI techniques that reduce environmental hazards and promote urban sustainability [84]. This study also attempts to find UGI indicators, referred to as UGS elements, according to the local built-in context that remains vital to enhancing urban planning. This research establishes that (based on the spatial context), each UGS element has a distinctive characteristic that plays a unique role in improving the quality of respective UGI indicators to fight climatic disasters (e.g., urban floods, drought, etc.). Additionally, the cohabitation of diverse vital taxonomy of green elements and UGI indicators can lead to developing a sustainable UGI framework, which is relevant to the local built environment. It also leads to accomplishing (nature-based) green policies to adapt to climate change through resilient land-use planning [15,85,86]), whereas such green planning approaches further naturally minimize the high risk of urban flooding [23,45,87,88] and build long-term climate-resilient environment. Therefore, developing such resilient strategies remains crucial in areas that are not only highly vulnerable to in-daunting climatic challenges [3,89] but also remain susceptible due to the geographical location, hence requiring a reactive planning system [25,36] in a situation where the expansion of urban functions remains escalated [90,91].

The harsh regional realities continue to put pressure on the land cover and, thereupon, the decline of urban green-spaces [35]. Thus, the regions required adequate and effective urban landscape and greening policies (ULGP). The upgradation of the existent policies and initiation of new urban plans needs to be tapped local community perspective. Such an approach is considered more effective in apprehending the intricacy of human and ecosystem interactions [38,39,51,52]. It stands crucial to identify the vital taxonomy of UGS elements. These elements will have the potential to identify the key/reliable/sustainable UGI indicators according to the native built-in environment.

This integration of the local concepts can build a consensus toward an integrated urban landscape and green infrastructure. It is built on the idea of stimulating community participation while considering them important stakeholders in executing the planning/process, though it is not much institutionalized and practiced yet [36,49,92]. So, this study endorses a communal approach to building a UGI indicators'-based model. Only such a model can contribute to building a green, climate-resilient city-state. This approach can better address ecological, socio-cultural, and economic issues in land use. This model facilitates building an eco-regional paradigm that supports the successful transition of green action plans (GAP) and serves the community more effectively at the grassroots level in the urban interface of the Peshawar, Mardan, and Charsadda districts of KP and beyond.

5. Conclusions

The empirical study has outlined an explicit quantitative research methodology for developing a rich body of multi-functional UGI-indicator-based framework/model grounded upon TBL sustainability. This scientific UGI model is backed by the local community's perspective, and it presents the significance and practicability of UGI indicators and the UGS elements as per the local built-in environment. The results exhibit that ten UGI indicators fall into the categories of "IMP" and the other eleven as "M-IMP", whereas only one indicator received the "E-IMP" level. Furthermore, a varied catalog of vital UGS elements (for UGI indicators) was presented, subject to the building spatial context of the KP region. This depicts community insight and satisfaction level towards the respective green spaces and their relationship with each UGI indicator while coping with climatic hazards. Moreover, this study has emphasized the role of the local inhabitants in establishing a sustainable UGI framework, meeting the standards of a green, climate-resilient city in the north-western region of Pakistan. The participatory planning (PP) approach is recognized as the best tool that effectively promotes and strengthens community stewardship in the planning process for urban green spaces at the grassroots level. All in all, this research study bridges the planning gap and improves collaboration processes among the local inhabitants and relevant government institutions. It is to overcome the gap between technical knowledge and expertise in NBGI to achieve resilience in land-use planning. It will build local capacity to fight climate uncertainties more cost-effectively than the traditional grey infrastructure.

In conclusion, these empirical findings highlight the role of native community members in developing a sustainable UGI-indicator-based framework/model according to socio-cultural and ecological contexts. This will lead to building an eco-friendly and (green) climate-resilient city-state, not only specific to the northwest urban regions of KP province (Pakistan) but having its application to other regions. The research will inevitably open up a new area to study the potential role of innovative and indigenous NBGI initiatives in addressing sustainable climate-risk management (SCRM) strategies according to the native spatial environment. This planning technique can pave the way to meeting the goal of a well-balanced relationship between anthropocentrism and eco-centrism activities, not only specific to the urban interface of the KP region but also across the country.

Policy Implications

This research proposes essential policies guidelines/changes to create resilient urbanism against climatic risks (such as urban flooding):

(1). Increase awareness and understanding among all the native inhabitants toward a better understanding of UGI planning, a sustainable, cost-efficient, and innovative nature-based climate adaptation strategy for spongy green cities.
(2). A need to develop an inclusive policy that supports community participation at all levels, which will then promote community ownership and further strengthens the planning process for UGS.
(3). Balanced, proactive planning reforms are essential that encourage collaborations among the decision-makers and the local community. It should be linked with bridging the planning gap and improving the scientific knowledge regarding green initiatives, extending from policy making to decision making and implementation for greener growth.
(4). Considering the UGI planning examples of the Netherlands and Germany, there is a high need to incentivize green grass-root initiatives that would foster eco-friendly living practices and local stewardship of green practices to build a sustainable environment.

6. Scope of Future Research

(1). Further research can be conducted to study the relationship of the same (and additional) variables across socio-demographic groups to design micro-level urban greening policies.
(2). The social dimension of the sustainable urban landscape and greening policies (ULGP) and frameworks at the macro, micro, and meso levels needs to be investigated that can help build a new cultural paradigm to support and monitor green urbanism.
(3). The scalability of urban green space (UGS) elements must coincide with the magnitude of the climate hazards, knowing the appropriate green)/natural-based climate mitigation and adaptation measures to plan safer, healthier, and climate-resilient urban regions.
(4). In studying and analyzing green spaces, it would be interesting to consider different species of green roofs in different climates. It will help to better understand the potential role of green roofs in reducing climatic stress and improving the ecosystems functions (ESF) and health/well-being of inhabitants. Green roofs are becoming increasingly popular, especially in high-density urban clusters, where open spaces are limited. It is easy to implement and monitor, and they offer similar benefits as traditional green spaces.
(5). Pandemics (such as COVID-19) though pose less stress and do not degrade the UGI indicator more exclusively; however, this aspect needs to be further explored. There

is a need to develop institutional and political indicators, and their potential role in NBGI infrastructure planning to address SCRM should be investigated.

Author Contributions: Conceptualization, M.R.; data curation: M.R.; methodology, M.R., D.G. and U.K.; software, M.R.; formal analysis, M.R.; validation.; M.R., D.G. and U.K.; writing—original draft preparation, M.R.; writing—review and editing, M.R., D.G. and U.K.; supervision, D.G. and U.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research, as a part of the Ph.D. dissertation, was funded by the Deutscher Akademischer Austauschdienst (DAAD), Government of Germany, grant number 57381412. TU-Dortmund University, Germany, funded the Article Processing Charges (APCs).

Institutional Review Board Statement: This research study was conducted according to the guidelines of the Declaration of Helsinki. Ethical review and approval at any stage were waived for this study, due to the reason that no sensitive/personal information (e.g., names, contact details, codes, etc.) were sought/gathered during data collection or at any stage of this research. This research study and the questions asked were limited to context-based questions to generate knowledge about the role of Urban Green Infrastructure (UGI) in planning for climate-resilient cities. The responses were generalized to draw meaningful context-based results.

Informed Consent Statement: Informed verbal consent was acquired from each person participant. Publishing consent: The authors state their willingness to publish this work after it has been approved.

Data Availability Statement: This manuscript contains all data produced or examined during this investigation.

Acknowledgments: The corresponding author declares the financial support was provided by DAAD-Deutscher Akademischer Austauschdienst (Ref. No.: 2018/19-57381412) for doctoral studies in Germany. Other than DAAD, the authors are grateful to TU-Dortmund University for paying Article-Processing Charges (APCs), which helped in the speedy publication of the research findings. I am also indebted to my brother for providing valuable support in collecting data from household field surveys during those challenging COVID-19 times in the Peshawar, Mardan, and Charsadda districts of KP province.

Conflicts of Interest: The authors have no relevant financial or non-financial interests to disclose.

Appendix A. Development of Conceptual Base Frameworks

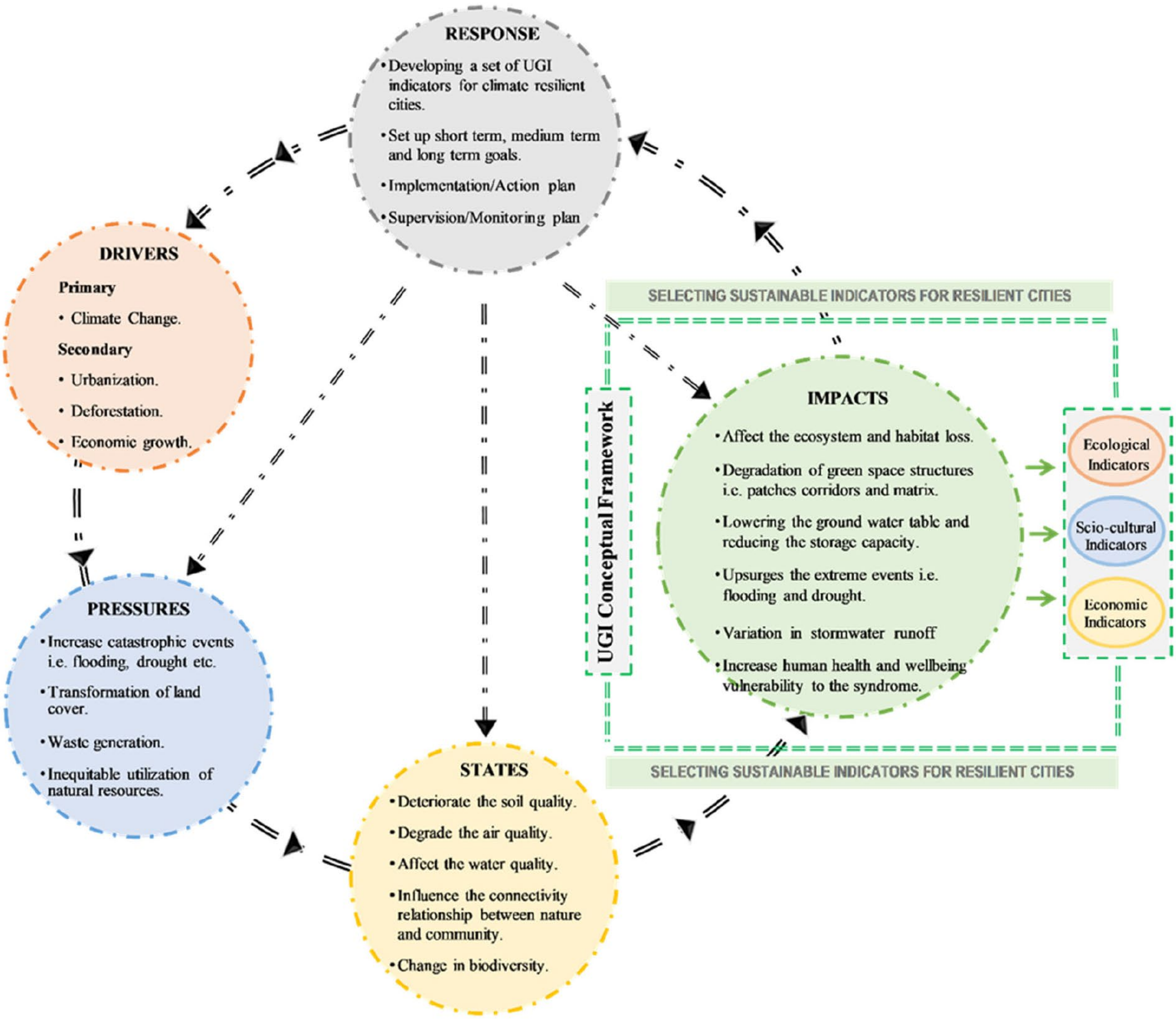


Figure A1. Relationship among the anthropogenic activities and UGI for resilient cities. Source: [48].

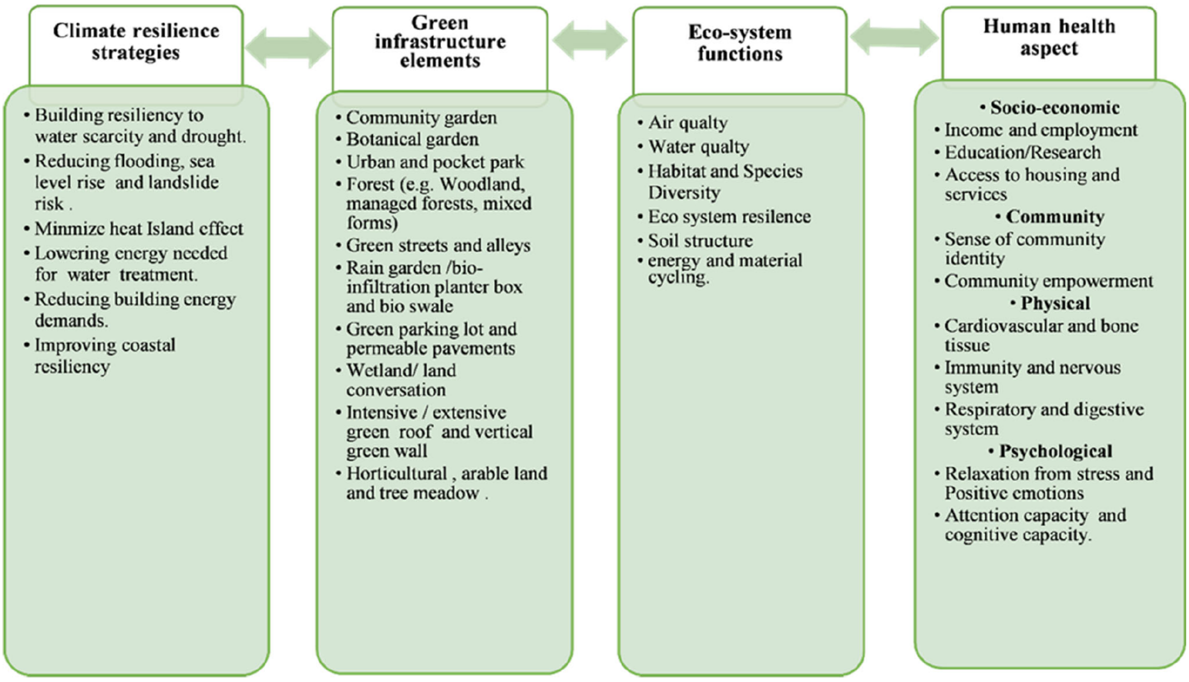


Figure A2. Conceptual base model: climate resilience strategies, ecosystem functions, human well-being, and GI elements. Source: [48].

Appendix B

Table A1. List of concepts evolved from the semi-structured meetings with native experts.

Mitigation of climate change	Adaptation to climate change	Water management
Green space networks	Ecosystem functions and services	Wildlife and biodiversity
Urban resilience	Organic food production	Energy-efficient building
Social cohesion/unity	A green economy	

Source: [34].

Appendix C

Based on the inputs provided by the participants in the pilot survey, some minor revisions were made, aimed to make the survey design more appropriate and time-efficient:

- "Section A: In the participant profile, a diverse category had also been incorporated into the question of gender class. In Pakistan, the government officially recognized "trans" as the third gender [80–82]".
- "In section b three-point Likert scale was updated into a five-point, and in Section C five-point Likert scale was transformed into a nine-point, aimed to achieve more variability among the respondent inputs and precision in the results".
- "To mitigate the ambiguity among the participant's feedback, certain queries of section c were also re-phrased".

Source: [34].

Appendix D

Identifying and validating the perspective, knowledge, beliefs, attitudes, and preferences of the native communities regarding the proposed definitions and possibilities of the UGI, urban resilience, climate change (CC), and adaptations to CC.

The following four questions were presented in section B of the community-based empirical survey executed in the KP districts of Charsadda, Peshawar, and Mardan, defining the concepts mentioned above according to the native built-in environment.

- "What does climate change mean for you?"
- "What does adaptation to climate change mean for you?"
- "What does urban resilience mean for you?"
- "What does green infrastructure mean for you?"

Source: [34].

References

1. Desa, U.N. *World Urbanization Prospects, the 2011 Revision*; Population Division, Department of Economic and Social Affairs, United Nations Secretariat: New York, NY, USA, 2014.
2. Desa, U.N. *World Urbanization Prospects 2018: Highlights (ST/ESA/SER. A/421)*; Population Division, Department of Economic and Social Affairs, United Nations Secretariat: New York, NY, USA, 2019.
3. Khayyam, U.; Munir, R. Flood in mountainous communities of Pakistan: How does it shape the livelihood and economic status and government support? *Environ. Sci. Pollut. Res.* **2022**, *29*, 40921–40940. [CrossRef] [PubMed]
4. Bratman, G.N.; Daily, G.C.; Levy, B.J.; Gross, J.J. The benefits of nature experience: Improved affect and cognition. *Landsc. Urban Plan.* **2015**, *138*, 41–50. [CrossRef]
5. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being: Synthesis*; Island Press: Washington, DC, USA, 2005.
6. IPCC. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation Special. In *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK, 2012. [CrossRef]
7. IPCC. *Climate Change 2014: Impacts, Adaptation and Vulnerability*; IPCC: Geneva, Switzerland, 2014. [CrossRef]
8. UNFPA. State of World Population 2007: Unleashing the Potential of Urban Growth. 2008. Available online: www.unfpa.org/swp/2007/english/chapter_3/index.html (accessed on 6 June 2020).
9. PBS. Pakistan Bureau of Statistics, Urban Demographic. 2018. Available online: http://www.pbs.gov.pk/ (accessed on 11 December 2020).
10. Naeem, S.; Cao, C.; Fatima, K.; Najmuddin, O.; Acharya, B.K. Landscape Greening Policies-based Land Use/Land Cover Simulation for Beijing and Islamabad—An Implication of Sustainable Urban Ecosystems. *Sustainability* **2018**, *10*, 1049. [CrossRef]
11. TEP. *Advancing the Delivery of Green Infrastructure: Targeting Issues in England's NorthWest*; The Environment Partnership: Helston, UK, 2005.
12. Benedict, M.A.; McMahon, E.T. *Green Infrastructure: Linking Landscapes and Communities, Urban Land*; Island Press: Washington, DC, USA, 2006.
13. Aldous, D.E. Greening South East Asian Capital Cities. In Proceedings of the 22nd IFPRA World Congress, Hong Kong, China, 15–18 November 2010; p. 14.
14. Tzoulas, K. Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landsc. Urban Plan.* **2007**, *81*, 167–178. [CrossRef]
15. Ahern, J. Green infrastructure for cities: The spatial dimension. In *Cities of the Future: Towards Integrated Sustainable Water and Landscape Management*; IWA Publishing: London, UK, 2007.
16. MacFarlane, R.; Davies, C.; Roe, M. *Green Infrastructure and the City Regions*; Discussion Paper; NECF: Gateshead, UK, 2005.
17. Davies, C.; McGloin, C.; MacFarlane, R.; Roe, M. *Green Infrastructure Planning Guide Project: Final Report*; WWF: Gland, Switzerland, 2006.
18. Weber, T.C.; Allen, W.L. Beyond on-site mitigation: An integrated, multi-scale approach to environmental mitigation and stewardship for transportation projects. *Landsc. Urban Plan.* **2010**, *96*, 240–256. [CrossRef]
19. Mell, I.; Allin, S.; Reimer, M.; Wilker, J. Strategic green infrastructure planning in Germany and the UK: A transnational evaluation of the evolution of urban greening policy and practice. *Int. Plan. Stud. Routledge* **2017**, *22*, 333–349. [CrossRef]
20. Lafortezza, R.; Davies, C.; Sanesi, G.; Konijnendijk, C. Green Infrastructure as a tool to support spatial planning in European urban regions. iForest—Biogeosciences and Forestry. *SISEF-Ital. Soc. Silvic. For. Ecol.* **2013**, *6*, 102–108. [CrossRef]
21. Monteiro, R.; Ferreira, J.C. Green Infrastructure Planning as a Climate Change and Risk Adaptation Tool in Coastal Urban Areas. *J. Coast. Res.* **2020**, *95* (Suppl. 1), 889–893. [CrossRef]
22. Gruehn, D. Landscape Planning as a Tool for Sustainable Development of the Territory—German Methodology and Experience. In *Environmental Security and Sustainable Land Use—With Special Reference to Central Asia*; Vogtmann, H., Dobretsov, N., Eds.; Springer: Dordrecht, The Netherlands, 2006; pp. 297–307.
23. Center for Clean Air Policy. *The Value of Green Infrastructure for Urban Climate Adaptation*; Center for Clean Air Policy: Washington, DC, USA, 2011; Volume 750, 52p.
24. MapAction, UN-OCHA. United Nations Office for the Coordination of Humanitarian Affairs New York: Pakistan/Kyber-Pakhtunkhwa: Flood Extent (2 September 2010) and Flood Affected. Available online: https://reliefweb.int/map/pakistan/pakistan-kyber-pakhtunkhwa-flood-extent-2-sept-2010-and-flood-affected-districts-31-aug (accessed on 11 December 2020).

25. Khayyam, U.; Noureen, S. Assessing the adverse effects of flooding for the livelihood of the poor and the level of external response: A case study of Hazara Division, Pakistan. *Environ. Sci. Pollut. Res.* **2020**, *27*, 19638–19649. [CrossRef]
26. Eckstein, D.; Künzel, V.; Schäfer, L. Global Climate Risk Index 2021. Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000–2019. 2020. Available online: http://germanwatch.org/en/download/8551.pdf (accessed on 11 June 2021).
27. Fahad, S.; Wang, J. Climate change, vulnerability, and its impacts in rural Pakistan: A review. *Environ. Sci. Pollut. Res.* **2020**, *27*, 1334–1338. [CrossRef]
28. Farooqi, A.B.; Khan, A.H.; Mir, H. Climate change perspective in Pakistan. *Pak. J. Meteorol.* **2005**, *2*, 11–21.
29. Fahad, S.; Jing, W.; Khan, A.A.; Ullah, A.; Ali, U.; Hossain, M.S.; Khan, S.U.; Huong, N.T.L.; Yang, X.Y.; Hu, G.Y.; et al. Evaluation of farmers' attitude and perception toward production risk: Lessons from Khyber Pakhtunkhwa Province, Pakistan. *Hum. Ecol. Risk Assess Int. J.* **2018**, *24*, 1710–1722. [CrossRef]
30. GoP. Pakistan Economic Survey. Finance Division, Govt. of Pakistan, Islamabad. 2010. Available online: https://www.finance.gov.pk/survey_1011.html (accessed on 11 November 2020).
31. WB. Forest Area (% of Land Change), World Bank. 17 August 2017. Available online: https://data.worldbank.org/indicator/AG.LND.FRST.ZS?locations=PK (accessed on 13 January 2022).
32. Pugh, T.A.; MacKenzie, A.R.; Whyatt, J.D.; Hewitt, C.N. Effectiveness of green infrastructure for improvement of air quality in urban street canyons. *Environ. Sci. Technol.* **2012**, *46*, 7692–7699. [CrossRef] [PubMed]
33. Mensah, C.A. Destruction of urban green spaces: A problem beyond urbanization in Kumasi city (Ghana). *Am. J. Environ. Prot.* **2014**, *3*, 1–9. [CrossRef]
34. Rayan, M.; Gruehn, D.; Khayyam, U. Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective. *Urban Clim.* **2021**, *38*, 100899. [CrossRef]
35. Waseem, S.; Khayyam, U. Loss of vegetative cover and increased land surface temperature: A case study of Islamabad, Pakistan. *J. Clean. Prod.* **2019**, *234*, 972–983. [CrossRef]
36. Ahsan, Ahmad. Urban Flood Risk Management in Pakistan. *Islamabad: Daily Times.* 2018. Available online: https://dailytimes.com.pk/280433/urban-flood-risk-management-in-pakistan/ (accessed on 4 December 2020).
37. Rana, I.; Routray, J. Multidimensional Model for Vulnerability Assessment of Urban Flooding: An Empirical Study in Pakistan. *Int. J. Disaster Risk Sci.* **2018**, *9*, 359–375. [CrossRef]
38. CABE. *Community-Led Spaces: A Guide for Local Authorities and Community Groups*; CABE Space: London, UK, 2010.
39. Harnik, P. The excellent city park system: What makes it great and how to get there. In *The Human Metropolis: People and Nature in the 21st-Century City*; Full book; University of Massachusetts Press: Amherst, MA, USA, 2006; p. 47.
40. Kim, T.-B. *Collaborative Governance for Sustainable Development in Urban Planning in South Korea*; University of Birmingham: Birmingham, UK, 2010.
41. Enger, S.C. *Planning for Parks, Recreation, and Open Space in Your Community*; Washington State Department of Community, Trade and Economic Development: Washington, DC, USA, 2005.
42. Baycan-Levent, T.; Van Leeuwen, E.; Rodenburg, C.; Nijkamp, P. *Development and Management of Green Spaces in European Cities: A Comparative Analysis*; Research Memorandum; FEWEB: Amsterdam, The Netherlands, 2002; p. 25.
43. Ahmad, N.; Anjum, G.A. Legal and institutional perplexities hampering the implementation of urban development plans in Pakistan. *Cities* **2012**, *29*, 271–277. [CrossRef]
44. Atta-ur-Rahman; Khan, A.N. Analysis of 2010-flood causes, nature and magnitude in the Khyber Pakhtunkhwa, Pakistan. *Nat. Hazards* **2013**, *66*, 887–904. [CrossRef]
45. Rouse, D.C.; Bunster-Ossa, I.F. *Green Infrastructure: A Landscape Approach*; American Planning Association: Chicago, IL, USA, 2013.
46. Zhang, X.; Wu, Y.; Shen, L. An evaluation framework for the sustainability of urban land use: A study of capital cities and municipalities in China. *Habitat Int.* **2011**, *35*, 141–149. [CrossRef]
47. Marques, R.C.; da Cruz, N.F.; Pires, J. Measuring the sustainability of urban water services. *Environ. Sci. Policy* **2015**, *54*, 142–151. [CrossRef]
48. Rayan, M.; Gruehn, D.; Khayyam, U. Green Infrastructure Planning. A Strategy to Safeguard Urban Settlements in Pakistan. In *Planning in Germany and Iran. Responding Challenges of Climate Change through Intercultural Dialogue*; Jafari, M., Gruehn, D., Sinemillioglu, H., Kaiser, M., Eds.; Mensch und Buch Verlag: Berlin, Germany, 2021; pp. 197–220.
49. Ashfaque, R.; Awan, M. *Final Report-Policy and Legal Reform Study (GEF-Protected Areas Management Project)*; Ministry of Environment, Government of Pakistan: Islamabad, Pakistan, 2015.
50. EC-European Commission. *Towards an EU Research and Innovation Policy Agenda for Nature-Based Solutions & Re-Naturing Cities, Final Report of the Horizon 2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities*; European Commission: Brussels, Belgium, 2015.
51. Rayan, M.; Khayyam, U.; Gruehn, D. Local Perspectives on Green Resilient Settlements in Pakistan. In *CIGOS 2021, Emerging Technologies and Applications for Green Infrastructure; Lecture Notes in Civil Engineering*; Ha-Minh, C., Tang, A.M., Bui, T.Q., Vu, X.H., Huynh, D.V.K., Eds.; Springer: Singapore, 2022; Volume 203. [CrossRef]

52. Weldon, S.; Bailey, C.; O'Brien, E. *New Pathways for Health and Well-Being in Scotland: Research to Understand and Overcome Barriers to Accessing Woodlands*; Report to Forestry Commission Scotland, Edinburgh; Forestry Commission Scotland: Edinburgh, UK, 2007.
53. Fors, H.; Molin, J.F.; Murphy, M.A.; van den Bosch, C.K. User participation in urban green spaces–For the people or the parks? *Urban For. Urban Green.* **2015**, *14*, 722–734. [CrossRef]
54. Hussnain, M.Q.; Anjum, G.A.; Wakil, K.; Tharanga, P.H. Improving Efficiency in Data Collection for Urban Development Plans through Information and Communication Technology. In Proceedings of the International Conference on Town Planning and Urban Management (ICTPUM), Lahore, Pakistan, 29–30 September 2014.
55. Wakil, K.; Hussnain, M.Q.; Yusuf, A.; Abdul Jabbar, J.; Project Report: Scenario Planning based Participatory Urban Growth Management Plans Using ICT. Islamabad. 2016. Available online: https://think-asia.org/handle/11540/7573 (accessed on 11 June 2022).
56. Nawaz-ul-Huda, S.; Burke, F.; Miandad, M.; Rana, M.N. Analysis of national assembly 55-rawalpindi franchise: An electoral GIS perspective of Pakistan. *Res. J. Sci. Technol.* **2011**, *2*, 35–48.
57. Correia, M.S. Sustainability: An overview of the triple bottom line and sustainability implementation. *Int. J. Strateg. Eng.* **2019**, *2*, 29–38. [CrossRef]
58. USEPA. *Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure*; EPA (USA): Washington, DC, USA, 2010.
59. Gill, S.E.; Handley, J.F.; Ennos, A.R.; Pauleit, S. Adapting cities for climate change: The role of the green infrastructure. *Built Environ.* **2007**, *33*, 115–133. [CrossRef]
60. Pauleit, S.; Ambrose-Oji, B.; Andersson, E.; Anton, B.; Buijs, A.; Haase, D.; Elands, B.; Hansen, R.; Kowarik, I.; Kronenberg, J.; et al. Advancing urban green infrastructure in Europe: Outcomes and reflections from the GREEN SURGE project. *Urban For. Urban Green* **2019**, *40*, 4–16. [CrossRef]
61. Lu, F.; Li, Z. A model of ecosystem health and its application. *Ecol. Model.* **2003**, *170*, 55–59. [CrossRef]
62. Chinyio, E.A.; Olomolaiye, P.O.; Corbett, P. Quantification of construction clients' needs through paired comparisons. *J. Manag. Eng.* **1998**, *14*, 87–92. [CrossRef]
63. Adetunji, I.O. Sustainable Construction: A Web-Based Performance Assessment Tool. Doctoral Dissertation, Loughborough University, Loughborough, UK, 2005.
64. Gavu, E.K. *Understanding Location and Neighbourhood Effects: An Analysis of the Housing Submarkets in Accra–Ghana*; Technische Universität Dortmund: Dortmund, Germany, 2021.
65. Braimah, N.; Ndekugri, I. Consultants' Perceptions on Construction Delay Analysis Methodologies. *J. Constr. Eng. Manag.* **2009**, *135*, 1279–1288. [CrossRef]
66. KPBOS. Khyber Paktunkhwa Bureau of Statistics. 2018. Available online: https://kpbos.gov.pk/ (accessed on 11 December 2020).
67. Pakzad, P.; Osmond, P.; Corkery, L. Developing key sustainability indicators for assessing green infrastructure performance. *Procedia Eng.* **2017**, *180*, 146–156. [CrossRef]
68. Luo, D.; Wan, X.; Liu, J.; Tong, T. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. *Stat. Methods Med. Res.* **2016**, *27*, 1785–1805. [CrossRef] [PubMed]
69. Beattie, A. Future career pathways in nursing and midwifery. A Delphi survey of nurses and midwives in South West England. *NT Res.* **2004**, *9*, 348–364. [CrossRef]
70. Wan, X. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med. Res. Methodol.* **2014**, *14*, 135. [CrossRef] [PubMed]
71. LGKP. Local Government Khyber Paktunkhwa. 2018. Available online: https://www.lgkp.gov.pk/districts/district-peshawar/ (accessed on 11 September 2020).
72. PMD. *Annual, Monthly Amount of Precipitation (mm) Report: Pakistan Metrological Department, Karachi City*; Pakistan Meteorological Department: Islamabad, Pakistan, 2019.
73. Johnson, T.P.; Pennell, B.E.; Stoop, I.A.; Dorer, B. (Eds.) *Overview of Questionnaire Design and Testing. Advances in Comparative Survey Methods: Multinational, Multiregional, and Multicultural Contexts (3MC)*; John Wiley & Sons: Hoboken, NJ, USA, 2018; p. 115.
74. Munn, P.; Drever, E. *Using Questionnaires in Small-Scale Research*; A Teachers' Guide; Scottish Council for Research in Education: Edinburgh, UK, 1990.
75. Babbie, E.R. *Survey Research Methods*; Wadsworth Pub.: Belmont, CA, USA, 1973.
76. Baruch, Y. Response Rate in Academic Studies-A Comparative Analysis. *Hum. Relat.* **1999**, *52*, 421–438. [CrossRef]
77. Likert, R. A technique for the measurement of attitudes. *Arch. Psychol.* **1932**, *22*, 55.
78. Page-Bucci, H. The value of Likert scales in measuring attitudes of online learners. 2003.
79. Singh, K. *Quantitative Social Research Methods*; Sage: Newcastle upon Tyne, UK, 2007.
80. Iqbal, N. Supreme Court Orders Equal Benefits for Transvestites. 2009. Available online: https://www.dawn.com/news/477909/supreme-court-orders-equal-benefits-for-transvestites (accessed on 13 May 2021).
81. Guramani, N.; National Assembly Passes Bill Seeking Protection of Transgender Rights. DAWN. 2018. Available online: https://www.dawn.com/news/1406400 (accessed on 13 May 2021).
82. Guramani, N.; Senate Unanimously Approves Bill Empowering Transgenders to Determine Their Own Identity. DAWN. 2018. Available online: https://www.dawn.com/news/1393766 (accessed on 13 May 2021).

83. Akadiri, O.P. *Development of a Multi-Criteria Approach for the Selection of Sustainable Materials for Building Projects*; University of Wolverhampton: Wolverhampton, UK, 2011.
84. European Union. *Green Infrastructure (GI)–Enhancing Europe's Natural Capital*; European Commission: Brussels, Belgium, 2013.
85. Matthews, T.; Lo, A.Y.; Byrne, J.A. Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landsc. Urban Plan.* **2015**, *138*, 155–163. [CrossRef]
86. Mazza, L.; Bennett, G.; De Nocker, L.; van Diggelen, R. Green infrastructure implementation and efficiency. In *Final Report for the European Commission, DG Environment on Contract ENV. B. 2/SER/2010/0059*; Institute for European Environmental Policy: Brussels, Belgium, 2011.
87. Beatley, T. *Green Urbanism: Learning From European Cities*; Island Press: Washington, DC, USA, 2000.
88. Nelson, M.; Ehrenfeucht, R.; Laska, S. Planning, plans, and people: Professional expertise, local knowledge, and governmental action in post-Hurricane Katrina New Orleans. *Cityscape* **2007**, *9*, 23–52.
89. NDMA. *National Disaster Management Authority, Annual Report 2010*; NDMA: Islamabad, Pakistan, 2010.
90. UNDP-Pakistan. Development Advocate Pakistan. *Sustain. Urban.* **2018**. Available online: https://www.undp.org/pakistan/publications/sustainable-urbanization. (accessed on 16 August 2021).
91. UNDP-Pakistan. Development Advocate Pakistan, Population Growth: Implications for Human Development. 2019. Available online: https://www.pk.undp.org/content/pakistan/en/home/library/development_policy/dap-vol6-iss1-population-growth.html (accessed on 16 August 2021).
92. Nizamani, A.A.; Shah, A.A. A review of forest policy trends for community participation in Pakistan. *Policy Trend Rep.* **2004**, *2004*, 28–34.

Article C

Key facts and author contributions

Reference	Rayan, M.; Gruehn, D.; Khayyam, U (2022 a). Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan. *Sustainability* 2022, 14, 7966. https://doi.org/10.3390/su14137966
Contributions	MR: 100% (character count: ca. 54,949)
Review	Double-blind peer review
Publication	Submitted: 6 June 2022 Accepted: 22 June 2022 Published: 29 June 2022

Signature:

_________________________ 03.01.2024

Muhammad Rayan Date

sustainability

MDPI

Article

Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan

Muhammad Rayan [1,*], Dietwald Gruehn [1] and Umer Khayyam [2]

[1] Research Group Landscape Ecology and Landscape Planning (LLP), Department of Spatial Planning, TU Dortmund University, 44227 Dortmund, Germany; dietwald.gruehn@tu-dortmund.de

[2] Department of Development Studies, School of Social Sciences and Humanities (S3H), National University of Sciences and Technology (NUST), Islamabad 44000, Pakistan; dr.umer@s3h.nust.edu.pk

* Correspondence: muhammad.rayan@tu-dortmund.de

Abstract: Climate-induced pressures spur on the need for urban green infrastructure (UGI) planning. This approach offers a possible way to improve ecosystem functionality and human well-being in adversely affected urban regions, wherein UGI is perceived as a green and nature-based climate change mitigation/adaptation strategy. In Pakistan, the Khyber Pakhtunkhwa (KP) province lacks such urban landscape and greening policies (ULGP) or legislative frameworks for transitioning to green action plans (GAP), to alleviate the risk of multi-climatic hazards. Thus, this study aims to investigate a sustainable UGI-indicator-based framework model, based on the due inclusion of the concerned stakeholders. The relative importance index (RII) and inter-quartile range (IQR) techniques are employed for field data analysis. The findings proclaim excellent reliability ($\alpha > 0.7$) and internal consistency, wherein sustainable UGI indicators are grouped based on their importance. The results portray the ecological and economic sustainability dimensions as being important (RII = 0.835 and RII = 0.807, respectively), socio-cultural dimensions as being moderately important (RII = 0.795), and a set of UGS elements (RII $\geq$ 0.77) as vital for bolstering individual UGI indicators. The main UGS elements emerging in each category can be grouped as follows: ecological category—"reducing rainwater runoff" (RII = 0.94); socio-cultural category—"enhancement of mental and physical health" (RII = 0.90); and eco category—"minimizing the risk of flood disasters" (RII = 0.96). The simulation results demonstrate the need for an inclusive perspective when building the urban green space (UGS) infrastructure (and standards) that will be most suitable for ensuring climate-resilient urban regions. This study contributes to putting the scientific research knowledge of the natural green-landscape-based (NBLB) approach into practice. The study calls for the establishment of an effective, pragmatic relationship between the urban landscape and greening policies, alongside a constructive relationship with the native inhabitants to ensure eco-friendly and resilient settlements.

Keywords: sustainable urban green indicators; urban green space (UGS); climate change; adaptation; participatory planning (PP) approach; Pakistan

Citation: Rayan, M.; Gruehn, D.; Khayyam, U. Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan. *Sustainability* **2022**, *14*, 7966. https://doi.org/10.3390/su14137966

Academic Editor: Baojie He

Received: 6 June 2022
Accepted: 22 June 2022
Published: 29 June 2022

1. Introduction and Background

The urban green space (UGS) infrastructure is currently garnering more attention in recognition of its significance for cities, whether developed, developing, or upcoming. Sustained urbanization remains necessary for sustainable development, wherein green urban planning is perceived as an effective strategy against anticipated climate change/environmental challenges [1–6]. Experts anticipate that the variability of anthropogenic forces will further influence climate change [7,8], as they have already transformed the urban outlook by greying the natural landscape. Accordingly, the pressure on green spaces is increasing due to unprecedented urban growth. There are already many climatic challenges evolving (e.g., flooding, drought, the urban heat island effect, etc.) [9,10].

Furthermore, the current situation is leading to ecological imbalances, disruptions to greenspace structures and ecosystem functions (ESF), and the loss of biodiversity and degraded health/well-being at all spatial levels. Consequently, urban green infrastructure (UGI) planning is emerging as a new pathway to ameliorating the disturbed socio-ecological systems through innovative green nature-based solutions [11–13]. UGI is defined as "a network composed of open spaces, waterways, gardens, forests, green corridors, trees on streets, and open spaces, bringing many social, economic and ecological benefits" [14]. An alternative version of UGI exists as "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife" [15]. UGI, a novel planning terminology, is a re-articulation of the present UGS planning idea [16,17], widely recognized as a green approach in sustainable climate-risk management (SCRM) that enhances (urban) ecosystem health [18]. Moreover, UGI and SCRM together have the potential to fight climate uncertainties more cost-effectively than the traditional grey infrastructure [19,20]. However, UGI's strength as a climate change mitigator is seldom perceived in developing countries, where it is instead associated with beautification—a non-essential urban amenity. Its actual potential to influence urban climate resilience against ever-rising environmental hazards is still less frequently considered [20–23].

Therefore, to address the underlying causes and destructive effects of climate change (CC), there is an immediate need to understand and link UGI and climate resilience concepts to land-use planning [24–27]. This will help to develop a sustainable UGI-indicator-based model, based on stakeholders' (i.e., policymakers, practitioners, academicians) and the local community's input under participatory planning (PP). Here, PP remains effective in promoting community stewardship to stimulate nature-based green (NBG) initiatives in land-use planning [28–33], to build a resilient city-state. At this juncture, a successful green transition is pivotal for executing a participatory planning approach [29,34], as such initiatives are necessary to stimulate UGS infrastructure, to better address ecological, socio-cultural, and economic issues regarding land use [35]. This also enhances cities' ecological resilience and the associated benefits for its dwellers against urban environmental hazards [20,36].

1.1. Problem Statement and Intended Intervention

Pakistan still lacks green policies and strategies for resilient land-use planning. There is room to place UGI at the center of SCRM to fight the ever-rising climate hazards [20,37,38]. This need for innovative UGI planning is linked to Pakistan's vast territory and multiplicity of dwellings (220 million inhabitants), where a significant portion of the population (39.22%) resides in urban areas [39]; this figure will have risen to 50% by the year 2030 [40,41], putting urban regions and inhabitants at risk of climatic catastrophes [42]. The growing number of natural catastrophes, especially constant flooding [37,43], has made Pakistan the eighth most vulnerable country in terms of natural calamities [44,45]. At the regional level in Pakistan, the Khyber Pakhtunkhwa (KP) province stands out as the region most hard-hit by a series of calamities, accounting for massive economic and human losses [20,36,46,47]. The damage is mainly linked to KP's topography and physical location [20,43] (Figure 1), which often results in natural catastrophes of varying magnitudes. These emerging issues are directly linked to inefficient land-use planning and backward policies that lack UGI and SCRM factors [20,23,36]. The lack of such innovative planning has led to a decline in green spaces in KP's cities: Peshawar, Mardan, and Charsadda. The loss of urban green spaces (UGS) is linked to a weak planning process, implementation issues, a lack of scientific knowledge and awareness, and the non-existence of a participatory planning (PP) approach, which is transforming green spaces within the built infrastructure [20,21,24,48–50]. Although efforts are underway to adapt to spatial technologies for developing land-use maps of major urban regions, such interventions would require time, resources, and infrastructure to develop an efficient data collection mechanism in the non-collaborative environment prevalent in Pakistan [20,38,51,52]. The country and the provinces must work to catch up with the CC policies of the developed nations (e.g., the Netherlands, Germany, and the UK), which already have UGI and SCRM policies in place to plan and design climate-resilient urban regions [4,11–13,53].

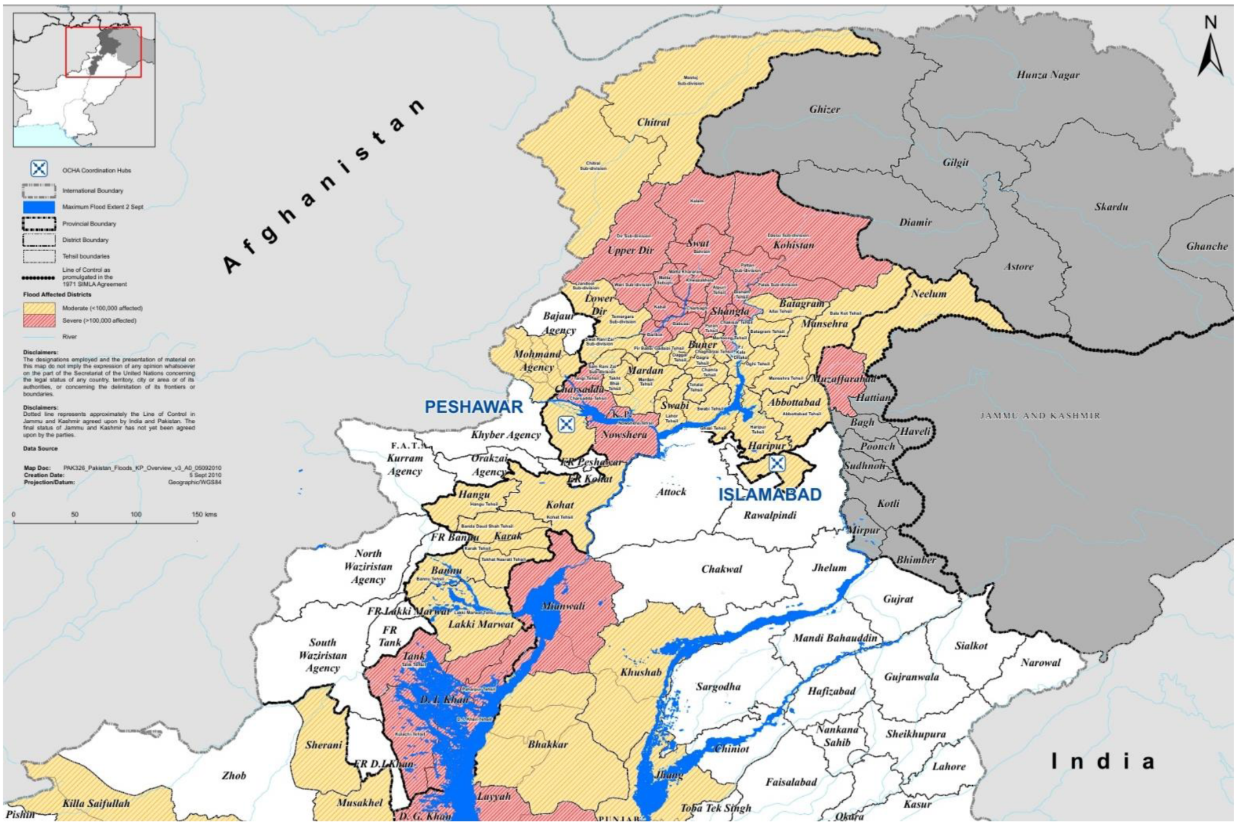


Figure 1. Khyber-Pakhtunkhwa (KP): Flood-affected urban centers. Source: [54].

Pakistan in general, and KP cities in particular, require immediate intervention to build a holistic PP approach for UGI and SCRM as such an approach carries the potential to improve the urban system/functions against the problems of a changing climate [15,35,55,56]. Such a UGI framework approach will encompass core sustainable UGI indicators, being interlinked with a diverse vital taxonomy of UGS elements, as jointly determined by all stakeholders in the native spatial environment. It will be helpful in defining the necessary pragmatic and proactive landscape and greening policies and strategies for planning resilient cities in KP. It would be naive to claim that the real drivers of climatic disasters are only linked to weak laws and their enforcement, a lack of clear legislative planning framework, and a reactive planning approach [57], yet in actuality, they are also linked to the inefficient implementation of such laws/policies that result in a decline in the number of natural green spaces [21,22]. This lack of both policies and their implementation has been systematically leading to the degradation and depletion of the natural green barriers, thereby endangering the urban ecology, human health, and well-being [58–60], and enabling destruction as a result of multi-climatic disasters on a rising scale [20,36,45,46], accentuating KP's vulnerability to natural catastrophes [47] and the negative impacts of calamities in catchment areas.

Thus, it is clear that PP is most needed for UGI in terms of efficient management or SCRM, in order to foster coordination among three tiered groups: decision-makers, experts, and the local community. These steps are mandatory to ensure efficient land-use planning, embedding input from all the concerned stakeholders so that a sustainable UGI framework can be developed (Appendix A). Such a model will then identify the potential taxonomy of UGS elements regarding the respective sustainable UGI indicators. These will be used relative to local contextual factors and the heterogeneity/socio-demographics of the stakeholders. This intervention would lead to the development of a rich body of multi-functional UGI indicator-based framework models, grounded upon "triple-bottom-line" sustainability, and adapted to the local context. This will then strengthen the climate-resilient strategies, green spaces, ecosystem functions, and human well-being.

Aim and Research Questions

The aim of this research study is to build a sustainable UGI indicator-based framework/model for identifying UGS elements, to enhance an area's resilience against climate hazards. This model is to be built using an inclusive approach, by engaging experts and the local community.

The research questions of this study are:

- RQ1. What are the main UGI indicators under MSEP?
- RQ2. What are the key UGS elements that can improve UGI resilience under SCRM?
- RQ3. What is the sustainable UGI indicator-based model needed to build a climate-resilient city?

2. Research Methodology

To achieve the aim of this research study (i.e., building a sustainable UGI indicator-based framework/model by identifying UGS elements), this study has consulted the local stakeholders (experts and community) in KP (Appendix A: Table A1). This cross-examination of the concerned stakeholders is positioned as part of empirical research that facilitates a holistic/in-depth investigation (Figure 2), not only to validate the findings (within the real-life context) but also to establish a rational standpoint between the stakeholders to design a sustainable UGI indicator-based framework/model. It is intended as an aid to designing innovative green avenues for climate change adaptation.

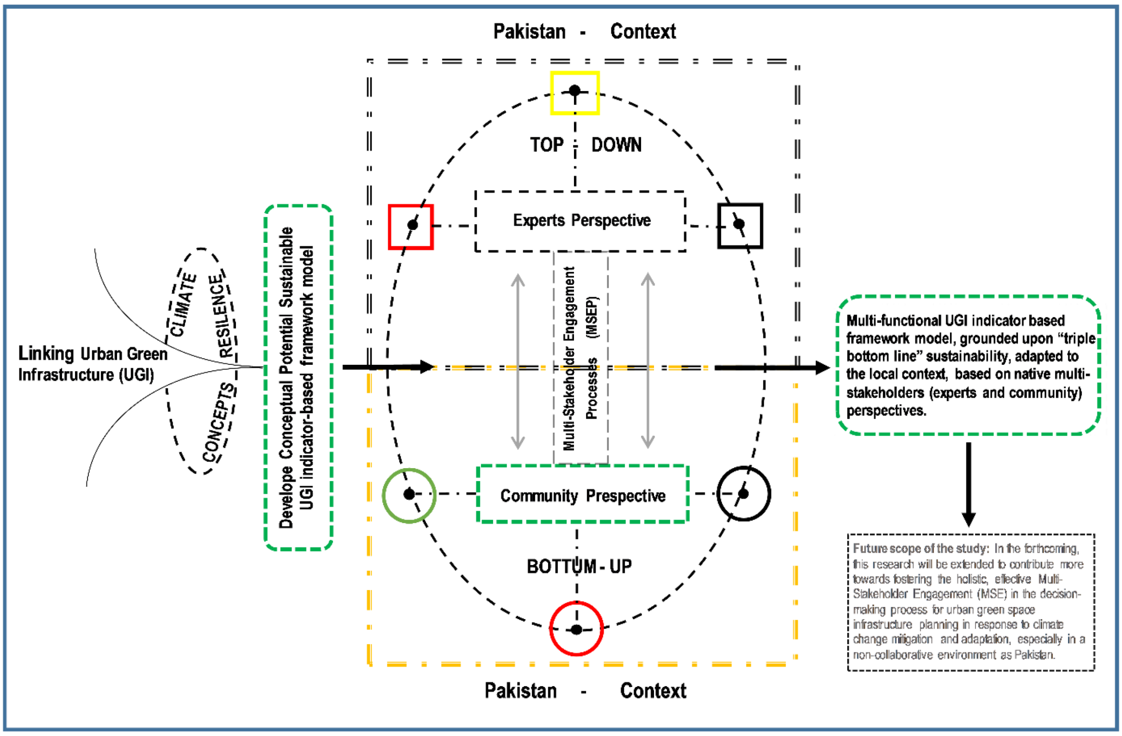


Figure 2. Conceptual framework. Source: Authors' own.

2.1. Probing the Potential UGI Indicator-Based Framework Model

The UGI model evolves around blending two paths: (a) creating a conceptual base on which to build the framework, which is extended to bond-building anthropogenic activities and UGI for resilient cities; (b) building climate resilience strategies that are based on ecosystem functions, human well-being, and UGI elements (for details, see Appendix B: Figures A1 and A2). Thus, the presented framework/model, as well as the resilience strategies, tackle or integrate different conceptual themes (i.e., green-space networks, energy management, water management, the green economy, wildlife and biodiversity, organic food, mitigation and adaptation, ecosystems, social cohesion, and resilience) that originated from the semi-structured discussions conducted through a field survey (Figure A3). These innovative themes project the potential role of the UGS infrastructure in addressing sustainable climate-risk management (SCRM). The consolidated integration of all three dimensions—ecological, socio-cultural, and economic dimensions—further leads to identifying UGI indicators (e.g., stormwater management, lessening noise pollution, improving air quality, etc.) for green urban planning. The proposed UGI indicators were mainly quantitative and were set based on expert and community responses (Figure 2). The relative index (RI) analysis technique was employed to investigate the insightful viewpoints offered by the local stakeholders (i.e., community and experts) to build a potential UGI framework, with the aim of reducing urban vulnerability.

2.2. Multi-Stakeholder Engagement Processes (MSEP)

Multi-stakeholder engagement processes (MSEP) remain effective as a participative planning approach to engaging the stakeholders. The stakeholders in this study are (a) the local community, for which an empirical survey was conducted (MARD: Mardan District, PESH: Peshawar District, CHAR: Charsadda District in the KP Province), and (b) experts to whom the field survey was extended (respondents from the GOV: Government, ACAD: Academicians, PRACT: Practitioners, and INGO: International Non-State/Government Actors/Org). Thus, MSEP here provided a holistic pathway to ensure the effective participation of the local/native stakeholders in the decision-making process: the experts as policymakers; practitioners; academicians, and the local community. MSEP is deployed in this research to develop a sustainable UGI indicator-based framework, which has its worth and, yet, is less explored in designing policies and frameworks for land-use planning and implementation [20,38,61,62]. However, MSEP remains effective for designing and implementing nature-based green infrastructure (NBGI) initiatives.

Hence, an MSEP-based pairwise examination is utilized here to identify and conceptualize the similarities across experts and the community perspective on UGI indicators that further lead to the taxonomy of UGS elements, dependent upon the socio-cultural and ecological context of the region. Additionally, MSEP deployment has verified and validated a set of core sustainable UGI indicators and UGS elements. This led to developing a richly multi-functional, inclusive, sustainable UGI indicator-based framework/model that can be deployed in the local built environment. Such a model allows the local inhabitants to interact with the development of innovative multi-functional urban green spaces, thereby alleviating the high risk of catastrophes (e.g., urban flooding, droughts, urban heat island (UHI) effects, etc.). All in all, MSEP has helped to develop a model that is eco-friendly and climate-resilient.

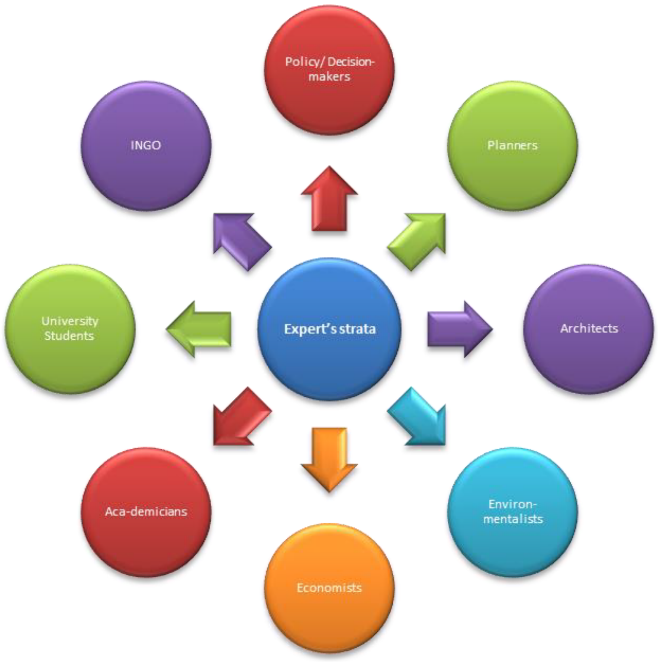
2.3. Survey Design and Sampling Technique

This research deployed two survey techniques to operationalize an in-depth empirical examination. The first was an expert-based perception survey that was extended to 212 respondents, of whom 172 were included in the final results. The rest of the questionnaires were excluded since the mandatory questions were not answered. The demographic information of the expert-based perception survey demonstrated that 45.9% were female and no participant was from the third-gender category, which choice was offered here since the government of Pakistan recognizes the identification of "trans" as a third gender [63–65]

(CI 95%, ±5% MoE). The questionnaires were assessed by the authors and put forward for analysis, as per Cochran (1977). A purposive sampling technique was used to sort the specific participants into nine distinct experts' strata (Table 1).

Table 1. Demographic information of the nine distinct experts' strata/group participants.

Gender	Percentage (%)
Male	54.1
Female	45.9
Education	
Primary education and below	0
Secondary education	0
Higher Secondary education	0
Tertiary/Higher education	93
Other	7
Expertise	
Building/Architecture	40.1
Infrastructure	11.0
Landscape planning	9.3
Urban planning	19.8
Horticulture/Arboriculture	1.7
Climate change/Ecology	8.1
Economy	2.9
Sociology	3.5
Other	3.5
Professional Experience	
Less than five years	30.8
Five to ten years	37.2
Eleven to fifteen years	20.9
More than fifteen years	11.0



The second primary data collection method was based on community-based empirical studies from the study districts of Peshawar, Mardan, and Charsadda. The study adopted two-point scale criteria to identify the municipality (Tehsil) and the sub-municipality (Union Council (UC)) in the selected study areas. Furthermore, the snowball technique was deployed to designate specific houses serving as a reference point, marking every fourth house/HH from the reference point. This was performed as no official lists of the residential houses within UCs exist. For data collection purposes, a structured questionnaire was deployed that was designed in several sections designated as A–C. Section A is aimed at verifying the participant's profile, knowledge, and experience. The category of "trans" as a third gender was included as it is officially recognized by the government of Pakistan. Section B encompassed four questions, explained in Appendix E, that verified and validated the local experts' and community's perspectives on the proposed possibilities and definitions of the UGI, climate change, climate change adaptation, and urban resilience. Section C is classified into three subsections (ecological, socio-cultural, and economic); each section includes multiple questions with the aim of rating and identifying the level of importance of each specific sustainable UGI indicator and its interrelationship with multiple green elements. Potential UGI indicators and elements were developed by the authors in preceding research studies [38]. This process resulted in our selecting the most vital green elements that enhanced the quality and standard of a particular UGI indicator and would create urban regions that are resilient against natural hazards such as flooding [20]. Figure A4 in Appendix D shows the prior pre-test/pilot survey, wherein the suitability and inclusivity of the questionnaires were checked. Community-based questionnaires targeted 192 HHs (CI 95%, ±5% MoE) (Appendix F: Table A2), with respondents coming from diverse socioeconomic backgrounds (Table 2).

Table 2. Demographic information of the community participants.

Gender	**Percentage (%)**
Masculine	65.6
Feminine	22.4
Diverse	-
Prefer not to say	12
Literacy	
No Education to Elementary	0
Secondary Education (SSC)	7.3
Intermediate	19.3
Higher Education	73.4
Other (informal)	2.6
Age	
Fifteen to twenty years old	0
Twenty to thirty years old	34.4
Thirty to forty years old	43.8
Forty to fifty years old	21.9
More than fifty years old	7.3

Source: Authors' elaboration, calculated using the survey data.

2.4. Data Analysis and Scoring

The Statistical Package for the Social Sciences (SPSS version 26) and Microsoft Excel software were employed to process the data gathered from experts and the community. A questions-based coding algorithm was utilized for parts B and C, which helped to segregate experts and community responses easily and to understand an inclusive multi-stakeholder perspective, according to the native built environment. A five-point Likert scale was deployed in part B and a nine-point Likert scale in part C[4], ranging from "extremely unimportant" to "extremely important". Positive and negative scales were employed to determine the variance in the significance levels among the specified UGI indicators and green-space elements (Table 3) as not all the green elements enhanced the health of the respective UGI indicators. Then, relative importance index (RII) and interquartile range (IQR) tests were applied to calculate the relative significance of each sustainable UGI indicator, as well as the UGS elements, as recommended previously [66–69]. This method is recognized as being the best for ordinal-scale surveys [70–73].

Table 3. Equation (1) can be used to calculate the RII value for enhancing the noise quality indicator.

$$RII = \Sigma W/(N \times A) \ldots\ldots\ldots\ldots\ldots (1)$$

W = Likert scale weights: assigned by participants to each indicator (1 to 9).
N = Total number of samples
A = The highest value on a Likert scale.

RII = (9 × 74) + (8 × 26) + (7 × 47) + (6 × 22) + (5 × 10) + (−4 × 6) + (−3 × 3) + (−2 × 1) + (−1 × 3)/(192 × 9) = 0.780
(as rated by a community member)

RII = (9 × 59) + (8 × 26) + (7 × 47) + (6 × 22) + (5 × 10) + (−4 × 2) + (−3 × 3) + (−2 × 0) + (−1 × 3)/(172 × 9) = 0.795
(as rated by planning experts)

Source: Authors' elaboration, calculated using the survey data.

Based on a relative index (community + expert), the significance of the respective UGI indicator was determined. To ensure a usable quantity of UGI indicators and a full set of the vital UGS elements, four strategies were deployed: (i) an average RII data set was derived from both top-down (planning experts) and bottom-up (community) sources to obtain specific RII values for each UGI indicator; (ii) based on the inclusive RII values of the respective UGI indicators, an average RII value was calculated for each dimension of sustainability (Table 4); (iii) the RII values were translated into the 9-point importance scale criterion (Figure 3), as suggested by [69,71,74]; and (iv) adding four more fundamental levels to obtain variance in the importance levels among the specified UGI indicators. These techniques helped to identify the significance level of each sustainability dimension.

The IQR was applied to identify the cut-off points (Table 5a,b), as suggested previously [19,67–70,73]. The IQR helped to determine the difference between the median of the lower (Q3) and the upper (Q1) half of the data. Lastly, Cronbach's alpha (α) reliability test confirmed the reliability of the data sets (α = 0.7); hence, they are acceptable for grounding the study findings (Figure 4).

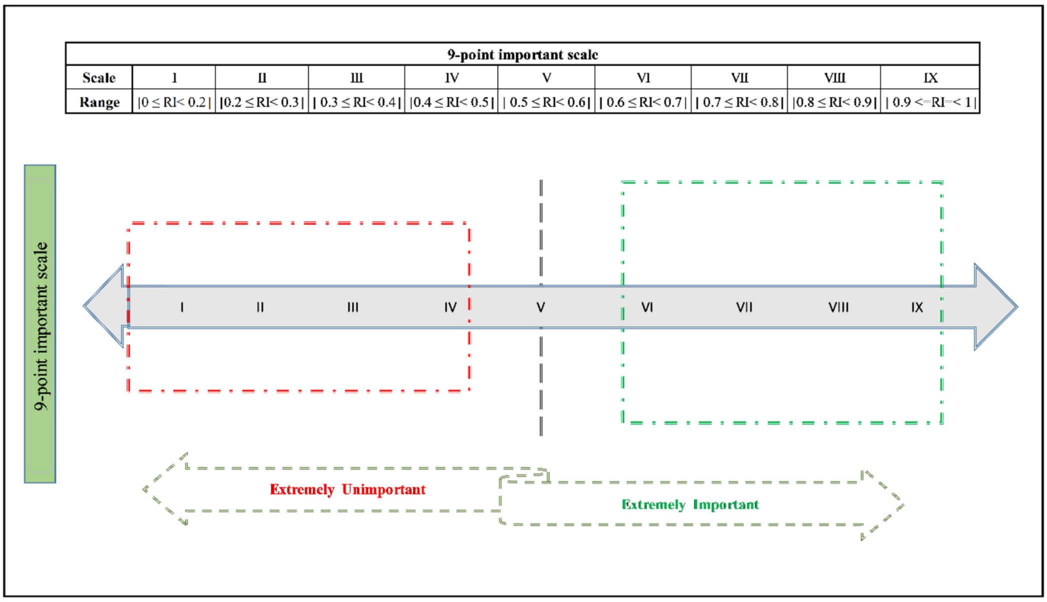


Figure 3. Criteria of the 9-point scale. Key: I—extremely unimportant; II—moderately unimportant; III—slightly unimportant; IV—unimportant; V—Low; VI—slightly important; VII—moderately important; VIII—important; IX—extremely important. ***Source***: Authors' elaboration.

Table 4. The UGI indicators' relative importance (RII) value: integrating bottom-up (community) and top-down (expert) perspectives.

Categories	Urban Green Infrastructure Indicators	Community Members Prespective (C-P) (Group A)			Community Members' + Planning Experts' Prespectives				Planning Experts Prespective (E-P) (Group B)		
		Participants (*N*)	**Overall Weight (W)**	**RII = Σ W/(N * A)**	**Mean (RII) (C-P + E-P)**	**UGI Indicator of ImportanceLevel**	**RII Average (Section-Wise)**	**Sustainability Dimension Importance Level**	**RII = Σ W/(N * A)**	**Total Weighted (W)**	**Respondents (*N*)**
	i. Optimize storm water management.										
	Increasing pervious surfaces	192	1441	0.834	0.836	IMP			0.837	1296.00	172.00
	Minimizing, retaining and organically purifying rainwater runoff.	192	1364	0.789	0.798	M-IMP			0.807	1250.00	172.00
	ii. Decreasing the impact of urban heat islands										
	Enhancing the quantity of the green spaces.	192	1517	0.878	0.890	IMP			0.903	1398.00	172.00
	Use of evaporative materials on the roofs, walls, and floors.	192	1287	0.745	0.742	M-IMP			0.740	1145.00	172.00
	iii. Enhancing air quality (e.g., extracting impurities).										
	Growing more green trees and installing a green barrier in a roadway.	192	1339	0.775	0.787	M-IMP			0.800	1238.00	172.00
	iv. Enhancing noise quality										
Ecological	Use a green sonic wall to reduce the minimum and maximum noise pollution (i.e., thick hedges could be provided with a small meadow for minimum noise and, for maximum noise reduction, wide borders of bamboo and deciduous trees could be provided).	192	1347	0.780	0.787	M-IMP	0.835	IMP	0.795	1230.00	172.00
	v. Lower emissions of carbon (e.g., elimination of greenhouse gas emissions via greenery)										
	Grow a greater density of trees for shade and use evaporating fabric for the paved surfaces.	192	1513	0.876	0.890	IMP			0.904	1400.00	172.00
	vi. Enhancing building energy performance.										
	Promote green energy-saving strategies.	192	1581	0.915	0.925	E-IMP			0.935	1448.00	172.00
	vii. Improved soil fertility and degradation condition.										
	Increase existing areas and plant trees to enhance soil stabilization.	192	1473	0.852	0.859	IMP			0.865	1339.00	172.00
	viii. Improve and safeguard the urban ecology										
	Improve and strengthen urban green network connectivity.	192	1428	0.826	0.833	IMP			0.840	1301.00	172.00

Table 4. *Cont.*

Categories	Urban Green Infrastructure Indicators	Community Members Prespective (C-P) (Group A)			Community Members' + Planning Experts' Prespectives				Planning Experts Prespective (E-P) (Group B)		
		Participants (*N*)	Overall Weight (W)	RII = Σ W/(N * A)	Mean (RII) (C-P + E-P)	UGI Indicator of ImportanceLevel	RII Average (Section-Wise)	Sustainability Dimension Importance Level	RII = Σ W/(N * A)	Total Weighted (W)	Respondents (*N*)
Socio-cultural	i. Agri-production (e.g., home gardening; urban farming; and community farming)	192	1411	0.817	0.819	IMP	0.795	M-IMP	0.822	1273.00	172.00
	ii. Enhancing social wellness.										
	Optimizing recreation and socialization activities.	192	1402	0.811	0.825	IMP			0.839	1299.00	172.00
	Improving the city's appeal (through various green elements).	192	1275	0.738	0.758	M-IMP			0.778	1205.00	172.00
	iii. Enhancing the mental and physical health of inhabitants (e.g., visual and physical exposure to open green areas has a beneficial effect on stress and anxiety reduction).	192	1509	0.873	0.872	IMP			0.870	1347.00	172.00
	iv. Providing ecological areas for research and education.	192	1304	0.755	0.758	M-IMP			0.762	1180.00	172.00
	v. Enhancing the connectivity of green areas to promote walking and biking opportunities.	192	1287	0.745	0.739	M-IMP			0.733	1134.00	172.00
Economic indicators	i. Enhance the value of property	192	1244	0.720	0.713	M-IMP	0.807	IMP	0.705	1092.00	172.00
	ii. Minimize healthcare expense	192	1369	0.792	0.806	IMP			0.820	1269.00	172.00
	iii. Decrease energy use (e.g., heating and cooling requirements.	192	1448	0.838	0.848	IMP			0.858	1328.00	172.00
	iv. Minimize the risk of flood disasters.	192	1544	0.894	0.907	E-IMP			0.920	1424.00	172.00
	v. Decrease the utilization of private cars by encouraging walking and biking opportunities (i.e., changing modes of transportation).	192	1377	0.797	0.802	IMP			0.806	1248.00	172.00
	vi. Show the value of eliminating air pollutants.	192	1331	0.770	0.768	M-IMP			0.766	1186.00	172.00

Keys: C-P: community perspective; E-P: (planning) experts' perspective. Source: Authors' calculations.

Table 5. (**a**). RII results of the UGS elements with regard to UGI indicators, rated by experts and community members. (**b**). Vital taxonomy of the UGS elements for the respective UGI indicators.

(a)

Categories	**Urban Green Infrastructure Indicators**	**Relative Index (RII) of UGS Elements (Community Prespective (C-P) + Experts Prespective (E-P)) RII = Σ W/(N * A)**									
		CG Mean Value (C-P + E-P)	**BG Mean Value (C-P + E-P)**	**UP Mean Value (C-P + E-P)**	**FO Mean Value (C-P + E-P)**	**GS Mean Value (C-P + E-P)**	**RG Mean Value (C-P + E-P)**	**GPA Mean Value (C-P + E-P)**	**WL Mean Value (C-P + E-P)**	**GRW Mean Value (C-P + E-P)**	**HO Mean Value (C-P + E-P)**
Ecological	i. Optimizing storm-water management.										
	Increasing pervious surfaces	0.71	0.73	0.79	0.90	0.73	0.83	0.66	0.85	0.65	0.65
	Minimizing, retaining and organically purifying rainwater runoff.	0.66	0.70	0.67	0.84	0.81	0.92	0.72	0.94	0.71	0.67
	ii. Decreasing the impact of urban heat islands (i.e., enhancing the number of green spaces and using evaporative materials on the roofs, walls and floors.	0.72	0.74	0.81	0.92	0.77	0.61	0.51	0.66	0.75	0.74
	iii. Enhancing air quality (e.g., extracting impurities).										
	Growing more green trees and installing a green barrier in a roadway.	0.69	0.70	0.75	0.89	0.80	0.52	0.60	0.71	0.76	0.68
	iv. Enhancing noise quality.										
	Use a green sonic wall to reduce the maximum noise pollution (i.e., thick hedges could be provided with a small meadow for minimum noise and, for maximum noise reduction, wide borders of bamboo and deciduous trees could be provided).	0.70	0.72	0.80	0.92	0.79	0.47	0.54	0.68	0.76	0.65
	v. Lower emissions of carbon (e.g., elimination of greenhouse gas emissions via greenery).										
	Grow a greater density of trees for shade and use evaporating fabric for the paved surfaces.	0.73	0.76	0.80	0.93	0.80	0.49	0.56	0.69	0.78	0.69
	vi. Enhancing building energy performance.										
	Promote green energy-saving strategies.	0.59	0.55	0.61	0.65	0.62	0.45	0.44	0.52	0.91	0.55
	vii. Improved soil fertility and degradation condition.										
	Increase existing areas and plant trees to enhance soil stabilization.	0.75	0.76	0.77	0.91	0.73	0.68	0.61	0.77	0.64	0.72
	viii. Improved and safeguard urban ecology										
	Improve and strengthen the urban green network connectivity.	0.72	0.82	0.79	0.93	0.73	0.51	0.56	0.77	0.74	0.73

Table 5. *Cont.*

(a)

Categories	Urban Green Infrastructure Indicators	Relative Index (RII) of UGS Elements (Community Prespective (C-P) + Experts Prespective (E-P)) RII = Σ W/(N * A)									
		CG Mean Value (C-P + E-P)	BG Mean Value (C-P + E-P)	UP Mean Value (C-P + E-P)	FO Mean Value (C-P + E-P)	GS Mean Value (C-P + E-P)	RG Mean Value (C-P + E-P)	GPA Mean Value (C-P + E-P)	WL Mean Value (C-P + E-P)	GRW Mean Value (C-P + E-P)	HO Mean Value (C-P + E-P)
Socio-cultural	i. Agri-production (e.g., home gardening; urban farming; and community farming).	0.88	0.66	0.63	0.75	0.56	0.37	0.38	0.50	0.68	0.87
	ii. Enhancing social wellness.										
	Optimizing recreation and socialization activities.	0.77	0.83	0.86	0.85	0.82	0.52	0.51	0.76	0.79	0.72
	Improving the city's appeal (through various green elements).	0.81	0.77	0.85	0.80	0.80	0.70	0.70	0.77	0.83	0.72
	iii. Enhancing the mental and physical health of inhabitants (e.g., visual and physical exposure to open green areas has a beneficial effect on stress and anxiety reduction).	0.86	0.77	0.85	0.90	0.77	0.47	0.54	0.80	0.70	0.68
	iv. Providing ecological areas for research and education.	0.79	0.85	0.74	0.89	0.70	0.58	0.53	0.81	0.76	0.82
	v. Enhancing the connectivity of green areas to promote walking and biking opportunities.	0.71	0.75	0.85	0.88	0.85	0.38	0.50	0.75	0.58	0.63
Economic indicators	i. Enhance the value of property.	0.80	0.80	0.89	0.67	0.77	0.60	0.62	0.61	0.87	0.71
	ii. Minimize healthcare expenses.	0.86	0.78	0.84	0.90	0.79	0.49	0.51	0.70	0.71	0.75
	iii. Decrease energy use (e.g., heating and cooling requirements).	0.71	0.70	0.79	0.81	0.72	0.58	0.53	0.65	0.91	0.67
	iv. Minimize the risk of flood disasters.	0.70	0.71	0.77	0.96	0.78	0.82	0.68	0.89	0.63	0.63
	v. Decrease the utilization of private cars by encouraging walking and biking opportunities (i.e., changing modes of transportation).	0.69	0.76	0.81	0.84	0.86	0.44	0.53	0.75	0.42	0.52
	vi. Show the value of eliminating air pollutants.	0.73	0.78	0.83	0.94	0.83	0.52	0.57	0.73	0.84	0.71

Table 5. *Cont*.

(b)								
Categories	**Urban Green Infrastructure Indicators**	**Interquartile Range (IQR) Methodology**				**Cut-Off Point.**	**Approved Number of UGS Elements (RII ≥ 0.77)**	**Approved Urban Green Space (UGS) Elements**
		Q1	**Q3**	**IQR = (Q3−Q1) (Median)**	**Mean**			
Ecological	i. Optimize storm-water management.							
	Increasing pervious surfaces.	0.68	0.82	0.73	0.77	0.77	4	UP; FO; RG; WL
	Minimizing, retaining and organically purifying rainwater runoff.	0.67	0.83	0.71	0.77	0.77	4	F0; GE; RG; WL
	ii. Decreasing the impact of urban heat islands (i.e., enhanced the quantity of the green spaces and using of evaporative materials on the roofs, walls and floors.	0.67	0.76	0.74	0.77	0.77	3	UP; FO; GS
	iii. Enhancing air quality (e.g., extracting impurities).							
	Growing more green trees and installing a green barrier in a roadway.	0.68	0.76	0.71	0.77	0.77	2	FO; GS
	iv. Enhancing noise quality.							
	Use a green sonic wall to reduce the maximum noise pollution (i.e., thick hedges could be provided with a small meadow for minimum noise and, for maximum noise reduction, wide borders of bamboo and deciduous trees could be provided).	0.65	0.78	0.71	0.77	0.77	3	UP; FO;GS
	v. Lower emissions of carbon (e.g., elimination of greenhouse gas emissions through greenery).							
	Grow a greater density of trees for shade and use evaporating fabric for the paved surfaces.	0.69	0.79	0.74	0.77	0.77	4	UP; FO; GS;GRW
	vi. Enhancing building energy performance.							
	Promote green energy-saving strategies.	0.53	0.62	0.57	0.77	0.77	1	GRW
	vii. Improved soil fertility and degradation condition.							
	Increase existing areas and plant trees to enhance soil stabilization.	0.69	0.77	0.74	0.77	0.77	3	UP; FO; WL
	viii. Improved and safeguard urban ecology							
	Improve and strengthen the urban green network connectivity.	0.72	0.79	0.79	0.77	0.77	4	BG; UP; FO; WL

Table 5. *Cont.*

(b)									
Categories	**Urban Green Infrastructure Indicators**	**Interquartile Range (IQR) Methodology**				**Cut-Off Point.**	**Approved Number of UGS Elements (RII ≥ 0.77)**	**Approved Urban Green Space (UGS) Elements**
		Q1	**Q3**	**IQR = (Q3−Q1) (Median)**	**Mean**			
Socio-cultural	i. Agri-production (e.g., home gardening; urban farming; and community farming).	0.52	0.73	0.73	0.77	0.77	2	CG; HO
	ii. Enhancing social wellness.							
	Optimizing the recreation, and socialization activities.	0.73	0.83	0.83	0.77	0.77	6	CG; BG; UP; FO; GS; GRW
	Improving the city's appeal (through various green elements).	0.73	0.81	0.81	0.77	0.77	7	CG; BG; UP; FO; GS; WL; GRW
	iii. Enhancing the mental and physical health of inhabitants (e.g., visual and physical exposure to open green areas has a beneficial effect on stress and anxiety reduction).	0.68	0.83	0.83	0.77	0.77	6	CG; BG; UP; FO; GS; WL
	iv. Provide ecological areas for research and education.	0.71	0.82	0.82	0.77	0.77	5	CG; BG; FO; WL; HO
	v. Enhance the connectivity of green areas to promote walking and biking opportunities.	0.59	0.82	0.82	0.77	0.77	3	UP; FO; GS
Economic indicators	i. Enhance the value of property.	0.63	0.80	0.80	0.77	0.77	5	CG; BG; UP; GS; GRW
	ii. Minimize healthcare expense.	0.70	0.82	0.82	0.77	0.77	5	CG; BG; UP; FO; GS
	iii. Decrease energy use (e.g., heating and cooling requirements).	0.65	0.77	0.77	0.77	0.77	3	UP, FO; GRW
	iv. Minimize the risk of flood disasters.	0.69	0.81	0.81	0.77	0.77	5	UP; FO; GS; RG; WL
	v. Decrease the utilization of private cars by encouraging walking and biking opportunities (i.e., changing modes of transportation).	0.52	0.80	0.80	0.77	0.77	3	UP; FO; GS
	vi. Show the value of eliminating air pollutants.	0.71	0.83	0.83	0.77	0.77	5	BG; UP; FO; GS;GRW

Source: Authors' calculations, using both expert and community survey data. Keys: CG: "community garden"; BG: "botanical garden"; UP: "urban park"; FO: "forest"; GS: "green streets"; RG: "rain garden and bio-swale"; GPA: "green permeable parking area"; WL: "wetland"; GRW: "green roofs and walls"; HO: "horticultural".

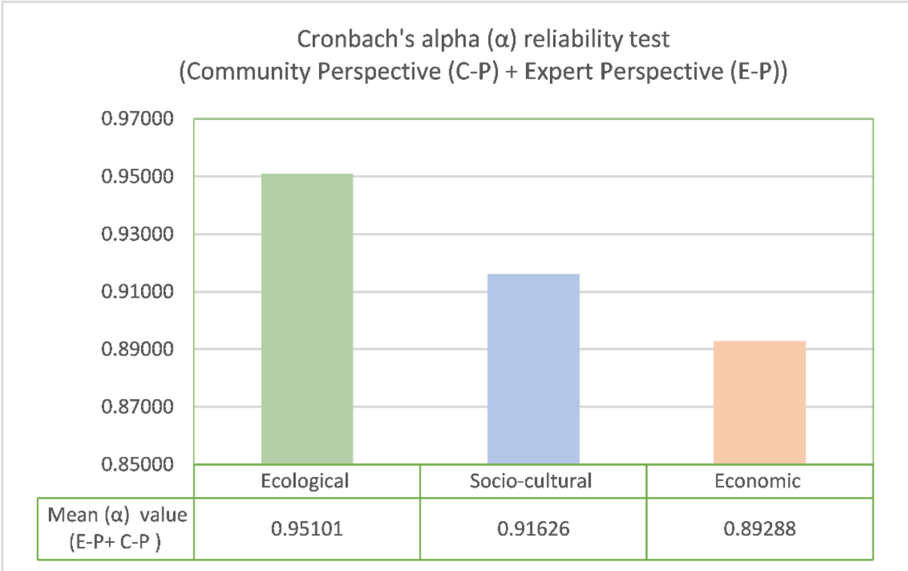


Figure 4. Cronbach's alpha reliability test. Source: Authors' calculations, using survey data.

3. Results

3.1. Experts' and Community Perspectives on Multiple Cross-Cutting Themes

This section clarifies the knowledge, beliefs, attitudes, and preferences of the planning experts and community of the study area regarding their understanding of the definitions of climate change (CC), adaptations to CC, urban resilience, and UGI concepts in response to the questions posed (Appendix E). The results highlight that the planning experts agree that options one, two, and seven are more effective than options three and five, compared to the community's preferences, with options one, two, six, and seven receiving a higher satisfaction approval vote (SAV) than options four and five (Figure 5). This shows the importance levels assigned by the experts and the community (and not the differences). The importance levels overlapped in most cases as both groups of stakeholders highlighted the importance of similar indicators. Hence, the overall outcome represents analogous options, such as option one, "increased global annual mean temperature", option two, "increased extreme weather events", and option seven, "increase in ecological damage", scoring > 75% Vote of Confidence (VoC). However, option six, "an increasing sea level", was not equally valued by both the groups (51.7% VoC by experts and 92.0% VoC by the community), yet a higher VoC regards it as an important variable. All these four possibilities can be perceived as a threshold level by which to define the notion of climate change in a native spatial environment.

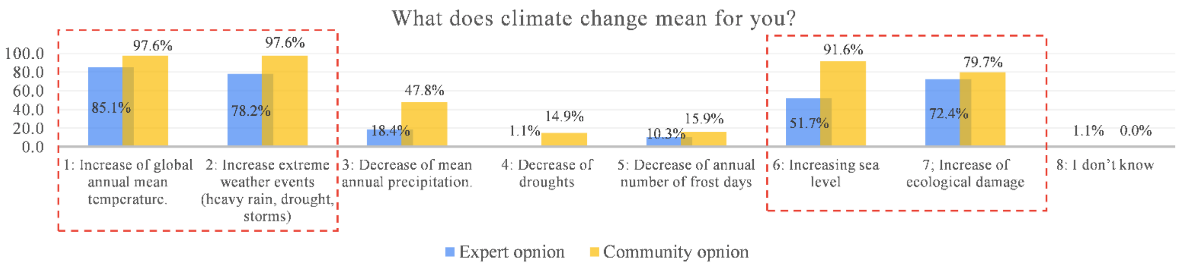


Figure 5. Understandings of climate change (CC). Source: Authors' calculations, using survey data.

Similarly, the subsequent results examine climate change adaptation. The experts considered options one and two more effective, earning 74.7% and 65.5% VoC, respectively, whereas the local community endorsed options one, two, three, four, and seven as extremely important, giving a score of >75% SAV (Figure 6). Hence, to operationalize the "adaptation to climate change "concept in the local urban context, all these five variables remain vital to enhancing the adaptive capacity and building resilience against ever-rising environmental hazards, i.e., urban flooding, drought, etc., across urban regions. These five overlapping variables stress the need to promote an eco-friendly and climate-resilient environment.

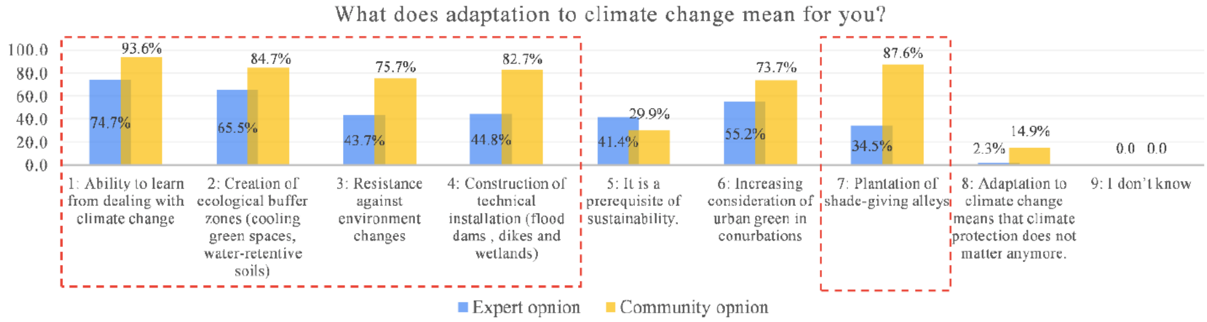


Figure 6. Understanding adaptations to climate change (CC). Source: Authors' calculations, using the survey data.

Further analysis elucidates the essence of urban resilience, which is established by understanding the local knowledge, characteristics, and attitudes regarding the potential possibilities. The community acknowledged that the main ($\frac{3}{4}$) potential variables are one, three, four, five, six and eight (with high positive scores), while the experts endorsed option one (Figure 7). The trend shows that adaptation to CC depends mainly upon one's ability to learn while dealing with climate change issues—adaptation to CC remains a subjective concept, yet it remains a necessity to encourage nature-based green infrastructure (NBGI) solutions by bolstering local mitigation/adaptation efforts.

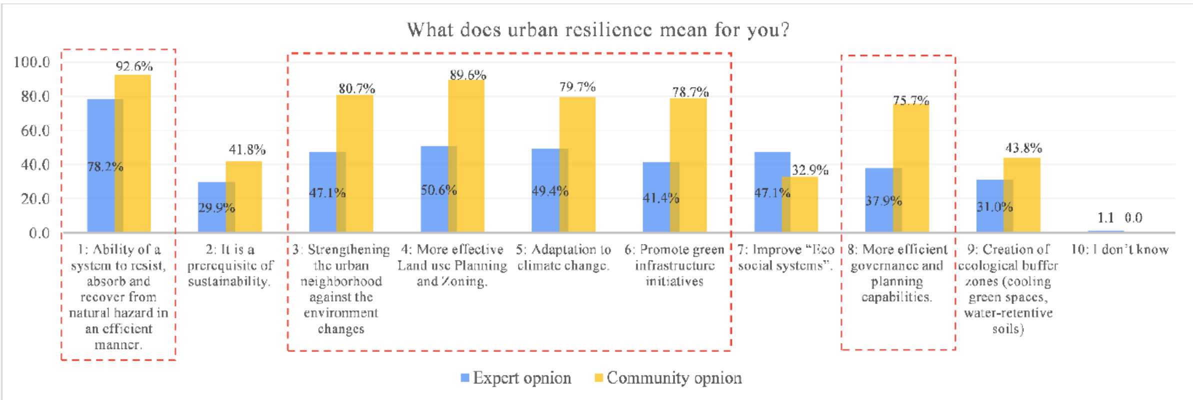


Figure 7. Defining urban resilience. Source: Authors' calculations, using the survey data.

Further results provide an understanding of UG and show that three-quarters (75.9%) of the experts acknowledged option two to be a high-priority attribute, whereas other options (e.g., one, three, and fourteen) received >50% VoC. On the other hand, the local community also recognized option two as a highly significant attribute (80.7% SAV). The community also endorsed options three, eight, one, four, seven, nine, twelve, and thirteen, with a confidence level between 60% and 75% (Figure 8). Hence, the planning experts highlighted all the possible potential variables that impact more accurately, so these need to be incorporated when bridging the planning gaps. This will then assist government institutions in building NGBI approaches for sustainable human settlements in KP and beyond. Furthermore, to foster a holistic PP approach, all nine potential possibilities are given below (as endorsed by both planning experts and the community), arranged by level of importance, and can be viewed as a yardstick to define UGI, each according to the native spatial context, i.e.:

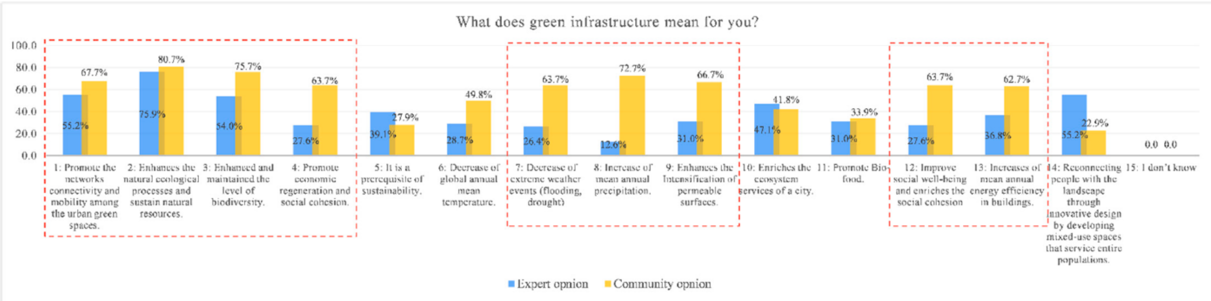


Figure 8. Defining the urban green infrastructure (UGI). Source: Authors' calculations, using the survey data.

Option 2: Enhancing the natural ecological processes and sustainability of resources.
Option 3: Enhancing and maintaining the level of biodiversity.
Option 8: Increases in annual mean precipitation.
Option 1: Promoting network connectivity and mobility among the urban green spaces.
Option 9: Enhancing the intensification of permeable surfaces.
Option 7: Decreases in extreme weather events (flooding, drought).
Option 12: Improving social well-being and enriching social cohesion.
Option 4: Promoting economic regeneration and social cohesion.
Option 13: Increases in the mean annual energy efficiency of buildings.

To summarize, the above results support: (a) the use of PP to endorse multiple optimal possibilities; (b) understandings of the notion of cross-cutting themes (e.g., CC, adaptation, urban resilience, and UGI) from the multi-stakeholder perspective; and c) acknowledging and encouraging community stewardship in the planning/decision-making process for NBGI initiatives. These steps can help to effectively tackle socio-environmental problems as a result of climate change. Such efforts can contribute to developing a richly multi-functional UGI indicator-based framework, grounded upon the "triple bottom line" of sustainability. Such a model can be adapted to the native spatial environment. This further contributes to strengthening the intricate reciprocity found among CC, UGI, UGS, and human health and well-being. This all contributes to climate-resilient and green-growth urban development.

3.2. RII and UGI Indicators for UGS Elements

The cumulative and empirical study findings are further clustered into three main groups. The first level focuses on the significance level of the twenty-two (primary and secondary) potential sustainable UGI indicators. The second level determines the importance level of each sustainability dimension (by summing up the average RII value of the sustainable indicators). The third and final level determines the vital taxonomy of UGS elements for enhancing the health of the respective UGI indicators, set against the constantly rising environmental threats to the urban interface of the KP region.

3.2.1. RII of Sustainable UGI Indicators (Experts and Community)

The first phase of this empirical study analyzes the collective responses of the experts and the community regarding the respective and potential UGI indicators (Table 4), which determines their significance and importance in the local environment. It then stimulates a holistic and effective MSPP approach to determining the importance of the UGI indicators.

The results showed that nine UGI indicators were declared to be most important (M-Imp. (RII: 0.713–0.798)). Eleven indicators were declared important (Imp. level (RII: 0.802–0.890)) and only two indicators belonged to the extremely important (E-Imp.) category (Table 4). This demonstrates the level of satisfaction regarding the UGI indicators in terms of enhancing an eco-friendly environment in the studied area. These results also show that the native stakeholders rated the sustainability factor across ecological and economic dimensions as being most important, and the socio-cultural dimension as moderately important. Thus, this human–nature relationship highlights the value of using NBGI solutions to strengthen the natural environment so that its inhabitants can fight against climatic hazards.

3.2.2. RII of UGS Elements with UGI Indicators (Experts and Community)

Here, the perspectives of the experts and the community were integrated to understand the relationship between UGS elements and UGI indicators in the native built context. This identifies the vital taxonomy of UGS elements for each UGI indicator (Table 5b), which plays a key role in strengthening the quality of potential UGI indicators. The results illustrate that most UGS elements were weighted above their mid-point (Table 5a). The average RII was 0.37 to 0.94, showing that, at times of disaster, not all the green elements positively enhanced the efficacy of the UGI indicators. This is linked to the local spatial, contextual, and socio-demographic factors that differ from area to area. However, to reach a rational standpoint, the vital taxonomy of UGS elements was determined for each sustainable indicator (Table 5b). This reinforces the functional linkage and health of the respective UGI indicator. Moreover, it strengthens the potential resilience of sustainable indicators, enhances our scientific knowledge, and builds the capacity of government institutions to shape successful NBGI solutions. These solutions then help to alleviate the negative impact of environmental hazards and promote an eco-friendly environment in the region.

3.2.3. Vital Taxonomy of UGS Elements

These results present the vital taxonomy of the UGS elements and their functional interlinkage with specific UGI indicators (Table 5b). The IQR value varied between 0.57 and 0.83 (with avg./cut-off point = 0.77), which helped to identify the set of core taxonomy UGS elements (as marked in blue in Table 5a). Thus, top-down vs. bottom-up stakeholders' perspectives emphasize that every individual UGS element has a distinctive quality and does not significantly improve the resilience of a specific UGI indicator, set against the anticipated environmental challenges in the native built context. Therefore, the effectiveness of green space structural attributes, in reality, depends on the eco-cultural and socio-environmental context of any region for which the PP approach, based on the integration of experts (i.e., policymakers, practitioners, and academicians) and the community, remains imperative. This deployment of the PP approach is necessary to understand the relationship between the respective UGS elements and the sustainable UGI indicators, leading to the development of a rich, multi-functional/inclusive/sustainable UGI indicator-based (framework) model, structured according to the local built environment. Such a composite indicator-based framework/model not only provides an opportunity to endorse and encourage the holistic representativeness of the MSPP approach in land-use planning but also contributes to the decision-making process for NBGI initiatives. Therefore, MSPP is recognized as the best tool for promoting community involvement to ensure green spaces. Green spaces and UGI will help to reduce urban vulnerability against the rising climatic hazards and will encourage reciprocity among CC, UGS, ESF, human health, and human well-being factors in urban settlements.

4. Discussion

This research is an effort toward acknowledging the native top-down (planning experts) and bottom-up (community) participatory approach—a pioneering step in developing a sustainable UGI indicator-based framework model regarding the issue of global climate change, thereby embedding it in the local context. Such a model connects local inhabitants and their perspectives with multi-functional urban green spaces. Studies into human behavior help to explain the NBGI techniques that naturally alleviate the high risk of environmental hazards [75,76] and promote urban sustainability [2]. This research inevitably opens new domains by which to incorporate indigenous/local knowledge to design an innovative, natural green landscape-based approach for climate change adaptation and mitigation. It can be used to identify, develop, and test the interlinkage between sustainable UGI indicators and green space (GS) elements. These elements can, then, be related to the native built contexts in areas such as the Peshawar, Mardan, and Charsadda districts of the province of KP, Pakistan.

This research study has deployed the multi-stakeholder engagement processes (MSEP) approach to engaging the stakeholders concerned (both experts and the community), which is otherwise less focused at the national level in Pakistan [36,61,77], than in the rest of the world [11,13]. The issue of low engagement in Pakistan has been linked to the community's limited knowledge and awareness of climate change, as well as a lack of participatory approaches for NBGI initiatives [23,30–33]. This ongoing scenario has seen the deterioration of urban settlements, urban resilience, and urban functions in the face of the constantly rising climatic changes. These obstacles are also found to obstruct the successful transition of GAP. Therefore, developing such NBGI strategies (under SCRM) remains vital in KP areas that are not only highly unfortified against daunting climatic challenges [32,45,46] but also remain vulnerable due to their geographical location. Hence, pragmatic and proactive urban greening policies (UGP) and strategies for resilient land-use planning [4,6,37] are required in a situation where the expansion of urban functions continues to escalate [78,79].

As seen in the results of this study, this upcoming discussion also corresponds to the major findings of this research. The study enhances the scientific literature on the NBGI topic on building a safe, green, resilient urban region fortified against climate change in the province of KP. Hence, to keep momentum, the following discussion is organized as per the study's three research questions.

In the first research question ("What are the main UGI indicators under MSEP?"), the study strove to explore and advance insight into the views of both the native planning experts (i.e., policymakers, practitioners, and academicians) and the community regarding the potential role of UGI. Furthermore, the green nature-based infrastructure proved to be a vital element in SCRM strategies and resilient land-use planning when tackling socio-environmental problems. The empirical study demonstrated here led to our identifying the significance of each respective and potential sustainable UGI indicator, in terms of their applicability and scale when building an eco-friendly urban environment in a developing country in general, and in KP in particular (Table 4). The results show that nine UGI indicators were declared as M-Imp, while the other eleven achieved an Imp level. In contrast, only two indicators belonged to the E-Imp category under MSPP. Furthermore, this study found that under the holistic MSPP approach, the ecological and economic dimensions of sustainability accrued a higher acceptance level than the socio-cultural dimensions. This demonstrates the importance level of each UGI indicator and sustainable dimension among the native multi-stakeholders in the built environment.

Moreover, the second research question ("What are the key UGS elements that can improve UGI resilience under SCRM?") strives to develop a vital taxonomy of UGS elements for sustainable UGI indicators, to mitigate climate change challenges in native urban settings. Therefore, every UGS element was empirically examined against the individual UGI indicator, in order to establish a strong agreement among the MSEP regarding SCRM. The results illustrate a broad pattern of variation in the definitive list of selected vital green elements (Table 5b)—the most essential and foremost outcome of the examination. This confirms that every individual UGS element has a distinctive quality and does not significantly improve the resilience of a specific UGI indicator in the face of anticipated environmental challenges. Likewise, the global studies affirm that the effectiveness of the UGS element depends on the spatial contextual factors (eco-cultural and socio-environmental) of any region where they are examined [5,19,80]. However, to reach a rational standpoint, the vital taxonomy was determined of the key UGS elements (Table 5b) that perform a pivotal role in strengthening the resilience of respective UGI indicators in addressing SCRM.

In the third and final research question ("What is the sustainable UGI indicator-based model to build a climate-resilient city?"), this study revealed that under MSPP, the coexistence of UGI indicators with key UGS elements can lead to the development of an inclusive UGI indicator-based framework—the main target of this study. Such a UGI framework model can build an eco-regional paradigm that can ensure green-resilient cities in KP and beyond. Additionally, this type of model can strengthen the intricate reciprocity among climate resilience strategies, GS, ESF, and human health/well-being. This, in turn, will enable the local community to develop proactive and pragmatic ULGPs for land use. This will inevitably open up a new domain of study, to gradually delve more deeply into innovative MSPP approaches when planning NGLB techniques for climate change adaptation. Such green adaptations can bring a balance between anthropocentric and environmentally friendly activities at the urban interface of any area.

5. Conclusions and Policy Implications

The research study posits that the urban green infrastructure poses a potential natural solution to building an eco-friendly and green climate-resilient city-state. Its aims are to reconnect inhabitants with nature, enhancing their knowledge of the multi-functional green infrastructure to build a new sustainable cultural paradigm that in turn supports green urban growth in the KP province of Pakistan. The projection of this green and resilient urban development is achieved by integrating a two-way sustainable development path that is top-down and bottom-up—presenting a more participatory and innovative approach. It has been established that local context influences the values and beliefs of both the native inhabitants and the planning experts. Additionally, a nature-based green infrastructure (NBGI), once it builds on the local realities, holds greater influence in addressing the attitudes and preferences of those same local stakeholders, both experts and members of the community. Hence, such a holistic participatory approach remains effective and pragmatic in building a taxonomy of UGS elements. It is unique, as it develops a relationship with the respective sustainable UGI indicators in the local built environment, wherein the development of an inclusive and sustainable UGI indicator-based framework/model embeds the local context. It has the potential to meet the standards and requirements of a green climate-resilient city-state under ULGP, in KP and beyond. It can further be established that a local, context-based model potentially modifies the sustainable UGI indicators for building the model, and comprehensively connects that model with multiple green elements to reshape urban land-use planning, ensuring a resilient city-state.

The establishment of a safe, eco-friendly, and resilient city-state halts damage to the country's natural green barriers, the depletion of UGS, and the greying of the natural landscape, which lead to catastrophes of various scales and impacts. Thus, UGS planning stands as a nature-based climate adaptation strategy that improves the multifunctionality and connectivity of green space networks. This stirs up and fosters ecosystem resilience, encourages biodiversity conversations, and ensures inhabitants' health as well as their well-being as they perceive it. Empowering the public via sustainable and resilient urban development plans supports the government in its efficient implementation of green action reform (GAR) programs, which also promote community cohesion in terms of UGS. This study bridges the planning gaps among the native multi-stakeholders by introducing a triple bottom line for sustainability. The debate is about developing proactive and pragmatic long-term urban greening policies (UGP) and strategies, to remodel and restructure land-use planning for sustainable human settlements. All in all, a sustainable UGI indicator-based framework/model can foster the NBGI approach, which is required to facilitate long-term sustainable climate-risk management (SCRM) in KP, Pakistan, and other regions.

This study presents a policy implication that can be drawn from this empirical investigation: there is a dire need to bolster MSPP in the urban landscape and urban greening

(ULUG) policymaking and strategy implementation for resilient land-use planning. The MSPP is an effective tool that encourages and promotes a sense of community stewardship in the planning/decision-making process for NBGI initiatives, to build an eco-friendly and climate-resilient urban environment in environmentally challenged urban regions. Such an approach contributes to increasing scientific research knowledge and awareness among all the native stakeholders (three-tier groups, comprising decision-makers, experts, and the local community), moving toward a better understanding of GI planning and presenting a sustainable, cost-efficient, and innovative green nature-based climate adaptation/mitigation strategy for sponge and/or green cities.

Author Contributions: Conceptualization, M.R.; data curation: M.R.; methodology, M.R, D.G. and U.K.; software, M.R.; formal analysis, M.R.; validation.; M.R., D.G. and U.K.; writing—original draft preparation, M.R.; writing—review and editing, M.R., D.G. and U.K.; supervision, D.G. and U.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Deutscher Akademischer Austauschdienst (DAAD), Government of Germany, grant number 57381412. TU-Dortmund University, Germany, funded the article processing charges (APCs).

Institutional Review Board Statement: This research study was conducted according to the guidelines of the Declaration of Helsinki. Ethical review and approval at any stage were waived for this study, due to the reason that no sensitive/personal information (e.g., names, contact details, codes, etc.) were sought/gathered during data collection or at any stage of this research. This research study and the questions asked were limited to context-based questions, to generate knowledge about the role of Urban Green Infrastructure (UGI) in planning for climate-resilient cities. The responses were generalized to draw meaningful context-based results.

Informed Consent Statement: Informed verbal consent was obtained in advance from all subjects involved in the study.

Data Availability Statement: This study contains all the data generated or analyzed during the study.

Acknowledgments: The author expresses his deep gratitude to the Deutscher Akademischer Austauschdienst (DAAD), Government of Germany, for the financial support under the Ph.D. research grant, Ref: funding programme/-ID: Forschungsstipendien—Promotionen in Deutschland, 2018/19 (57381412) for doctoral studies in Germany. Other than DAAD, the authors are grateful to TU-Dortmund University for paying APC, which helped in the speedy publication of the research findings. Moreover, I would like to thank the experts/policymakers of planning institutions in Pakistan for their valuable information and assistance in executing the planning experts' survey. I am also indebted to my brother Muneeb Khan, who offered valuable support in the community data collection during these challenging times of COVID-19. To conclude, I would like to extend my gratitude to Fawad Akthar, Zeeshan Khan, and Imran Khan, for their time and cooperation during the household field survey in the Peshawar, Mardan, and Charsadda districts, KP province.

Conflicts of Interest: The authors have no conflict of interest to declare.

Appendix A. Potential Urban Green Infrastructure (UGI) Indicator-Based Framework

Table A1. Proposed UGI indicators, inter-linked with multiple GI elements and technologies.

This Section Encompassed Questions with the Aim of Identifying UGI Indicators, Interlinked with Multiple GI Elements and Technologies for Resilient Land-Use Planning. Indicators Are Classified According to the "Triple Bottom Line" of Sustainability, Which Highlights the Importance of the Natural and Manmade Environment in Land-Use Planning.

Categories	Green Infrastructure Indicators	Reference	Green Infrastructure Elements and Technologies. Please Rate Your Opinion between 1 and 10 on the Likert Scale. 1. Highly Insignificant, 2. Slightly Insignificant, 3. Moderately Insignificant. 4. Insignificant, 5. Neutral, 6. Not Sure, 7. Slightly Significant, 8. Moderately Significant, 9. Significant, 10. Highly Significant									
			GI 1	GI 2	GI 3	GI 4	GI 5	GI 6	GI 7	GI 8	GI 9	GI 10
Ecological	**1. Optimizing storm-water management**											
	Increasing pervious surfaces.	Green infrastructure is suitable for handling rainfall. (Buishand, 2007), [81] Increased rainwater retention and flooding. (Wise et al., 2010, [82]										
	Minimizing, retaining and organically purifying rainwater runoff.											
	2. Reducing the urban heat island effect											
	Increasing the percentage of green surfaces.	Lowering the mean radiant temperature via trees and other plants. (Jacobs et al., 2015), [83]										
	Applying evaporative materials on roof, walls and ground surfaces.											
	3. Air quality improvement (e.g., pollutant removal, altering wind flow)											
	Implementing green impermeable screens in a street canyon and planting a higher concentration of green trees.	(Nowak et al., 2006 and Yang et al., 2008), [84,85] Green screens reduce air pollution in urban environments. (Pugh et al., 2012; Wise et al., 2010), [82,86]										
	4. Noise quality improvement											
	Applying a green sound barrier for limited and higher noise reductions (i.e., for limiting noise, thick hedges with a small piece of grassland can be provided and for higher noise, broadleaved deciduous trees and a thick border of bamboo can be provided).	Dense vegetation structures reduce noise intensity. (Samara and Tsitsoni, 2011), [87] Limited noise reduction. (Van Renterghem et al., 2014) [88]										
	5. Reduced carbon emissions (e.g., avoiding greenhouse gas emission through cooling)											
	Planting a higher concentration of trees for shade and using evaporating material for hard landscaping.	Urban green spaces lower emissions. (Weilenmann et al., 2005) [89]										
	6. Improve energy efficiency in buildings											
	Optimize green energy0saving techniques.	Green roofs improve building energy consumption. (Mentens, 2006; Akbari and Taha, 1992), [90,91]										

Table A1. *Cont.*

This Section Encompassed Questions with the Aim of Identifying UGI Indicators, Interlinked with Multiple GI Elements and Technologies for Resilient Land-Use Planning. Indicators Are Classified According to the "Triple Bottom Line" of Sustainability, Which Highlights the Importance of the Natural and Manmade Environment in Land-Use Planning.												
Categories	**Green Infrastructure Indicators**	**Reference**	**Green Infrastructure Elements and Technologies.**									
			Please Rate Your Opinion between 1 and 10 on the Likert Scale. 1. Highly Insignificant, 2. Slightly Insignificant, 3. Moderately Insignificant. 4. Insignificant, 5. Neutral, 6. Not Sure, 7. Slightly Significant, 8. Moderately Significant, 9. Significant, 10. Highly Significant									
			GI 1	**GI 2**	**GI 3**	**GI 4**	**GI 5**	**GI 6**	**GI 7**	**GI 8**	**GI 9**	**GI 10**
Ecological	**7. Enhanced soil quality and erosion.**											
	Intensification of permeable surfaces and optimization of soil stability.	(McKinney, 2006), [92]										
	8. Enhance and protect urban biodiversity											
	Promote the connectivity and mobility between urban green spaces.	Biodiversity is the baseline component in GI planning. (Weber et al., 2006), [93] Promoting conservation. (Adam,1994), [94]										
Socio-cultural	**1. Food production (e.g., urban agriculture, kitchen gardens, and community gardens)**	Gardening offers relief from work stress. (Hartig et al.,2014), [95] Introducing urban food forestry. (Clark and Nicholas, 2013), [96]										
	2. Improving social well-being.											
	Optimizing the opportunities for recreation and social interaction and enhancing the attractiveness of the city.	Green spaces should be close to residences and enhance city attractiveness. (Giles-Corti et al., 2005), [97] Taking ownership of green spaces. (Weldon et al., 2007), [98]										
	Enhanced attractiveness of the city (diverse landscape features).											
	3. Improving physical and mental well-being (i.e., visual and physical access to green spaces have a positive relationship with stress reduction and anxiety).	Green exercise is more psychologically beneficial. (Pretty et al., 2005, Bratman et al., 2015), [99,100] Neighborhoods living with a higher density of trees (Kardan et al., 2017), [101]										
	4. The provision of outdoor sites for education and research.	(McDonnell et al.,2008), [102]										
	5. Improving accessibility and connectivity to encourage cycling and walking opportunities.	People walk 20% more in green spaces. (De Vries et al., 2010), [103]										

Table A1. *Cont.*

This Section Encompassed Questions with the Aim of Identifying UGI Indicators, Interlinked with Multiple GI Elements and Technologies for Resilient Land-Use Planning. Indicators Are Classified According to the "Triple Bottom Line" of Sustainability, Which Highlights the Importance of the Natural and Manmade Environment in Land-Use Planning.												
Categories	**Green Infrastructure Indicators**	**Reference**	**Green Infrastructure Elements and Technologies. Please Rate Your Opinion between 1 and 10 on the Likert Scale. 1. Highly Insignificant, 2. Slightly Insignificant, 3. Moderately Insignificant. 4. Insignificant, 5. Neutral, 6. Not Sure, 7. Slightly Significant, 8. Moderately Significant, 9. Significant, 10. Highly Significant**									
			GI 1	**GI 2**	**GI 3**	**GI 4**	**GI 5**	**GI 6**	**GI 7**	**GI 8**	**GI 9**	**GI 10**
Economic indicators	**1. Amplified property values.**	(Shoup and Ewing 2010), [104]										
	2. Savings in healthcare cost.	(Shoup and Ewing 2010), [104]										
	3. Reduced energy consumption (e.g., cooling and heating demands).	(Weilenmann et al., 2005) (Mentens, 2006, Akbari and Taha, 1992), [89–91]										
	4. Reduced risk of flood damage.	(Gordon-Walker et al., 2007; Wise et al., 2010). [82,105]										
	5. Reducing private car use by increased walking and cycling (e.g., shifting travel mode).	(McPherson and Muchnick, 2005; De Vries et al., 2010), [103,106]										
	6. Value of air pollutant removal/ avoidance.	(Pugh et al., 2012; Wise et al., 2010), [82,86]										

Keys: (GI 1: Community Garden; GI 2 = Botanical Garden; GI 3 = Urban and pocket park; GI 4 = Forest; GI 5 = Green streets and alleys; GI 6 = Rain Garden/bio-infiltration, planter box and bioswale; GI 7 = Green parking lot and permeable pavements; G8 = Wetland/land conversation; GI 9 = Intensive/extensive green roof and vertical green wall; GI 10 = Horticultural areas, arable land, and tree meadows). Source. Authors' own elaboration [38].

Appendix B. Development of Conceptual Base Frameworks

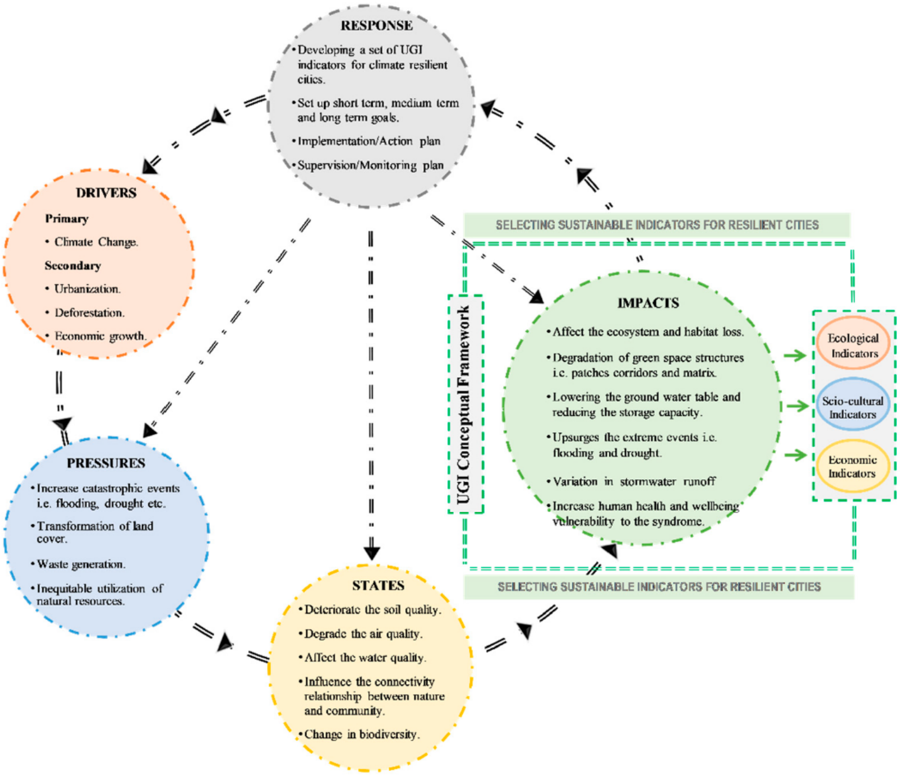


Figure A1. Relationship among the anthropogenic activities and UGI for resilient cities. Source: Authors' own elaboration [38].

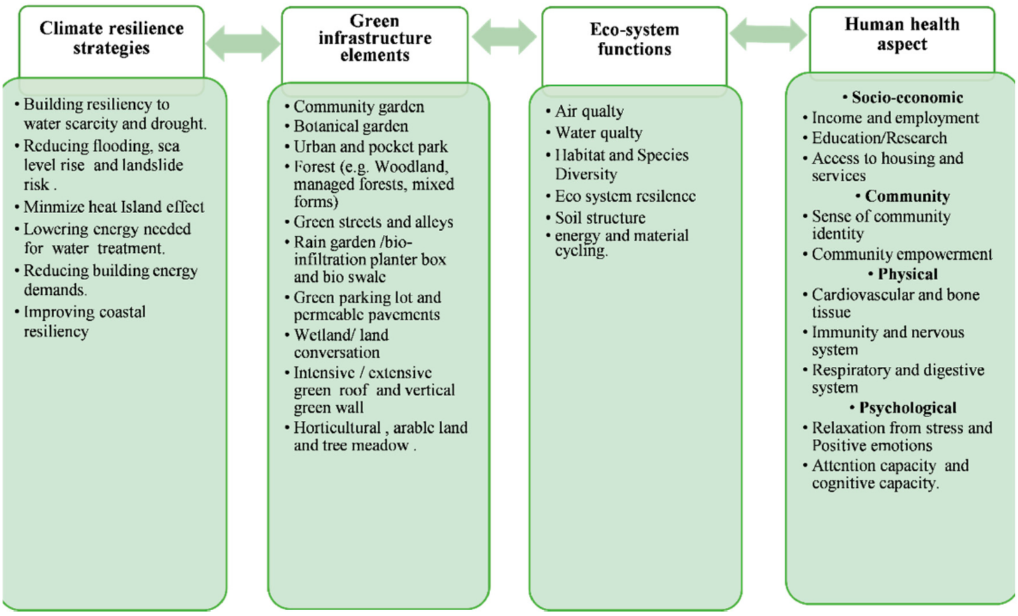


Figure A2. Conceptual base model: climate resilience strategies, ecosystem functions, human well-being, and GI elements. Source: Authors' own elaboration [38].

Appendix C

Figure A3. List of concepts evolved from the semi-structured meetings with native experts. Source: Authors' own elaboration.

Appendix D

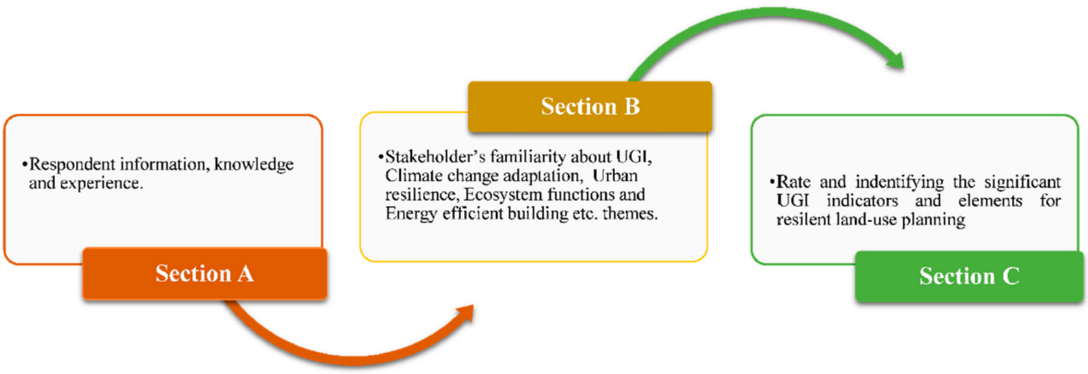


Figure A4. Hierarchical sections of an in-depth (expert and community) questionnaire survey. Source: Authors' own elaboration [20].

Appendix E

Verifying and validating the local multi-stakeholder (planning experts and community members) perspective, knowledge, beliefs, attitudes, and preferences on the proposed potential possibilities and definitions of the UGI, urban resilience, climate change, and adaptations.

The following four questions appeared in section B of the community-based empirical survey and expert-based perception survey, defining the notion of the aforementioned themes, depending on the native spatial context.

- "What does climate change mean for you"?
- "What does adaptation to climate change mean for you"?
- "What does urban resilience mean for you"?
- "What does green infrastructure mean for you"?

Appendix F

Table A2. Sample size for the community survey.

District	Tehsil *(Selection Based on a High Urban Population)*	Tehsil Population	Union Council Population *(Selection Based on a High Urban Population with the Integration of the Interquartile Range Technique (IQR)*	Sample size Population with 95 CI and + 5 Margins of Error	Average HH Size *(Source: KP Bureau of Statistics)*	HH Sample 399.6/6.2 399.5/7 339.7/5.6
Mardan	Mardan	1,403,394	411,148	399.6	6.2	64
Charsadda	Charsadda	804,194	350,483	399.5	7	57
Peshawar	Town3	8,210,59	575,409	399.7	5.6	71

Source: Authors' own elaboration [77], compilation from the KP Bureau of Statistics (2018) [107].

References

1. EC-European Commission. *Towards an EU Research and Innovation Policy Agenda for Nature-Based Solutions & Re-Naturing Cities, Final Report of the Horizon 2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities*; European Commission: Brussels, Belgium, 2015.
2. European Union. *Green Infrastructure (GI)–Enhancing Europe's Natural Capital*; European Commission: Brussels, Belgium, 2013.
3. Mazza, L.; Bennett, G.; De Nocker, L.; van Diggelen, R. *Green Infrastructure Implementation and Efficiency*; Final Report for the European Commission, DG Environment on Contract ENV.B.2/SER/2010/0059; Institute for European Environmental Policy: Brussels, Belgium, 2011.
4. Matthews, T.; Lo, A.Y.; Byrne, J.A. Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landsc. Urban Plan.* **2015**, *138*, 155–163. [CrossRef]
5. USEPA. *Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure*; EPA (USA): Washington, DC, USA, 2010.
6. Ahern, J. Green infrastructure for cities: The spatial dimension. In *Cities of the Future: Towards Integrated Sustainable Water and Landscape Management*; IWA Publishing: London, UK; Citeseer: Princeton, NJ, USA, 2007.
7. IPCC. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation Special, Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK, 2012. [CrossRef]
8. IPCC. *Climate Change: Impacts, Adaptation and Vulnerability*; Cambridge University Press: Cambridge, UK, 2014. [CrossRef]
9. Desa, U.N. *World Urbanization Prospects, the 2011 Revision, Population Division*; Department of Economic and Social Affairs, United Nations Secretariat: New York City, NY, USA, 2014.
10. Desa, U.N. *World Urbanization Prospects 2018: Highlights (ST/ESA/SER. A/421)2019'*; United Nations: New York City, NY, USA, 2019.
11. Mell, I.; Allin, S.; Reimer, M.; Wilker, J. Strategic Green Infrastructure Planning in Germany and the UK: A Transnational Evaluation of the Evolution of Urban Greening Policy and Practice. *Int. Plan. Studies.* **2017**, *22*, 333–349. [CrossRef]
12. Lafortezza, R.; Davies, C.; Sanesi, G.; Konijnendijk, C.C. Green Infrastructure as a tool to support spatial planning in European urban regions. *Ifor.-Biogeosci. For. SISEF-Ital. Soc. Silvic. For.* **2013**, *6*, 102–108. [CrossRef]
13. Monteiro, R.; Ferreira, J.C. Green Infrastructure Planning as a Climate Change and Risk Adaptation Tool in Coastal Urban Areas. *J. Coast. Res.* **2020**, *95*, 889–893. [CrossRef]
14. TEP. *Advancing the Delivery of Green Infrastructure: Targeting Issues in England's NorthWest*; The Environment Partnership: Helston, UK, 2005.
15. Benedict, M.A.; McMahon, E.T. *Green Infrastructure: Linking Landscapes and Communities, Urban Land*; Island Press: Washington, DC, USA, 2006.
16. MacFarlane, R.; Davies, C.; Roe, M. *Green Infrastructure and the City Regions, Discussion Paper*; NECF: Dunston, UK, 2005.
17. Davies, C.; Macfarlane, R.; Mcgloin, C.; Roe, M. *Green Infrastructure Planning Guide, Project: Final Report*; WWF: Gland, Switzerland, 2006.
18. Weber, T.C.; Allen, W.L. *Beyond On-Site Mitigation: An Integrated, Multi-Scale Approach to Environmental Mitigation and Stewardship for Transportation Projects, Landscape and Urban Planning*; Elsevier: Amsterdam, The Netherlands, 2010.
19. Gill, S.E.; Handley, J.F.; Ennos, A.R.; Pauleit, S. Adapting cities for climate change: The role of the green infrastructure. *Built Environ.* **2007**, *33*, 115–133. [CrossRef]
20. Rayan, M.; Gruehn, D.; Khayyam, U. Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective. *Urban Clim.* **2021**, *38*, 100899. [CrossRef]
21. Naeem, S.; Cao, C.; Fatima, K.; Najmuddin, O.; Acharya, B.K. Landscape greening policies-based land use/land cover simulation for Beijing and Islamabad-An implication of sustainable urban ecosystems. *Sustainability* **2018**, *10*, 1049. [CrossRef]
22. Waseem, S.; Khayyam, U. Loss of vegetative cover and increased land surface temperature: A case study of Islamabad, Pakistan. *J. Clean. Prod.* **2019**, *234*, 972–983. [CrossRef]
23. Khayyam, U.; Waseem, S. Carbon emission as a result of forest land change in Islamabad, Pakistan. In *Climate Change Science*; Elsevier: Amsterdam, The Netherlands, 2021; pp. 41–57.
24. Greiving, S.; Fleischhauer, M. Climate resilience and environmental justice: State of research and implementation in planning practice in Germany and beyond. *Town Plan. Rev.* **2022**, *93*, 111–137. [CrossRef]

25. Kuhlicke, C.; Albert, C.; Bachmann, D.; Birkmann, J.; Borchardt, D.; Fekete, A.; Greiving, S.; Hartmann, T.; Hansjürgens, B.; Jüpner, R.; et al. Five Principles for Climate-Proof Municipalities and Cities. 2021. Available online: https://www.ufz.de/index.php?en=48382 (accessed on 3 June 2022).
26. Greiving, S. Resilience/Robustness. 2018. Available online: https://nbn-resolving.org/urn:nbn:de:0156-559919109 (accessed on 3 June 2022).
27. Greiving, S. Spatial planning and dealing with uncertainties associated with future disasters. In *Spatial Planning and Resilience Following Disasters: International and Comparative Perspectives*; Policy Press: Bristol, UK, 2016; p. 321.
28. Baycan-Levent, T.; Van Leeuwen, E.; Rodenburg, C.; Nijkamp, P. Development and management of green spaces in European cities: A comparative analysis. *Res. Memo.* **2002**, *2002*, 25.
29. CABE. *Community-Led Spaces: A Guide for Local Authorities and Community Groups*; CABE Space: London, UK, 2010.
30. Davidson, S. Spinning the wheel of empowerment. *Planning* **1998**, *1262*, 14–15.
31. Harnik, P. The excellent city park system: What makes it great and how to get there. In *The Human Metropolis: People and Nature in the 21st-Century City*; University of Massachusetts: Amherst, MA, USA, 2006.
32. Kim, T.-B. *Collaborative Governance for Sustainable Development in Urban Planning in South Korea*; University of Birmingham: Birmingham, UK, 2010.
33. Enger, S.C. *Planning for Parks, Recreation, and Open Space in Your Community*; Washington State Department of Community, Trade and Economic Development: Washington, DC, USA, 2005.
34. Munir, R.; Khayyam, U.; Adil, I.H. Perceptions of Glacier Grafting: An Indigenous Technique of Water Conservation for Food Security in Gilgit-Baltistan, Pakistan. *Sustainability* **2021**, *13*, 5208. [CrossRef]
35. Fors, H.; Molin, J.F.; Murphy, M.A.; van den Bosch, C.K. User participation in urban green spaces—For the people or the parks? *Urban Urban Green* **2015**, *14*, 722–734. [CrossRef]
36. Rayan, M.; Khayyam, U.; Gruehn, D. Local Perspectives on Green Resilient Settlements in Pakistan. In *CIGOS 2021, Emerging Technologies and Applications for Green Infrastructure. Lecture Notes in Civil Engineering*; Ha-Minh, C., Tang, A.M., Bui, T.Q., Vu, X.H., Huynh, D.V.K., Eds.; Springer: Berlin/Heidelberg, Germany, 2022; Volume 203. [CrossRef]
37. Khayyam, U. Floods: Impacts on livelihood, economic status and poverty in the north-west region of Pakistan. *Nat. Hazards* **2020**, *102*, 1033–1056. [CrossRef]
38. Rayan, M.; Gruehn, D.; Khayyam, U. Green Infrastructure Planning. A Strategy to Safeguard Urban Settlements in Pakistan. In *Planning in Germany and Iran. Responding Challenges of Climate Change through Intercultural Dialogue*; Jafari, M., Gruehn, D., Sinemillioglu, H., Kaiser, M., Eds.; Mensch und Buch Verlag: Berlin, Germany, 2021; pp. 197–220.
39. PBS. Pakistan Bureau of Statistics, Urban Demographic. 2018. Available online: http://www.pbs.gov.pk/ (accessed on 11 December 2020).
40. Jan, B.; Iqbal, M. Urbanization trend and urban population projections of Pakistan using weighted approach. *Sarhad J. Agric.* **2008**, *24*, 173–180.
41. Haider, M.; Badami, M.G. *Urbanization and Local Governance Challenges in Pakistan. Environment and Urbanization ASIA*; SAGE Publications: New Delhi, India, 2010; Volume 1, pp. 81–96.
42. UN-OCHA. *Pakistan Flood Relief and Early Recovery Response plan*; United Nations Office for the Coordination of Humanitarian Affairs: New York, NY, USA, 2010.
43. Khayyam, U.; Noureen, S. Assessing the adverse effects of flooding for the livelihood of the poor and the level of external response: A case study of Hazara Division, Pakistan. *Environ. Sci. Pollut. Res.* **2020**, *27*, 19638–19649. [CrossRef]
44. Eckstein, D.; Künzel, V.; Schäfer, L. Global Climate Risk Index 2021. Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000–2019. 2020. Available online: http://germanwatch.org/en/download/8551.pdf (accessed on 11 June 2021).
45. NDMA. *National Disaster Management Authority, Annual Report 2010*; NDMA: Islamabad, Pakistan, 2010.
46. Khayyam, U.; Munir, R. Flood in mountainous communities of Pakistan: How does it shape the livelihood and economic status and government support? *Environ. Sci. Pollut. Res.* **2022**, *29*, 40921–40940. [CrossRef]
47. Atta-ur-Rahman; Khan, A.N. Analysis of 2010-flood causes, nature and magnitude in the Khyber Pakhtunkhwa, Pakistan. *Nat. Hazards* **2013**, *66*, 887–904. [CrossRef]
48. Khayyam, U. What (Not) Advances Effective Community-Driven Development? A Socio-Economic & Politico-Cultural Analysis of the Pashtun Ethnic Society of FATA, Pakistan. Ph.D. Thesis, Universität Münster, Münster, Germany, 2016.
49. Alvi, S.; Khayyam, U. Mitigating and adapting to climate change: Attitudinal and behavioural challenges in South Asia. *Int. J. Clim. Chang. Strateg. Manag.* **2020**, *12*, 477–493. [CrossRef]
50. Ahmad, N.; Anjum, G.A. Legal and institutional perplexities hampering the implementation of urban development plans in Pakistan. *Cities* **2012**, *29*, 271–277. [CrossRef]
51. Hussnain, M.Q.; Anjum, G.A.; Wakil, K.; Tharanga, P.H. Improving Efficiency in Data Collection for Urban Development Plans through Information and Communication Technology. In Proceedings of the International Conference on Town Planning and Urban Management (ICTPUM), Lahore, Pakistan, 29–30 September 2014.
52. Wakil, K.; Hussnain, M.Q.; Yusuf, A.; Abdul Jabbar, J. Project Report: Scenario Planning based Participatory Urban Growth Management Plans Using ICT. Islamabad. 2016. Available online: https://think-asia.org/handle/11540/7573 (accessed on 11 June 2022).

53. Demuzere, M.; Orru, K.; Heidrich, O.; Olazabal, E.; Geneletti, D.; Orru, H.; Bhave, A.G.; Mittal, N.; Feliú, E.; Faehnle, M. Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. *J. Environ. Manag.* **2014**, *146*, 107–115. [CrossRef] [PubMed]
54. MapAction, UN-OCHA. United Nations Office for the Coordination of Humanitarian Affairs New York: Pakistan / Kyber-Pakhtunkhwa: Flood Extent (2 Sept 2010) and Flood Affected. Available online: https://reliefweb.int/map/pakistan/pakistan-kyber-pakhtunkhwa-flood-extent-2-sept-2010-and-flood-affected-districts-31-aug (accessed on 11 December 2020).
55. Sturiale, L.; Scuderi, A. The role of green infrastructures in urban planning for climate change adaptation. *Climate* **2019**, *7*, 119. [CrossRef]
56. UN-SDG. The Sustainable Development Goals Report: United Nations Department of Economic and Social Affairs. 2019. Available online: https://www.un-ilibrary.org/content/books/9789210478878/read (accessed on 6 December 2021).
57. Ahsan, A. Urban Flood Risk Management in Pakistan. Islamabad: Daily Times. 2018. Available online: https://dailytimes.com.pk/280433/urban-flood-risk-management-in-pakistan/ (accessed on 8 June 2021).
58. Bano, R.; Khayyam, U. Industrial air pollution and self-reported respiratory and irritant health effects on adjacent residents: A case study of Islamabad Industrial Estate (IEI). *Air Qual. Atmos. Health* **2021**, *14*, 1709–1722. [CrossRef]
59. Mensah, C.A. Destruction of urban green spaces: A problem beyond urbanization in Kumasi city (Ghana). *Am. J. Environ. Prot.* **2014**, *3*, 1–9. [CrossRef]
60. Naveed, Z.; Khayyam, U. Smog and cognitive issues in the school going children of Lahore and Islamabad, Pakistan. *Int. J. Environ. Sci. Technol.* **2022**, 1–16. [CrossRef]
61. Ashfaque, R.; Awan, M. *Final Report-Policy and Legal Reform Study (GEF-Protected Areas Management Project)*; Ministry of Environment, Government of Pakistan: Islamabad, Pkistan, 2015.
62. Nizamani, A.A.; Shah, A.A. A review of forest policy trends for community participation in Pakistan. *Policy Trend Rep.* **2004**, *2004*, 28–34.
63. Iqbal, N. Supreme Court Orders Equal Benefits for Transvestites. 2009. Available online: https://www.dawn.com/news/477909/supreme-court-orders-equal-benefits-for-transvestites (accessed on 13 May 2021).
64. Guramani, N. National Assembly passes bill seeking protection of transgender rights. In: DAWN. 2018. Available online: https://www.dawn.com/news/1406400 (accessed on 13 May 2021).
65. Guramani, N. Senate Unanimously Approves Bill Empowering Transgenders to Determine Their Own Identity. 2018. Available online: https://www.dawn.com/news/1393766 (accessed on 13 May 2021).
66. Beattie, A.; Hek, G.; Ross, K.; Galvin, K. *Future Career Pathways in Nursing and Midwifery. A Delphi Survey of Nurses and Midwives in South West England, NT Research*; SAGE Publications: London, UK, 2004. [CrossRef]
67. Monette, D.R.; Sullivan, T.J.; DeJong, C.R. *Applied Social Research: A Tool for the Human Services*; Nelson Education: Scarborough, ON, Canada, 2013.
68. Wan, X.; Wang, W.; Liu, J.; Tong, T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med. Res. Methodol.* **2014**, *14*, 135. [CrossRef]
69. Luo, D.; Wan, X.; Liu, J.; Tong, T. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. *Stat. Methods Med. Res.* **2016**, *27*, 1785–1805. [CrossRef]
70. Chinyio, E.A.; Olomolaiye, P.O.; Corbett, P. Quantification of construction clients' needs through paired comparisons. *J. Manag. Eng.* **1998**, *14*, 87–92. [CrossRef]
71. Adetunji, I.O. Sustainable Construction: A Web-Based Performance Assessment Tool. Ph.D. Thesis, Loughborough University, Loughborough, UK, 2005.
72. Gavu, E.K. *Understanding Location and Neighbourhood Effects: An Analysis of the Housing Submarkets in Accra–Ghana*; Technische Universität Dortmund: Dortmund, Germany, 2021.
73. Braimah, N.; Ndekugri, I. Consultants' Perceptions on Construction Delay Analysis Methodologies. *J. Constr. Eng. Manag.-Asce* **2009**, *135*, 1279–1288. [CrossRef]
74. Akadiri, O.P. *Development of a Multi-Criteria Approach for the Selection of Sustainable Materials for Building Projects*; University of Wolverhampton: Wolverhampton, UK, 2011.
75. Foster, J.; Lowe, A.; Winkelman, S. The value of green infrastructure for urban climate adaptation. *Cent. Clean Air Policy* **2011**, *750*, 1–52.
76. Rouse, D.C.; Bunster-Ossa, I.F. *Green Infrastructure: A Landscape Approach*; American Planning Association: Chicago, IL, USA, 2013.
77. Rayan, M.; Gruehn, D.; Khayyam, U. Planning for Sustainable Green Urbanism: An Empirical Communal-Based Study on Green Infrastructure Indicators in Pakistan. *Land Use Policy* **2022**. *under review*.
78. UNDP-Pakistan. Development Advocate Pakistan. Sustain. Urbanization. 2018. Available online: https://www.undp.org/pakistan/publications/sustainable-urbanization (accessed on 16 August 2021).
79. UNDP-Pakistan. Development Advocate Pakistan, Population Growth: Implications for Human Development. 2019. Available online: https://www.pk.undp.org/content/pakistan/en/home/library/development_policy/dap-vol6-iss1-population-growth.html (accessed on 16 August 2021).
80. Pauleit, S.; Ambrose-Oji, B.; Andersson, E.; Anton, B.; Buijs, A.; Haase, D.; Elands, B.; Hansen, R.; Kowarik, I.; Kronenberg, J.; et al. Advancing urban green infrastructure in Europe: Outcomes and reflections from the GREEN SURGE project. *Urban For. Urban Green.* **2019**, *40*, 4–16. [CrossRef]

81. Buishand, A.; Wijngaard, J. *Statistiek van Extreme Neerslag Voor Korte Neerslagduren*; KNMI: De Bilt, The Netherlands, 2007.
82. Wise, S.; Braden, J.; Ghalayini, D.; Grant, J.; Kloss, C.; MacMullan, E.; Morse, S.; Montalto, F.; Nees, D.; Nowak, D.; et al. Integrating valuation methods to recognize green infrastructure's multiple benefits. In *Low Impact Development 2010: Redefining Water in the City*; ASCE Publications: Reston, VA, USA, 2010; pp. 1123–1143.
83. Jacobs, C.; Elbers, J.; Brolsma, R.; Hartogensis, O.; Moors, E.; Márquez, M.T.R.-C.; van Hove, B. Assessment of evaporative water loss from Dutch cities. *Build. Environ.* **2015**, *83*, 27–38. [CrossRef]
84. Nowak, D.J.; Crane, D.E.; Stevens, J.C. Air pollution removal by urban trees and shrubs in the United States. *Urban For. Urban Green.* **2006**, *4*, 115–123. [CrossRef]
85. Yang, J.; Yu, Q.; Gong, P. Quantifying air pollution removal by green roofs in Chicago. *Atmospheric Environ.* **2008**, *42*, 7266–7273. [CrossRef]
86. Pugh, T.A.M.; MacKenzie, A.R.; Whyatt, J.D.; Hewitt, C.N. Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons. *Environ. Sci. Technol.* **2012**, *46*, 7692–7699. [CrossRef]
87. Samara, T.; Tsitsoni, T. The effects of vegetation on reducing traffic noise from a city ring road. *Noise Control Eng. J.* **2011**, *59*, 68–74. [CrossRef]
88. Van Renterghem, T.; Botteldooren, D.; Verheyen, K. Road traffic noise shielding by vegetation belts of limited depth. *J. Sound Vib.* **2012**, *331*, 2404–2425. [CrossRef]
89. Weilenmann, M.F.; Vasic, A.-M.; Stettler, P.; Novak, P. Influence of Mobile Air-Conditioning on Vehicle Emissions and Fuel Consumption: A Model Approach for Modern Gasoline Cars Used in Europe. *Environ. Sci. Technol.* **2005**, *39*, 9601–9610. [CrossRef]
90. Mentens, J.; Raes, D.; Hermy, M. Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? *Landsc. Urban Plan.* **2006**, *77*, 217–226. [CrossRef]
91. Akbari, H.; Taha, H. The impact of trees and white surfaces on residential heating and cooling energy use in four Canadian cities. *Energy* **1992**, *17*, 141–149. [CrossRef]
92. McKinney, M.L. Urbanization as a major cause of biotic homogenization. *Biol. Conserv.* **2006**, *127*, 247–260. [CrossRef]
93. Weber, T.; Sloan, A.; Wolf, J. Maryland's Green Infrastructure Assessment: Development of a comprehensive approach to land conservation. *Landsc. Urban Plan.* **2006**, *77*, 94–110. [CrossRef]
94. Adams, L.W. In our own backyard. *J. Urban For.* **1994**, *92*, 24–25.
95. Hartig, T.; Mitchell, R.; de Vries, S.; Frumkin, H. Nature and Health. *Annu. Rev. Public Health* **2014**, *35*, 207–228. [CrossRef]
96. Clark, K.H.; Nicholas, K.A. Introducing urban food forestry: A multifunctional approach to increase food security and provide ecosystem services. *Landsc. Ecol.* **2013**, *28*, 1649–1669. [CrossRef]
97. Giles-Corti, B.; Broomhall, M.H.; Knuiman, M.; Collins, C.; Douglas, K.; Ng, K.; Lange, A.; Donovan, R.J. Increasing walking: How important is distance to, attractiveness, and size of public open space? *Am. J. Prev. Med.* **2005**, *28*, 169–176. [CrossRef]
98. Weldon, S.; Bailey, C.; O'Brien, E. *New Pathways for Health and Well-Being in Scotland: Research to Understand and Overcome Barriers to Accessing Woodlands*; Report to Forestry Commission Scotland: Edinburgh, UK, 2007.
99. Pretty, J.; Peacock, J.; Sellens, M.; Griffin, M. The mental and physical health outcomes of green exercise. *Int. J. Environ. Health Res.* **2005**, *15*, 319–337. [CrossRef]
100. Bratman, G.N.; Daily, G.C.; Levy, B.J.; Gross, J.J. The benefits of nature experience: Improved affect and cognition. *Landsc. Urban Plan.* **2015**, *138*, 41–50. [CrossRef]
101. Kardan, O.; Gozdyra, P.; Misic, B.; Moola, F.; Palmer, L.J. Neighborhood greenspace and health in a large urban center. In *Urban Forests*; Apple Academic Press: New York, NY, USA, 2017; pp. 77–108.
102. McDonnell, M.J.; Pickett, S.T.A.; Groffman, P.; Bohlen, P.; Pouyat, R.V.; Zipperer, W.C.; Parmelee, R.W.; Carreiro, M.M.; Medley, K. Ecosystem processes along an urban-to-rural gradient. In *Urban Ecology*; Springer: Boston, MA, 2008; pp. 299–313.
103. De Vries, S.I.; Hopman-Rock, M.; Bakker, I.; HiraSing, R.A.; Van Mechelen, W. Built Environmental Correlates of Walking and Cycling in Dutch Urban Children: Results from the SPACE Study. *Int. J. Environ. Res. Public Health* **2010**, *7*, 2309–2324. [CrossRef] [PubMed]
104. Shoup, L.; Ewing, R. *The Economic Benefits of Open Space, Recreation Facilities and Walkable Community Design*; A Research Synthesis; Active Living Research, a National Program of the Robert Wood Johnson Foundation: Princeton, NJ, USA, 2010.
105. Gordon-Walker, S.; Harle, T.; Naismith, I. *Cost-Benefit of SUDS Retrofit in Urban Areas*; Environment Agency: Rotherham, UK, 2007.
106. McPherson, E.G.; Muchnick, J. Effects Of Street Tree Shade On Asphalt Concrete Pavement Performance. *Arboric. Urban For.* **2005**, *31*, 303–310. [CrossRef]
107. KPBOS. Khyber Paktunkhwa Bureau of Statistics. 2018. Available online: https://kpbos.gov.pk/ (accessed on 11 December 2020).

Appendix D: Survey Questionnaire

Key facts and author contributions

Reference	Questionnaire for native experts and households (HHs) community survey.

Signature:

________________________ ___03.01.2024____

Muhammad Rayan Date

Questionnaire for native experts and households (HHs) community survey.

.

technische universität dortmund

Fakultät Raumplanung
Lehrstuhl Landschaftsökologie und Landschaftsplanung

Questionnaires on urban green infrastructure (UGI) planning and governance
سبز مقامات اور گورننس کے حوالے سے سوالنامہ

Section A: Personal Information — معلومات یکشن اے: ذاتیس

Name of the participant? (optional)
جواب دہندگان کا نام؟

The email address of the participant? (optional)
جواب دہندگان کا ای میل؟

Gender? صنف؟

مرد Male	عورت Female
Diverse مختلف	Prefer not to say کہنا نہیں ترجیح دیتے ہیں

Please identify your industrial sector? (multiple answers is possible)

Building /Architecture	Urban planning	Economy
Infrastructure	Horticulture/Arboriculture	Sociology
Landscape	Ecology	other

Which city did you belong to? (optional)
آپ کس شہر سے تعلق رکھتے ہی ؟

Year of experience in the field? کام میں تجربہ؟

- Less than five years
- Five to ten years
- Eleven to fifteen years
- More than fifteen years

Qualification of the participant? **Primary ; Secondary ; Higher-Sec ; High-Education**
جواب دہندگان کی تعلیم اہلیت ؟

Section B : Information about the present land use planning policies and governance in reference to urban green spaces (UGS)
شہری سبز مقامات کے حوالے سے موجودہ زمینی استعمال کی منصوبہ بندی کی پالیسیاں اور حکمرانی کے بارے میں معلومات .

Please rate your opinion between, 1 to 10 Likert scales; 1.Strongly disagrees; 5 Netural. And 10.Strongly agrees.
براہ کرم ، 1 سے 10 لیکرٹ اسکیل کے درمیان اپنی رائے کی درجہ بندی کریں - 1. پوری طرح سے متفق نہیں ہوں اور 10. مکمل اتفاق کریں

Q1: In your opinion, has the quality of green space in your city for recreational and as habitat for plants and animals improved during the last 15 years?
آپ کی رائے میں ، کیا پچھلے 15 سالوں میں آپ کے شہر میں تفریحی اور پودوں اور جانوروں کے رہائش کے لئے سبز جگہ کے معیار میں بہتری آئی ہے؟

Q2: Is your city administration emphasis on conserving and restoring urban green spaces?
کیا آپ کی شہری انتظامیہ شہری سبز مقامات کے تحفظ اور بحالی پر زور دے رہی ہے؟

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

Q3: Is your city administration emphasis on developing new green spaces in urban regions?

کیا آپ کی شہری انتظامیہ شہری علاقوں میں سبز مقامات کی ترقی پر زور دے رہی ہے؟

Q4: What are the greatest accomplishments of your region regarding green infrastructure projects during the last 15 years? Kindly, share one or two concrete Initiatives that deliver recreational or natural habitat facilities. Precisely elaborate on the reasons for selecting these projects.

پچھلے 15 سالوں میں سبز مقامات پروجیکٹس کے حوالے سے آپ کے علاقے کی سب سے بڑی کامیابیں کیا ہیں؟ برائے مہربانی ، ایک یا دو ٹھوس اقدامات کا اشتراک کریں جو تفریحی یا قدرتی رہائش کی سہولیات فراہم کرتے ہیں۔
ان منصوبوں کے انتخاب کی وجوہات کے بارے میں واضح طور پر وضاحت کریں۔

Q5: What are the foremost obstructions for urban green infrastructure planning in your region?

آپ کے علاقے میں میں سبز مقامات کی منصوبہ بندی میں سب سے بڑی رکاوٹیں کیا ہیں؟

Q6: Who is involved in present Land-use planning, specifically for green space in your region? (Multiple answers possible).

آپ کے علاقے میں زمینی استعمال کی موجودہ منصوبہ بندی میں کون شامل ہے ، خاص طور پر سبز مقامات منصوبہ بندی کے لئے؟

Government official	**Academicians**	**Experts**
Non-Government organization	**Community**	**Neighbourhood associations groups**

Q7: Please rate your opinion between, 1 to 5 Likert scale; 1, Not participate; 2, slightly participate; 3, Not sure; 4, moderately participate; 5, highly participate

براہ کرم ، 1 ، 5 لیکرٹ اسکیل کے درمیان اپنی رائے کی درجہ بندی کریں۔ 1، نہیں؛ 2، قدرے؛ 3، یقین نہیں ہے؛ 4، اعتدال پسند؛ 5 ، بہت زیادہ

Is the community representatives are involved in present Land-use planning, specifically for green space in your region?

کیا کمیونٹی کے نمائندے موجودہ زمینی استعمال کی منصوبہ بندی میں شامل ہیں؟ خاص طور پر ، گرین اسپیس پلاننگ کے لئے؟

Q8: What are the foremost causes that obstruct community participation? (Why is this so)?

کون سے اہم وجوہات ہیں جو کمیونٹی کی شرکت میں رکاوٹ ہیں؟ (ایسا کیوں ہے؟)

Q9: Which department is responsible for land-use planning in reference to green space Planning policies and implementation?

سبز مقامات کی منصوبہ بندی, پالیسیوں اور عمل درآمد کے حوالے سے کون سا محکمہ زمینی استعمال کی منصوبہ بندی کا ذمہ دار ہے؟

National level: قومی سطح	Provincial level صوبائی سطح:	District Level : ضلعی سطح

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

Section C: This section encompassed questions with the aim to verify how familiar community are with the urban green Infrastructure, urban resilience, climate change, and climate adaptation topics.

اس سیکشن میں یہ سوال شامل ہے کہ اس بات کی تصدیق کی جائے کہ کتنے افراد شہری سبز انفراسٹرکچر ، شہری لچک ، ماحولیاتی تبدیلی ، موسمیاتی تبدیلی موافقت کے موضوعات سے واقف ہیں۔

What does climate change mean for you? (multiple answer is possible) آپ کے لئے ماحولیاتی ا میکا ک یلیتبد یمطلب ہے؟		**What does adaptation to climate change mean for you?** آپ ا مطلب ہے؟یموافقت کا ک یوں کیلیتبد یاتیکے لئے موسم	
Increase of global annual mean temperature. ں اضافیسطح پر سالانہ اوسط درجہ حرارت م یعالم		Ability to learn from dealing with climate change تیصلاح یکھنے کیوں سے نمٹنے سے ریلیتبد یاتیموسم	
Increase extreme weather events (heavy rain, drought, storms) ں اضافیواقعات م ید موسمیطوفان) شد ، یز بارش ، خشک سالیت)		Creation of ecological buffer zones (cooling green spaces, water-retentive soils) . یمٹ ییرقرار رکھنے وال یل (سبز جگہوں کو ٹھنڈا کرنا ،پانیتشک یفر زون ک یاتیماحول)	
Decrease of mean annual precipitation. ا یکم یوسط سالانہ بارش ک		Resistance against environment changes. وں کے خلاف مزاحمتیلیتبد یماحول ک	
Decrease of droughts یکم یک یخشک سال		Construction of technical installation (flood dams , dikes and wetlands) تکنیکی تنصیب کی تعمیر (سیلاب ڈیمز ، ڈائکس اور ویلی لینڈز)	
Decrease of annual number of frost days یں کمیسالانہ تعداد م یٹھنڈ کے دن ک		It is a prerequisite of sustainability. ک شرط ہےیا یہ استحکام کی	
Increasing sea level – ں اضافیسطح سمندر م		Increasing consideration of urban green in conurbations شہروں میں سبز رنگ کے بارے میں غور و فکر کرنا	
Increase of ecological damage ں اضافینقصان م یاتیماحول		Plantation of shade-giving alleys سایہ دینے والے گلیوں کی شجرکاری	
I don't know ں پتہیمجھ نہ		Adaptation to climate change means that climate protection does not matter anymore. کے تحفظ یاتیوں موسمیلیتبد کی تبدیلی کے مطابق موافقت کا مطلب یہ ہے کہ یاتیوں موسمیلیتبد سے اب کوئی فرق نہیں پڑتا ہے	
It means………….. اس کا مطلب ہے		I don't know ں پتہیمجھ نہ	
What does green infrastructure mean for you? (multiple answer is possible) آپ کے لئے سبز بنیادی ڈھانچے کا کیا مطلب ہے ؟		**What does urban resilience mean for you? (multiple answer is possible)** آپ کے لئے شہری لچک کیا معنی رکھتی ہے؟	
Promote the networks connectivity and mobility among the urban green spaces. شہری سبز مقامات کے مابین نیٹ ورک کے رابطے کو فروغ دیں۔		Ability of a system to resist, absorb and recover from natural hazard in an efficient manner. ایک موثر انداز میں قدرتی خطرے سے مزاحمت ، جذب اور بازیافت کرنے کے نظام کی اہلیت	
Enhances the natural ecological processes and sustain natural resources. قدرتی ماحولیاتی عمل کو بہتر بناتا ہے اور قدرتی وسائل کو برقرار رکھتا ہے		It is a prerequisite of sustainability. ک شرط ہےیا یہ استحکام کی	

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

Enhanced and maintained the level of biodiversity. حیاتیاتی تنوع کی سطح کو بڑھانا اور برقرار رکھنا		Strengthening the urban neighbourhood against the environment changes. ماحولیاتی تبدیلیوں کا مقابلہ برادری کو مضبوط بنانا۔	
Promote economic regeneration and social cohesion. معاشی تخلیق نو اور معاشرتی ہم آہنگی کو فروغ دیں		More effective Land use Planning and Zoning. زمینی استعمال سے زیادہ موثر منصوبہ بندی اور حلقہ بندی	
A prerequisite of sustainability. ک شرط ہےیا یہ اســـتحکام کـی		Adaptation to climate change. موسمیاتی تبدیلیوں کی تبدیلیوں پر مبنی موافقت۔	
Decrease of global annual mean temperature. عالمی سطح پر سالانہ اوسط درجہ حرارت میں کمی۔		Promote green infrastructure initiatives سبز بنیادی ڈھانچے کے اقدامات کو فروغ دینے	
Decrease of extreme weather events (flooding, drought) شدید موسمی واقعات میں کمی (سیلاب ، خشک سالی)		Improve "Eco social systems". ماحولیاتی معاشرتی نظام کو بہتر بنانا۔	
Increase of mean annual precipitation. اوسطا سالانہ بارش میں اضافہ۔		More efficient governance and planning capabilities. زیادہ موثر حکمرانی اور منصوبہ بندی کے کام	
Enhances the Intensification of permeable surfaces. جذبات والا مقامات کی شدت میں اضافہ		Creation of ecological buffer zones (cooling green spaces, water-retentive soils) ماحولیاتی بفر زون کی تشکیل کی طرح سبز مقامات ، پانی کو متاثر کرنے والی والٹی مٹی وغیرہ	
Enriches the ecosystem services of a city. شہر کا ماحولیاتی نظام بہتر بناتا ہے		I don't know ں پتـــــیمجھ نہ	
Promote Bio-food. قدرتی کھانے کو فروغ دیں		It means………….. اس کا مطلب ہے	
Improve social well-being and enriches the social cohesion معاشرتی بہبود اور معاشرتی ہم آہنگی کو بہتر بنائیں۔			
Increases of mean annual energy efficiency in buildings. عمارات میں سالانہ توانائی کی اوسط کارکردگی میں اضافہ۔			
Reconnecting people with the landscape through innovative design by developing mixed use spaces that service entire populations. جدید ڈیزائن کے لوگ کو سبز مقامات سے جوڑنا۔			
I don't know ں پتـــــیمجھ نہ			

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie
und Landschaftsplanung

Theme	How important are these topic to you? ہ آپ کے لئےی عنوان کتنا اہم ہے ؟					Is your department aware with this? کیا آپ کا ڈپارٹمنٹ اس سے واقف ہے؟				
	Not Imp ںیہن اہم	Slightly Imp تھوڑا سا اہم	Not sure یقین نہیں	Mod- Imp اعتدال پسند اہم	Ext-Imp انتہائی اہم	High-unaware بہت ادہیز واقف ںیہن	Slightly aware تھوڑا سا آگاہ	Not sure ںیہن ںیقی	Mod- aware اعتدال سے آگاہ	High-aware بہت آگاہ
Climate change یاتیموسم یلیتبد										
Urban green Infrastructure (UGI): یشہر ںیگر نفراسٹرکچر										
Biodiversity: ماحول یاتیح										
Ecosystem services: یاتیماحول نظام										
Social cohesion /Unity. یسماج ہم یآہنگ										
A green economy سبز شتیمع										
Urban resilience: یشہر لچک										
Adaptation to climate change: یاتیموسم یلیتبد یک واقفت										
Water management : یپان کے انتظام										
Organic food production. یقدرت غذا یک داواریپ										
Energy efficient building یتوانائ سے موثر عمارت										

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

Theme	**Is it considered in plan or policy of your city?** کیا آپ کے شہر کے منصوبے یا پالیسی میں اس پر غور کیا جاتا ہے؟					**If yes, please mention the plan/ policy title.** اگر ہاں ، تو براہ کرم منصوبہ / پالیسی کے عنوان کا ذکر کریں
	Not - considered غور ینہ ایک	**Slightly- Consi** تھوڑا سا غور	**Not sure** نیقی ینہ	**Mod-Consi** تھوڑا سا غور	**High- Consid** بہت ادہیز غور	
Climate change یاتیموسم یلیتبد						
Urban green Infrastructure (UGI): یشہر نیگر نفراسٹرکچر						
Biodiversity: ماحول یاتیح						
Ecosystem services: یاتیماحول نظام						
Social cohesion /Unity. یسماج ہم یآہنگ						
A green economy سبز شتیمع						
Urban resilience: یشہر لچک						
Adaptation to climate change: یاتیموسم یلیتبد یک وافقت						
Water management : یپان کے انتظام						
Organic food production. یقدرت غذا یک داواریپ						
Energy efficient building یتوانائ سے موثر عمارت						

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

This section encompassed questions with the aim to identify the sustainable Urban green Infrastructure indicators relationship with multiple green space elements.

اس حصے میں یہ سوالات شامل ہیں ، جس کا مقصد مختلف سبز مقامات کے ساتھ پائیدار شہری سبز بنیادی ڈھانچے کے اشارے کی نسبت/ تعلقات کی نشاندہی کرنا ہے

ECOLOGICAL INDICATORS. **ماحولیاتی اشارے.**

Please rate your opinion between, 1 to 9 Likert scales; 1. Highly Insignificant, 2.Slightly Insignificant, 3.Moderately Insignificant, 4.Insignificant, 5 Balance, 6. Slightly significant, 7.Moderately significant, 8.Significant, 9.Highly Significant.

براہ کرم ، 1 سے 10 لیکرٹ اسکیل کے درمیان اپنی رائے کی درجہ بندی کریں 1. انتہائی کم اہم 2. تھوڑا سا کم اہم 3. اعتدال پسند کم اہمیت کا حامل ، 4. کم اہم 5. توازن 6. قدرے اہم ، 7. معتدل اہم 8. اہم 9. انتہائی اہم

1. Which Urban Green Infrastructure (UGI) elements optimize rainwater management?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر بارش کے پانی کے انتظام کو بہتر بناتے ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

2. Which Urban Green Infrastructure (UGI) elements reduce urban heat island effects?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر شہری گرمی کے اثرات کو کم کرتے ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

3. Which Urban Green Infrastructure (UGI) elements improve noise quality?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر شور کے معیار کو بہتر بناتا ہے؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

4. Which Urban Green Infrastructure (UGI) elements reduce carbon emission (e.g. avoided greenhouse gas emission through cooling?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر شور کاربن کے اخراج کو کم کرتے ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

5. Which Urban Green Infrastructure (UGI) elements improve energy efficiency in buildings?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر عمارتوں میں توانائی کی کارکردگی کو بہتر بناتا ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

6. Which Urban Green Infrastructure (UGI) elements enhance soil quality and erosion?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر مٹی کے معیار اور کٹاؤ کو بہتر بناتا ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

7. Which Urban Green Infrastructure (UGI) elements enhance and protect urban biodiversity?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر شہری حیاتیاتی تنوع کو بہتر اور محفوظ بناتا ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

SOCIO-CULTURAL INDICATORS.

سماجی ثقافتی اشارے

Please rate your opinion between, 1 to 9 Likert scales; 1. Highly Insignificant, 2.Slightly Insignificant, 3.Moderately Insignificant, 4.Insignificant, 5 Balance, 6. Slightly significant, 7.Moderately significant, 8.Significant, 9.Highly Significant.

براہ کرم ، 1 سے 10 لیکرٹ اسکیل کے درمیان اپنی رائے کی درجہ بندی کریں 1. انتہائی کم اہم 2. تھوڑا سا کم اہم 3. اعتدال پسند کم اہمیت کا حامل ، 4. کم اہم 5. توازن 6. قدرے اہم ، 7. معتدل اہم 8. اہم 9. انتہائی اہم

1. Which Urban Green Infrastructure (UGI) element promotes food production (e.g. urban agriculture; kitchen gardens; and community gardens)

کھانے کی پیداوار کو فروغ دیتا ہے (جیسے شہری زراعت, باورچی خانے کے باغات اور اور برادری کے باغات)

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

2. Which Urban Green Infrastructure (UGI) elements improve social well-being and enhance the attractiveness of the city?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر معاشرتی بہبود کو بہتر بناتے ہیں اور شہر کی کشش کو بڑھا رہے ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

3. Which Urban Green Infrastructure (UGI) elements improve physical and mental well-being?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر جسمانی اور ذہنی تندرستی کو بہتر بناتا ہیں ؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

4. Which Urban Green Infrastructure (UGI) elements provide places for education and research?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر تعلیم اور تحقیق کے لئے جگہ فراہم کرتے ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

5. Which Urban Green Infrastructure (UGI) elements improve accessibility and connectivity to encourage walking and cycling opportunities?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر رسائی اور رابطے کو بہتر بناتے ہیں جو سائیکلنگ اور پیدل چلنے کے مواقع کی حوصلہ افزائی کرنے میں مدد کرتا ہے

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

ECONOMIC INDICATORS.

اقتصادی اشارے

Please rate your opinion between, 1 to 9 Likert scales; 1. Highly Insignificant, 2.Slightly Insignificant, 3.Moderately Insignificant, 4.Insignificant, 5 Balance, 6. Slightly significant, 7.Moderately significant, 8.Significant, 9.Highly Significant.

براہ کرم ، 1 سے 10 لیکرٹ اسکیل کے درمیان اپنی رائے کی درجہ بندی کریں 1. انتہائی کم اہم 2. تھوڑا سا کم اہم 3. اعتدال پسند کم اہمیت کا حامل ، 4. کم اہم
5. توازن 6. قدرے اہم ، 7. معتدل اہم 8. اہم 9. انتہائی اہم

1. Which Urban Green Infrastructure (UGI) element amplified property values?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر نے پراپرٹی کی اقدار کو بڑھاوا دیا ہیں؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

2. Which Urban Green Infrastructure (UGI) elements save healthcare costs?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر صحت کی دیکھ بھال کے اخراجات بچاتے ہیں ؟

Community Garden کمیونٹی زرعی باغات	Botanical Garden نباتات کے باغات	Urban park شہری پارک	Forest جنگلات	Green streets سبز گلیاں	Rain garden بارش کے باغات	Permeable parking lot جذب ہونے والا پارکنگ	Wetland مرطوب زمین	Green roof & wall سبز چھتیں اور دیواریں	Horticultural باغبانی

technische universität dortmund

Fakultät Raumplanung

Lehrstuhl Landschaftsökologie und Landschaftsplanung

3. Which Urban Green Infrastructure (UGI) elements reduce energy consumption (e.g. Cooling and heating demands)?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر توانائي کے استعمال کو کم کرتے ہیں (جیسے کولنگ اور ہیٹنگ کی ضروریات)؟

Community Garden	Botanical Garden	Urban park	Forest	Green streets	Rain garden	Permeable parking lot	Wetland	Green roof & wall	Horticultural
کمیونٹی زرعی باغات	نباتات کے باغات	شہری پارک	جنگلات	سبز گلیاں	بارش کے باغات	جذب ہونے والا پارکنگ	مرطوب زمین	سبز چھتیں اور دیواریں	باغبانی

4. Which Urban Green Infrastructure (UGI) elements reduce the risk of flood damages?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر سیلاب سے ہونے والے نقصانات کے خطرے کو کم کرتے ہیں؟

Community Garden	Botanical Garden	Urban park	Forest	Green streets	Rain garden	Permeable parking lot	Wetland	Green roof & wall	Horticultural
کمیونٹی زرعی باغات	نباتات کے باغات	شہری پارک	جنگلات	سبز گلیاں	بارش کے باغات	جذب ہونے والا پارکنگ	مرطوب زمین	سبز چھتیں اور دیواریں	باغبانی

4. Which Urban Green Infrastructure (UGI) elements reduce private car use by increasing walking and cycling travel mode?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر گاڑیوں کا استعمال کم کرکے ، پیدل چلنے اور سائیکل چلانے کے مواقع میں اضافہ کرتے ہیں۔ (جیسے سفری انداز کو تبدیل کرنا)

Community Garden	Botanical Garden	Urban park	Forest	Green streets	Rain garden	Permeable parking lot	Wetland	Green roof & wall	Horticultural
کمیونٹی زرعی باغات	نباتات کے باغات	شہری پارک	جنگلات	سبز گلیاں	بارش کے باغات	جذب ہونے والا پارکنگ	مرطوب زمین	سبز چھتیں اور دیواریں	باغبانی

5. Which Urban Green Infrastructure (UGI) elements optimize the value of air pollutant removal?

کون سے شہری گرین انفراسٹرکچر (IGU) عناصر فضائی آلودگی کو ختم کرنے کی قدر میں اضافہ کرتے ہیں؟

Community Garden	Botanical Garden	Urban park	Forest	Green streets	Rain garden	Permeable parking lot	Wetland	Green roof & wall	Horticultural
کمیونٹی زرعی باغات	نباتات کے باغات	شہری پارک	جنگلات	سبز گلیاں	بارش کے باغات	جذب ہونے والا پارکنگ	مرطوب زمین	سبز چھتیں اور دیواریں	باغبانی