Master of Disaster Management Advanced Research Thesis on

Prioritization of Urban Adaptation Measures for Climate Change in Dhaka under the National Adaptation Plan 2023-2050

Fahmid Mohtasin

Master of Disaster Management 2nd Semester

Session: 2021-2022

Examination Roll: 128511

Class Roll: 3108

Institute of Disaster Management and Vulnerability Studies (IDMVS)

University of Dhaka

This thesis is submitted to the Institute of Disaster Management and Vulnerability Studies, University of Dhaka, for the partial fulfillment of the degree of Masters of Disaster Management

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Submitted by

Fahmid Mohtasin
Master of Disaster Management 2nd Semester
Session: 2021-2022
Examination Roll: 128511
Class Roll: 3108
Institute of Disaster Management and Vulnerability Studies
University of Dhaka

Under the Supervision of

Jafrin Jabin Madhubi
Lecturer
Institute of Disaster Management and Vulnerability Studies
University of Dhaka

Under the Co-supervision of

Bivuti Bhusan Sikder
Assistant Professor
Institute of Disaster Management and Vulnerability Studies
University of Dhaka

This thesis is submitted to the Institute of Disaster Management and Vulnerability Studies, University of Dhaka, for the partial fulfillment of the degree of Masters of Disaster Management

DECLARATION

I hereby declare that the presented findings of this research titled, *"Prioritization of urban adaptation measures for climate change in Dhaka under the National Adaptation Plan (2023-2050)"* are the results of my own sincere efforts and no part of this thesis has been submitted elsewhere for publication or degree.

Fahmid Mohtasin

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University of Dhaka

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Name of the applicant	Fahmid Mohtasin
Examination Roll	128511
Class Roll	3108
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ABSTRACT

Climate change adaptation is mandatory for LDCs like Bangladesh which stand to lose the most from its effects. While these effects do threaten coastal communities significantly, the disproportionate impact on urban areas like Dhaka city is also an inescapable reality. The unpredictable weather patterns coupled with unplanned development and exponential population growth has made Dhaka especially vulnerable to the impacts of climate change. The government of Bangladesh plans to offset these impacts in urban areas by implementing a number of interventions and activities as a part of the greater National Adaptation Plan 2023-2050. This study aimed to prioritize the proposed activities in a comprehensive manner from the perspective of a non-partisan and independent third party using the multi-criteria analysis methodology. This was achieved by identifying the relevant adaptation options, developing several criteria through which they would be measured, and gathering expert opinions in the form of scores on the established criteria. These scores were then weighted and normalized, and were used to develop rankings for the adaptation options both on the basis of 'priority' and 'complexity'. The findings of the study offer valuable insights for policymakers. Avoiding leakages in the city's WASH systems and maintaining a 25% green space held the highest positions in terms of priority. The experts also supported the restoration of previously existing natural drainage channels rather than constructing new networks. This also tied into the prevalent practice of encroaching open lands, and illegal waste dumping. Employing IT-based mechanisms for drainage systems, decentralization of development initiatives, and artificial groundwater recharge revealed to be the most complex options, with experts often preferring simpler alternatives. Adaptation initiatives focused on the youth were found to be some of the most feasible options while also maintaining acceptable priority scores. The perspectives gathered from these findings can support the future decision-making processes pertaining to adaptation initiatives in Dhaka city. Furthermore, the study can encourage community engagement through sharing knowledge on adaptation activities, and may also inspire further research into the subject matter.

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LIST OF ACRONYMS

UNFCC	United Nations Framework Convention on Climate Change
ND-GAIN	University of Notre Dame's Global Adaptation Index
AQI	World Air Quality Index
LDC	Least Developed Country
SIDS	Small Island Developing States
NDC	Nationally Determined Contributions
COP	Conference of the Parties
GCHA	Global Climate and Health Alliance
MoEF	Ministry of Environment and Forest
NAP	National Adaptation Plan
MoEFCC	Ministry of Environment, Forest and Climate Change
CBA	Cost-Benefit Analysis
CEA	Cost-Effectiveness Analysis
MCDA	Multi-Criteria Decision Analysis
PM	Particulate Matter
UNDP	United Nations Development Program
UN	United Nations
FAO	Food and Agriculture Organization
UNCHS	United Nations Centre for Human Settlements
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
WFP	World Food Programme
UNITAR	United Nations Institute for Training and Research

UNEP	United Nations Environment Programme
UK	United Kingdom
NCS	National Conservation Strategy
NEC	National Conservation Strategy
NEMAP	National Environmental Management Action Plan
CCC	Climate Change Cell
CDMP	Comprehensive Disaster Management Program
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
CCU	Climate Change Unit
BCCTF	Bangladesh Climate Change Trust Fund
BCCRF	Bangladesh Climate Change Resilience Fund
MDTF	Multi-Donor Trust Fund
ccGAP	Climate Change And Gender Action Plan
NAPA	National Adaptation Programme of Action
GHG	Green House Gas
NPDM	National Planning for Disaster Management
BCCAP	Bangladesh Climate Change Strategy and Action Plan
GoB	Government of Bangladesh
M&E	Monitoring and Evaluation
MCA	Multi-Criteria Analysis
SWM	South-Western Coastal Area and Sundarbans
CHT	Chattogram Hill Tracts
DBA	Drought Prone and Barind Area
URB	Urban Areas
WASH	Water, Sanitation and Hygiene

WASA	Water Supply and Sewerage Authority
DWASA	Dhaka Water Supply and Sewerage Authority
IWRM	Integrated Water Resources Management
IT	Information Technology
ICT	Information and Communications Technology
HCF	Health Care Facility
WHO	World Health Organization
LGI	Local Government Institution
MAR	Managed Aquifer Recharge
USD	United States Dollar
IPCC	Intergovernmental Panel on Climate Change
COVID-19	Corona Virus Disease of 2019
SARS	Severe Acute Respiratory Syndrome
3R	Reduce, Recycle, Recovery
OECM	Other Effective area-based Conservation Measures
DAP	Detailed Area Plan
LID	Low-Impact Development
BNBC	Bangladesh National Building Code
O&M	Operations and Maintenance
PPP	Public-Private Partnership
AMR	Antimicrobial Resistance
MoU	Memorandum of Understanding
UKCIP	United Kingdom Climate Impacts Programme
KII	Key Informant Interview
SLR	Sea Level Rise

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Chapter 1: Introduction

1. Introduction

1.1. Background of the Study

Adaptation strategies have become growing practices in addressing the noticeable shifts in global climate. The cities in particular are struggling all over the world to adapt to the continuously changing climate. Urban areas across the globe are facing the dual challenge of rapid urbanization as well as the effects of climate change. Alongside grappling with increasing population density, the cities are also facing growing threats posed by unpredictable weather patterns, sea level rise (SLR), and other hazards posed by climate change. Furthermore, the developing countries are the worst sufferers of climate change despite having some of the lowest contribution to the overall greenhouse gas emissions (Haque et al., 2012). Many essential and innovative strategies are being adopted by the developing countries as a part of a broader effort to build resilience and reduce the vulnerability to the adverse effects of climate change. In most cases, international organizations such as the World Bank and the United Nations Framework Convention on Climate Change (UNFCCC) are supporting such strategies by providing guidance, funding, and technical assistance (UNFCCC, 2007). For instance, developing early warning system, undertaking community-based adaptations, water harvesting in urban areas, etc. are some very common adaptation strategies prevalent in India, China, Brazil and Uganda. *Figure 1* visualizes results according to a report by the World Economic Forum, where seemingly visible progress was seen in the continents of Asia as well as the Middle East. This was due to the adaptation contributions of countries including Malaysia, China, and Singapore. The advances made in some of the countries in the African continent also requires mentioning, as well as the adaptation mechanisms in Chile and Brazil. When considering Europe, the eastern nations of Georgia, Belarus, and Poland seem more advanced with adaptation mechanisms than their counterparts (Myers, 2015). This continent-wise performance was extracted in light of the University of Notre Dame's Global Adaptation Index (ND-GAIN), which assessed the ability of the countries to cope with the potential effects of climate change. The ND-GAIN metric considers a total of 45 distinct factors that develop vulnerability scores and readiness scores, which are then combined to determine the final score.

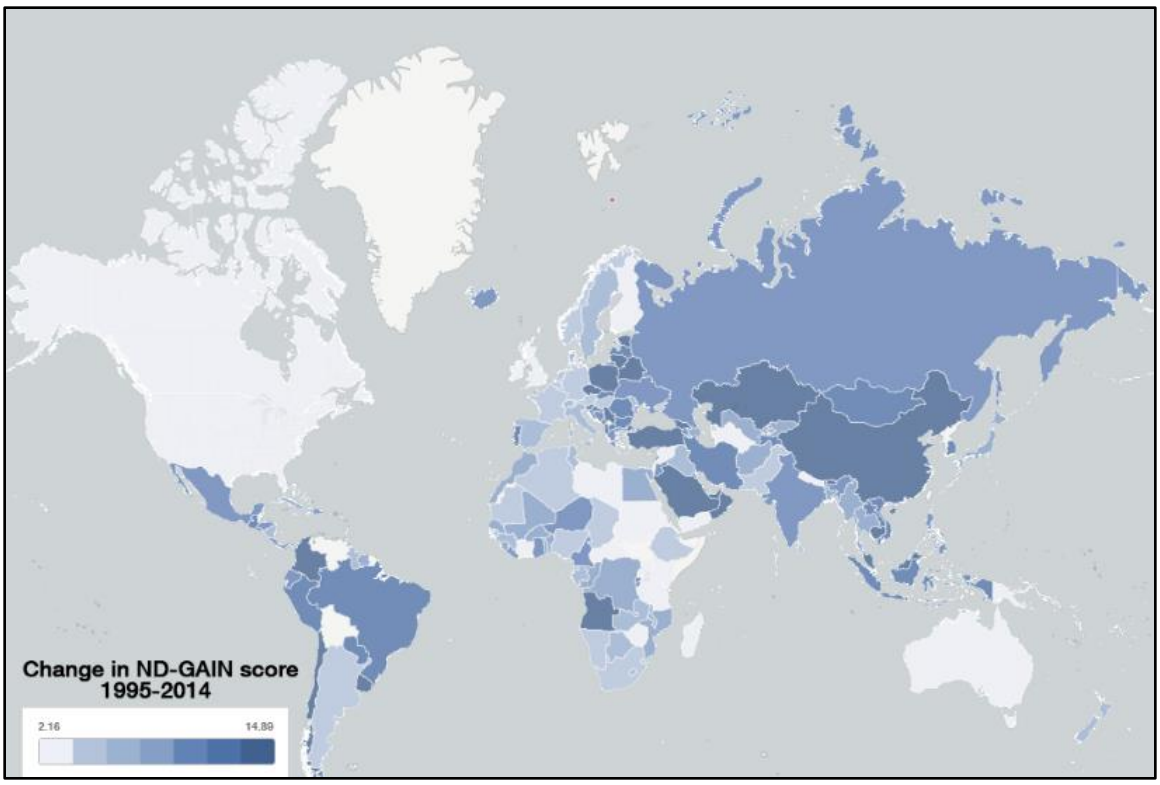


Figure 1: Progress made by different countries of the world from 1995 - 2014 in adapting to climate change (Chen et al., 2015)

Climate change has become extremely prevalent in Bangladesh, and the most unpleasant condition has manifested in Dhaka, the capital city that is currently accommodating more than 20 million people. It is not only one of the most populated cities in the world but also the second most polluted city as per the World Air Quality Index ranking, 2023. Furthermore, Dhaka has been the target destination for a large number of migrants as well as victims of climate-induced displacement looking for better opportunities, resulting in its rapidly expanding population in recent decades. In developing countries like Bangladesh, resources are limited and vulnerability to climate change is very high (Makungo & Nkuna, 2023). According to a report by the UNFCCC, the developing countries are predicted to face water and food shortages, as well as greater risks to health and life due to climate change (UNFCCC, 2007). 93% of Least Developed Countries (LDCs) and Small Island Developing States (SIDS) have submitted enhanced national climate pledges or plans to do so. These climate pledges and/or plans are, essentially, self-defined 5-year-long adaptation and mitigation goals that each country designs for itself, which is also known as Nationally Determined Contributions (NDCs). The NDCs play a crucial role in the global effort towards building a more

sustainable and climate-resilient future. The NDCs are the core of the landmark international treaty, the **Paris Climate Agreement**, adopted in 2015 during the **21st Conference of the Parties (COP21)** under the UNFCCC. The agreement has been ratified by 195 states. It recognizes that climate change is a global challenge that requires collective action by all countries and its primary goal is to limit global warming to well below 2 degrees Celsius in reference to pre-industrial levels, with efforts to limit it to 1.5 degrees Celsius within the second half of this century (Huang, 2019). The Paris Agreement requires each Party (country) to prepare, communicate, and submit their NDCs every five years to the UNFCCC secretariat, which are then recorded in a public registry maintained by the secretariat to ensure transparency and accountability in tracking countries' climate actions. The Paris Agreement encourages a ratcheting up of ambition over time to guarantee a future that is livable for everyone. Parties may adjust their existing NDCs to enhance their level of ambition at any time. While developed countries aim for rapid emission reductions, developing countries have more flexible timelines, considering equity and sustainable development.

The NDCs, when broken down, reveal a country government's objectives pertaining to climate change. They act as an effective measure for the international community for climate actions being considered in neighbouring countries. The Global Climate and Health Alliance (GCHA) has, thus, operationalized the concept and developed 'Healthy NDC Scorecards' by analyzing five distinct categories: health impacts, health in adaptation measures, health co-benefits, economics and finance. These categories all held 3 points, and therefore, a possible total score for any country was 15. The overall prominence and integration of health was also considered into the scoring process. The GCHA provides an annual report of countries' health scores based on updated NDC details provided by country governments. The most recent publication from the GCHA in this regard came in 2023, where Burundi was discovered to be the country with the highest score among a total of 120 countries. *Figure 2* provides details into the scoring process and Burundi's success (Global Climate and Health Alliance, 2023).

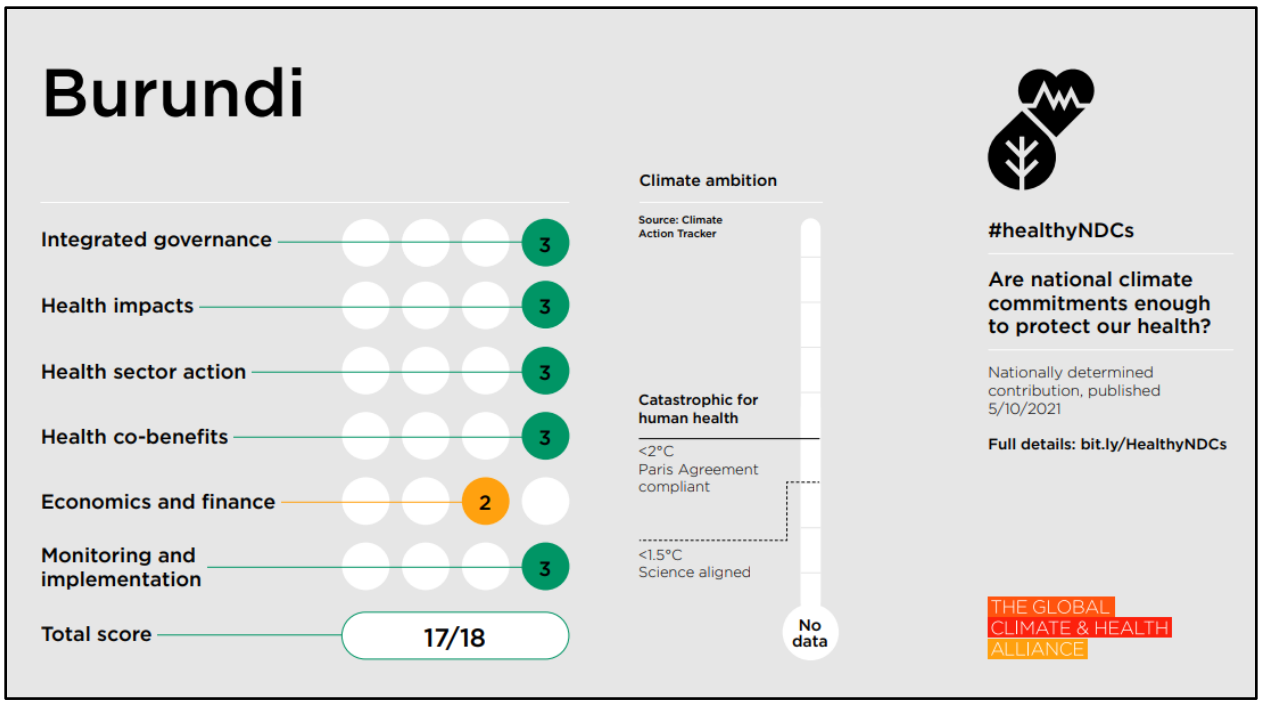


Figure 2: Healthy NDC Scorecard 2023 Edition (Global Climate and Health Alliance, 2023)

Side by side with other nations, Bangladesh is also contributing to climate action by incorporating matters of environmental sustainability at local, regional and national levels in various ways. For example, the **Article 18A** of the Constitution of the People's Republic of Bangladesh (Act No. of 1972) proclaims:

"The State shall endeavor to protect and improve the environment and to preserve and safeguard the natural resources, bio-diversity, wetlands, forests and wild life for the present and future citizens"

Moreover, the NAP (2023-2050) was formulated in October 2022 to promote climate action and adopt sustainability practices. The policy was thorough and took into account 11 different climate stress areas and developed 113 interventions based on localized requirements, and allotted a total of BDT 20,037 billion for them. 12 of these interventions were strictly for urban areas, for which, 3,307 Billion BDT was allotted (MoEFCC, 2022).

1.2 Rationale of the Study

Dhaka is the seventh most overpopulated city, and one of the least resilient cities in the world (Economist Impact, 2023). In terms of air quality, it may be considered unlivable by international standards, as can be seen in *figure 3*. Deep-rooted complexities are embedded into every aspect of the day-to-day lives of its residents, which is only worsened by the climate change and sustainability issues.

For a country like Bangladesh, which is only responsible for 0.56% of total CO2 emissions globally, the threats are quite disproportionate. It is ranked 7th on the list of countries most vulnerable to the impacts of climate change (United Nations Bangladesh, 2024). Given this information, it is clear that the primary focus for Bangladesh should be adaptation rather than mitigation at this stage.

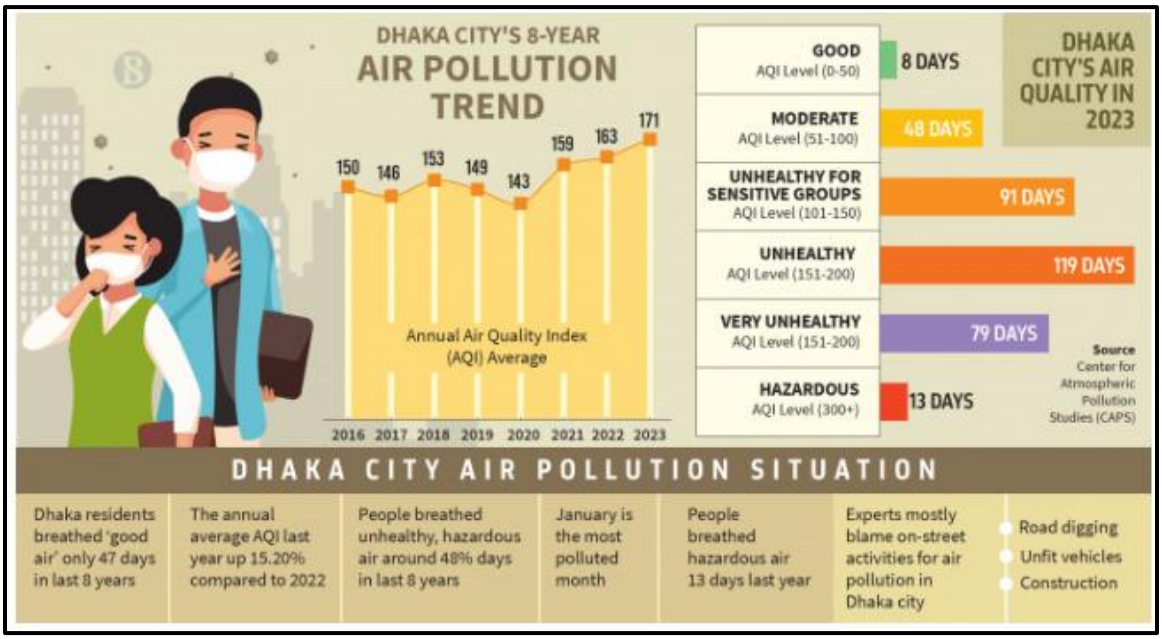


Figure 3: Air Pollution Trends in Dhaka City over the Last 8 Years (M. J. Islam, 2024)

A study by Anguelovski and Carmin (2011) observed the climate actions in urban governance context and their findings highlighted how the cities are motivated in climate actions as per their own internal goals (Anguelovski & Carmin, 2011). The constraints prevail in the technical capacity of the system, bureaucratic complexities, and social restrictions. The authors suggested a legitimate and capacity building approach in building climate programs. The actions and practices are more

embedded in mitigation and adaptation of new technologies and measures into already existing plans.

Mitigation, adaptation and coping are three widely used terms in the context of climate change resilience and disaster response. They are closely related and interchangeably used in most cases, but they have some subtle differences. Coping, mitigation and adaptation to climate change and variability entails plans for different periods of time, which distinguishes these concepts (Dessalegn, 2018). Coping refers to short term responses to the impacts of events, while adaptation and mitigation refers to longer term adjustments to more permanent climate changes (Van Der Geest & Warner, 2015). Adaptation and coping mechanisms can be deployed at individual level, but mitigation requires a collective effort at the higher level. Coping is oriented towards survival, temporary, driven by crisis, often degrades resource base and prompted by absence of initiatives whereas adaptation is continuous, long-lasting, utilizes resources more efficiently and sustainable, includes planning, integrates the past and present strategies, and aimed at finding alternatives (Makungo & Nkuna, 2023). Coping helps to withstand or minimize the adverse effects of climate change, mitigation focuses on addressing the root cause of climate change by curbing greenhouse gas emissions, and adaptation is about preparing for the new climate that is already upon us.

Due to a lack of technical capacity, expertise, and resources, it is often difficult for developing countries to implement their planned activities (Haque et al., 2012; Mirza, 2003). Hence, it is necessary to assess the adaptation measures in order to identify and prioritize which are to be implemented first hand while simultaneously meeting the risk reduction and local goals. Stakeholders' participation is often sidelined while undertaking development or climate change adaptation projects, which could lead to uninformed decisions (Haque, 2016).

The most popular approaches used for prioritizing adaptation options include cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and multi-criteria decision analysis (MCDA) (Haque, 2016). Each approach has its own merit, but none of them can be considered perfect for prioritization of adaptation options. The CBA allows comparison between the economic cost of implementing an adaptation option and the direct benefits resulting from the reduced or avoided damages/cost that would otherwise be caused by climate change in the case of inaction (Rome et al., 2019). The CBA is the most suitable for assessing no and low regret options in the market

sector in the case of low or predictable uncertainties related to climate risk probabilities (Rouillard, J. et al., 2016). On the other hand, the CEA is an appraisal technique used for ranking climate change alternative measures on the basis of costs and effectiveness, where the highest rank is assigned to the most cost-effective strategy. The MCDA approach prioritizes a range of climate change adaptation strategies against multiple criteria while considering the preferences of the stakeholders. This approach can be effectively applied in case of areas and sectors in which single criterion-based methodologies do not apply as well as in cases where important social and environmental impacts cannot be expressed in terms of monetary values (Nautiyal & Goel, 2021).

This study takes a multi-criteria analysis approach to evaluating adaptation measures. These criteria can be both quantitative and qualitative. Thus, it can accommodate both types not being restricted like Cost Benefit Analysis or Cost Effectiveness Analysis. Moreover, it allows a participatory process for the assessment, i.e. all the stakeholders can participate at different stages of assessment. Not only that, but the United Nations advocates MCA as the preferred method to assess adaptation options and policies (Haque, 2016). Therefore, this study will attempt to assess projects under the newly devised NAP 2023-2050 under the scope of an MCA. The Ministry of Environment, Forest, and Climate Change formulated a national adaptation strategy for 2030 to 2050 for the People's Republic of Bangladesh. In this study, we are mainly going to focus on relevant adaptation options required for developing resilience in the notoriously polluted Dhaka metropolitan.

1.3 Research Gaps

It has been mentioned previously that the NAP 2023-2050 devised 113 interventions focusing on 11 distinct climate stress areas. These interventions have been prioritized using the multi-criteria analysis methodology themselves within the policy document. However, in this case only two classes were created for the interventions; ‘High Priority’ and ‘Moderate Priority’.

Furthermore, each of the 113 interventions include a wide array of activities that have not been prioritized. For example, the 12 interventions that center around urban areas include 86 activities among them. Prioritizing these measures for implementation is crucial for maximizing efficiency and benefits, particularly in the capital city of Dhaka. Given the highly localized nature of the effects of climate change, contextualization of these adaptation measures is necessary in this process, taking into account the social, political, environmental, and climatic conditions of the metropolitan area (Shepherd et al., 2006; Swart & Raes, 2007). To address this issue, climate coping and adaptation strategies that are developed need to be prioritized to identify those that may yield better results when implemented. Taking these matters into consideration, the contribution of local experts knowledgeable in urban development and climate change adaptation cannot be understated in this regard.

Policymakers, development partners, and the civil society at large may also benefit from a deeper analysis of the proposed adaptation measures by non-partisan third parties. However, given how recently the NAP 2023-2050 has been published, the scope of independent research in appraising its planned projects in the urban landscape has been quite limited. This study aims to fill that gap by approaching local experts and stakeholders, and testing whether their needs and opinions are coherent with the results of the national policy.

1.4 Objectives of the Study

Broad Objective

Providing policymakers, development partners, and the civil society at large with a detailed appraisal of the proposed urban adaptation measures in the NAP 2023-2050.

Specific Objectives

This study wishes to measure adaptation measures under the NAP 2023-2050 against the opinions of experts and stakeholders in the urban development and climate change adaptation of Dhaka city using specific criteria both for prioritization and level of complexity. Therefore, the specific objectives of this study include –

1. Developing a ranking of proposed urban adaptation measures based on their priority and complexity to provide perspectives if faced with limited time or resources.

2. Providing a detailed perspective to policymakers for future climate change adaptation policies or revisions.

3. Increasing the knowledge and awareness of Dhaka City's civil society regarding climate change adaptation.

4. Providing a reference point for further research in appraising adaptation interventions

1.5 Limitations of the Study

Similar to most social science research, this study also faced a number of challenges during its operational period almost. Some of the major limitations are described below –

1. The NAP 2023-2050 mentions its plan to develop local adaptation plans at a later occasion, however, during the time of this research being conducted, no such local plan was publicly available and the Dhaka South and North City Corporations were uncooperative in providing any information regarding this issue. Therefore, the options identified can theoretically apply to all urban areas of Bangladesh. They are not localized to Dhaka. The availability of a Dhaka-based local adaptation plan in the future would allow for a more targeted study.
2. The NAP 2023-2050 failed to clarify on the cost of an individual activity under a particular intervention. Therefore, the activities identified could not be measured against their cost.
3. A large number of experts needed to be reached in order to score the adaptation options and develop a ranking. Many of these experts were high ranking officials in their respective organizations and, often at times, were not readily available to participate in a 60 minute interview. This introduced significant scheduling challenges and many experts were outright unresponsive as well.
4. During the interview, it was difficult to hold the patience of the high ranking experts. They would often generalize their answers and attach the same score to every criteria for an adaptation option. In order to avoid that, they were reminded on the definitions of the distinct criteria were repeated verbally and on the questionnaire script.

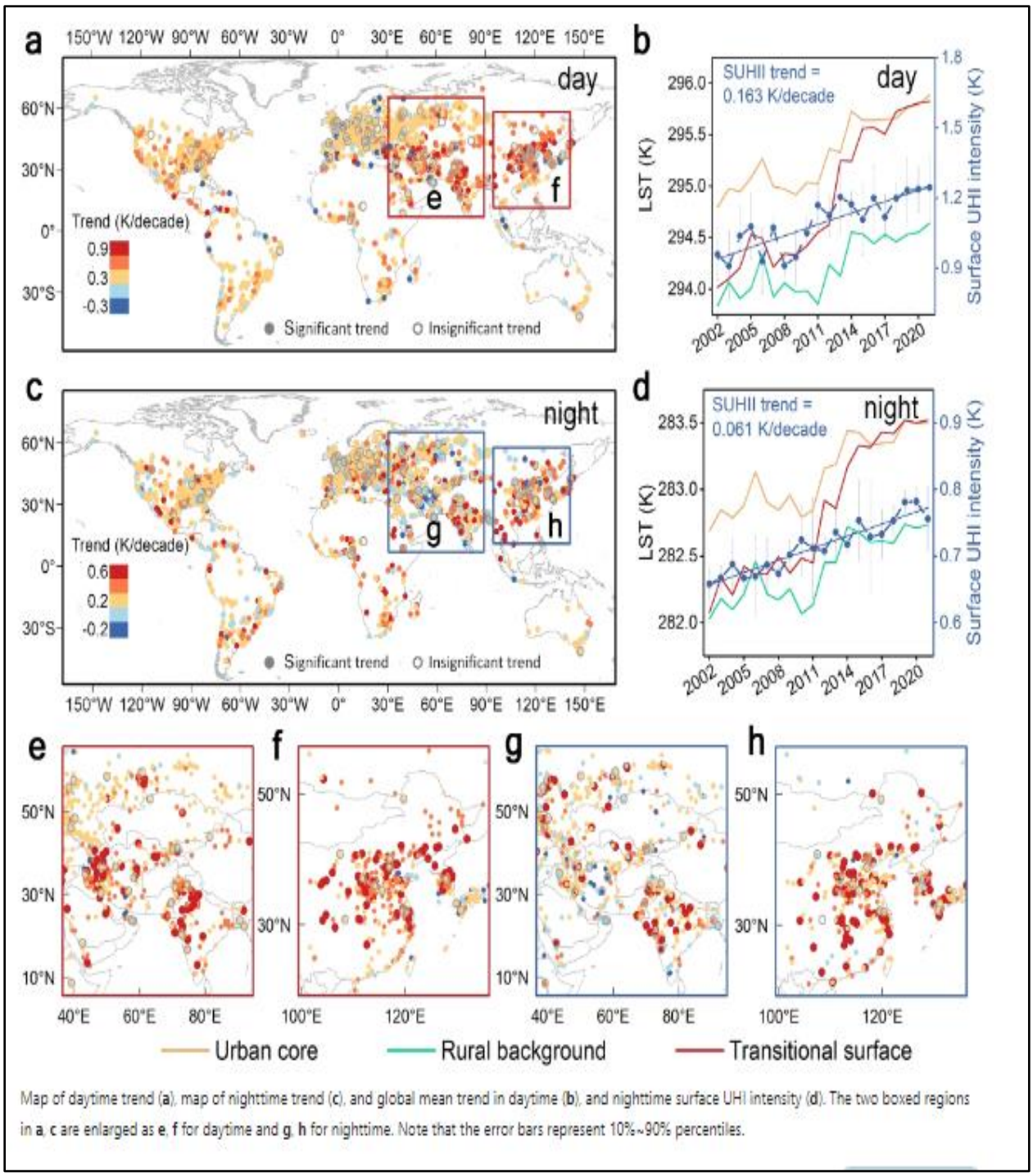
Chapter 2: Literature Review

2.0 Literature Review

2.1. Climate Change in the Urban Landscape

The recent decade has witnessed an unprecedented degree of deteriorating changes in the global urban climate, which has been predominantly exacerbated by man-made disasters and human endeavors. The effects of climate change are far-reaching and disproportionately impact developing countries (Haque et al., 2012). These nations face unique challenges due to their limited resources, social vulnerabilities, and geographical exposure. Climate change poses significant risks to developing countries, affecting their sustainable development, health, and well-being. Many developing countries are situated in low-latitude regions, such as Nigeria, Cambodia, Honduras, Bangladesh and many more. Due to geographic disadvantage, these countries often experience low precipitation and high temperatures, which aggravates water scarcity, affects agriculture, and impacts overall livelihoods (UNFCCC, 2007). Unfortunately, these nations have fewer financial, technological, and social resources; trammeling their capacity to implement effective mitigation and adaptation strategies.

The impacts of climate change are more evident in the metropolitan areas compared to the countryside. Urban areas, or metropolises, play a crucial role in this context. The majority of studies related to this topic primarily demonstrate the significant rise in urban temperatures. They show, for example, that urbanization has intensified global warming through urban heat island effect that emanates from the increased heat absorption by buildings, roads, and other infrastructure, leading to higher temperatures within cities (Tyagi et al., 2021). The mass migration from rural to urban areas further adds to the existing state of deterioration in the cities. Furthermore, urban areas serve as the hotspots for air pollution due to industrial activities, transportation, and higher levels of energy consumption. Consequently, pollutants like particulate matter (PM) impacts human health alongside influencing climate forcing and meteorological phenomena. *Figure 4* shows a comparison between global warming in urban and rural areas through statistical analysis of satellite land surface temperatures from 2002 to 2021 (Liu et al., 2022). The study concludes that the temperature of urban city clusters worldwide is currently 29% greater than their rural counterparts.



Map of daytime trend (**a**), map of nighttime trend (**c**), and global mean trend in daytime (**b**), and nighttime surface UHI intensity (**d**). The two boxed regions in **a**, **c** are enlarged as **e**, **f** for daytime and **g**, **h** for nighttime. Note that the error bars represent 10%~90% percentiles.

Figure 4: Global Warming Trends in Urban and Rural Areas from 2002 to 2021 (Liu et al., 2022)

2.2 Adaptation Options for Urban Landscapes

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as *"adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts."* Following adaptation options for urban landscapes is not just a choice — it is a necessity. By prioritizing resilience, health, equity, and sustainability, cities can thrive even in the face of climate uncertainty. As the cities around the world grapple with the impacts of climate change, implementing these strategies becomes crucial for a multitude of reasons.

Urban areas are particularly vulnerable to extreme weather events, rising temperatures, and sea level rise (Consalo, 2022). Adaptation measures enhance the ability to withstand and recover from these challenges. On the other hand, cities can adapt better to the changing scenario by incorporating green infrastructure, sustainable design, and climate-responsive planning. Besides, well-designed urban landscapes encourage physical activity, reduce stress, and enhance overall quality of life. Furthermore, green spaces, trees, and natural habitats improve air quality, reduce heat island effects, and promote physical and mental health (Alizadeh & Hitchmough, 2019). Hence, well-planned adaptation ensures equitable access to green spaces, clean air, and other benefits. To this end, European ministers of environment and health have committed to urgent actions to reduce the impact of climate change, improve air quality, and integrate nature and biodiversity considerations into health policies. The Budapest Declaration emphasizes the right to a clean, healthy, and sustainable environment for all (Jabbar et al., 2022).

Vulnerable communities often bear the brunt of climate impacts. Community engagement fosters resilience and empowers residents to actively participate in shaping their urban environment. Countries across Europe and central Asia have taken action to stop 1.4 million preventable deaths every year from climate change and pollution (WHO, 2023). By preserving and restoring natural areas, cities contribute to global conservation efforts. Native plant species and diverse ecosystems support local wildlife. Urban forests, wetlands, and green corridors provide habitat and promote biodiversity (Kowarik et al., 2019). As an added bonus, adaptation options can even create jobs in construction, landscaping, and maintenance (Agba et al., 2021). Energy-efficient buildings and water-saving practices reduce utility costs for residents and businesses.

Adaptation planning must always be context specific and a region's own environmental, climatic, social, and political conditions have to be considered (Swart & Raes, 2007). To incorporate

contextual aspects, involvement of local experts and stakeholders is recommended. Furthermore, specification of policy priorities for a particular context promotes successful implementation of adaptation plans (Bierbaum & Stults, 2013). Regarding operational adaptation measures, involving local stakeholders can contribute to effective priority setting. This study attempts to rank the adaptation options available and existing literature (Acharjee et al., 2020) have found that ranking of options in this manner ensures that the prioritization is done in the most effective way possible, while meeting all the requirements.

2.3 Urban Resilience and Sustainability Practices

Over half of humanity lives in urban settings, and this figure is projected to rise to be doubled by 2050 (Landrigan et al., 2022). The concepts of 'sustainability' and 'urban resilience' have been intertwined as a prerequisite for creating livable, adaptable, and environmentally conscious cities. In fact, urban resilience and sustainability are not separate goals; they intersect and reinforce each other (Alizadeh & Hitchmough, 2019). By integrating these principles, cities can thrive in the face of challenges while safeguarding the planet for generations to come.

Urban resilience has been defined as *"the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity (Meerow et al., 2016)."*

Sustainable urban landscapes contribute to global climate goals by reducing emissions, conserving resources, and enhancing resilience. Cities that adapt proactively are better positioned for the future. Hence, investing in resilient infrastructure now prevents costly retrofits in the future (Romero-Lankao et al., 2016).

Strong social networks, community cohesion, and inclusivity enhance resilience. In this regard, preparedness is key, which primarily includes early warning systems, emergency response plans, and community engagement followed by comprehensive risk assessment (such as floods, earthquakes, or pandemics) and strategic planning to mitigate them (Cvetković & Šišović, 2024). In addition, a robust infrastructure (transport, utilities, communication) ensures continuity during crises. So, climate-proofing infrastructure against extreme weather events can be considered vital.

These efforts may not mitigate all risks, but it can facilitate an equitable recovery following a disaster by virtue of empowering vulnerable populations (Tierney & Oliver-Smith, 2012).

Many studies show that diverse economies are more adaptable. Therefore, cities should foster innovation, entrepreneurship, and job creation as economic diversification reduces dependence on specific sectors (Duranton & Puga, 2001; Feldman & Audretsch, 1999). On a different note, protecting natural ecosystems (forests, wetlands, green spaces) contributes to resilience. That is why sustainable land use and conservation are essential to pave the way for a greener future.

Sustainability focuses on meeting present needs without compromising the ability of future generations to meet theirs. In 2024, cities are actively pursuing sustainable practices through green rooftops and walls, built by incorporating vegetation on buildings, which ultimately reduces energy consumption, improves air quality, and manages stormwater (Pineda-Martos & Calheiros, 2021). Needless to say, afforestation mitigates climate change and enhances well-being. Urban parks, green corridors, and native plantings enhance biodiversity. Cities are reclaiming unused spaces for community gardens and wildlife habitats. Sustainable cities prioritize social justice, affordable housing, and access to amenities for all (Chava & Newman, 2016). Inclusivity ensures a resilient and thriving urban fabric.

Buildings in metropolitan cities consume a significant portion of energy. So, sustainable design, efficient appliances, and renewable energy sources are crucial. Zero-carbon buildings are a priority. Keeping that in mind, cities are moving toward circular models, emphasizing recycling, reusing, and reducing waste (Maalouf & Agamuthu, 2023). Public transportation, cycling lanes, and pedestrian-friendly streets reduce congestion and emissions. Electric and shared vehicles play a role in sustainable mobility. Thus, sustainable consumption patterns promote resource conservation.

2.4 Adaptation Measures Globally

A global review conducted by the Grantham Research Institute on climate change and the environment reveals that a significant majority of countries have enacted laws and policies to address climate change adaptation (Michal Nachmany et al., 2019). The global review identified 658 national climate change adaptation laws and policies across 100 countries. These frameworks

guide adaptation efforts. At least 15 national funds direct finance toward adaptation activities, emphasizing the importance of financial support.

While many countries identify floods and droughts as major hazards, other impacts such as ocean acidification remain under-addressed. Framework laws and policies often include provisions related to adaptation plans, information generation, regulation, and early warning systems. Though a number of countries have set priorities for adaptation action, more complex solutions are largely missing. These include investing in physical and social infrastructure required to adapt to climate change (Schweikert et al., 2018). Other gaps involve enhanced investment in public goods beyond hazard early warning systems, explicit reference to building codes and land use planning, and incentives for adaptation.

Among the National Climate Change Policies, the Climate Change Act 2008 sets out a policy framework for reducing domestic emissions and ensuring adaptation to climate change. This policy enacted by the United Kingdom (UK) produces a Climate Change Risk Assessment to identify risks and follows it with a National Adaptation Programme every five years (Lorenzoni & Benson, 2014). Similarly, Nigeria's National Climate Change Policy focuses on mitigation and adaptation measures. It aims to enhance national capacity to adapt, raise climate-related science and technology, increase public awareness, and strengthen institutions for climate change governance (Onyimadu & Uche, 2021).

2.5 National Policies for Climate Change Adaptation

National policies for climate change adaptation have evolved significantly since the beginning of the 21st century. Governments worldwide have recognized the urgency of addressing climate change impacts and have developed various strategies to adapt to these challenges (Biesbroek et al., 2010). While progress has been made, addressing complex challenges and ensuring equitable adaptation remain critical priorities for all nations. The UN has been proactively launching initiatives to motivate its member states to contribute to environmental preservation and enhance climatic conditions for more than five decades (Sethi & Schepers, 2014). It has been playing a key role in shaping international action to protect our environment and mitigate climate change. Some of the remarkable initiatives taken by the agencies under UN in this regard are shown in *table 1*.

Table 1: Role of UN Agencies in Environmental Preservation and Climate Improvement (N. Islam, 2012)

Organization	Specific Initiatives
FAO	➢ Provides technical advice and assistance ➢ Advises government on agriculture policy ➢ Provides forum to discuss food and agriculture issues ➢ Implements commitment to Agenda 21
UNCHS	➢ Localizing Agenda 21
UNCTAD	➢ Analyzes the impact of commodity production and processing on the environment
UNESCO	➢ Man and Biosphere Programme in 1971 ➢ International Geological Correlation Programmes (launched in 1972) ➢ International Hydrological Programmes ➢ Intergovernmental Oceanographic Commission
UNIDO	➢ Formulates environment policy ➢ Provides help in case of environmental conventions
WFP	➢ Different projects related to the protection and improvement of the environment

UNITAR	➢ Builds capacity for the application of international legal agreements and conventions ➢ Conducts training on the Environmental Laws
UNDP	➢ Assists countries in realizing the goals of Agenda 21 ➢ Formulates national country program ➢ Builds institutional capacity
UNEP	➢ Coordinates environmental conventions activities ➢ Develops policy instrument ➢ Develops and implements environmental policy and law ➢ Increases the capacity of government to use environmental information for decision making ➢ Prepares action plan for sustainable development ➢ Coordinates Global Environmental Facility

The first and foremost thing worth mentioning regarding the state initiatives for tackling climate change is the insertion of Article 18A to the Constitution as per the Fifteenth Amendment (Act XIV of 2011), section 12. The second one is the establishment of the Ministry of Environment and Forest and Climate Change (MoEFCC), which is responsible for discussing, planning and developing policy and programmes on climate change issues in the government system as demonstrated in *table 2* and *figure 5*.

Table 2: Policies Developed by the Government of Bangladesh (GoB) Regarding Environment, Climate Change, and Disaster Management

Programme/ Policy/ Strategy	**Year**	**Brief Description**
National Conservation Strategy (NCS)	1991	Identifies different issues, suggests strategies for sustainable development and gives recommendations for implementation.
Environment Policy	1992	Provides guidelines for ensuring sustainable development in Bangladesh by incorporating 15 sectors.
National Environmental Council (NEC)	1992	Established just before the Rio Conference to review implementation of the National Environmental Policy and to take necessary actions for resolving plausible environmental issues Bangladesh may face
National Environmental Management Action Plan (NEMAP)	1995	Embodies the first people's participatory bottom up environmental planning exercise in the world.
Climate Change Cell (CCC)	2004	Established under the Comprehensive Disaster Management Program (CDMP) to

		provides the central focus for the governments' climate change related work.
Bangladesh Climate Change Strategy and Action Plan (BCCSAP)	2009	Formulated through a fully counseling process including government, development partners and civil society as the outcome of COP-13.
Climate Change Unit (CCU)	2010	Established under MoEF with national level experts to implement projects in vulnerable areas.
Bangladesh Climate Change Trust Fund (BCCTF)	2010	Established through the passage of the Climate Change Trust Act, 2010. It is a government trust that utilizes funds to take action against problems caused by climate change and to implement and evaluate climate change mitigation projects.
Bangladesh Climate Change Resilience Fund (BCCRF)	2010	A multi-donor trust fund (MDTF), to gather and distribute climate adaptation funding for Bangladesh through World Bank
Climate Change And Gender Action Plan (ccGAP)	2013	Prepared with an aim to ensure gender equality into climate change related policies, strategies and interventions.

Intended Nationally Determined Contributions (INDC)	2015	Sets out a number of mitigation actions that will help limit the country's GHG emissions.
National Adaptation Programme of Action (NAPA)		A plan prepared by the MoEF as a report to the COP of the UNFCCC which recites the country's most vital and instant needs to acclimatize to climate change
National Planning for Disaster Management (NPDM)		Five-year long comprehensive risk reduction culture plan with emphasis on capacity strengthening. The first plan was constituted for the term 2010-15 and the second one for 2016-20.
Bangladesh Delta Plan, 2100		A strategic and comprehensive planning document integrating all the individual sectoral plans that covers the longest period (50-100 years) and also one that identifies and prioritizes investable sectors for action to reduce climate risk and environmental losses in the delta region. It has provision for addition and amendments as and when new information becomes available.

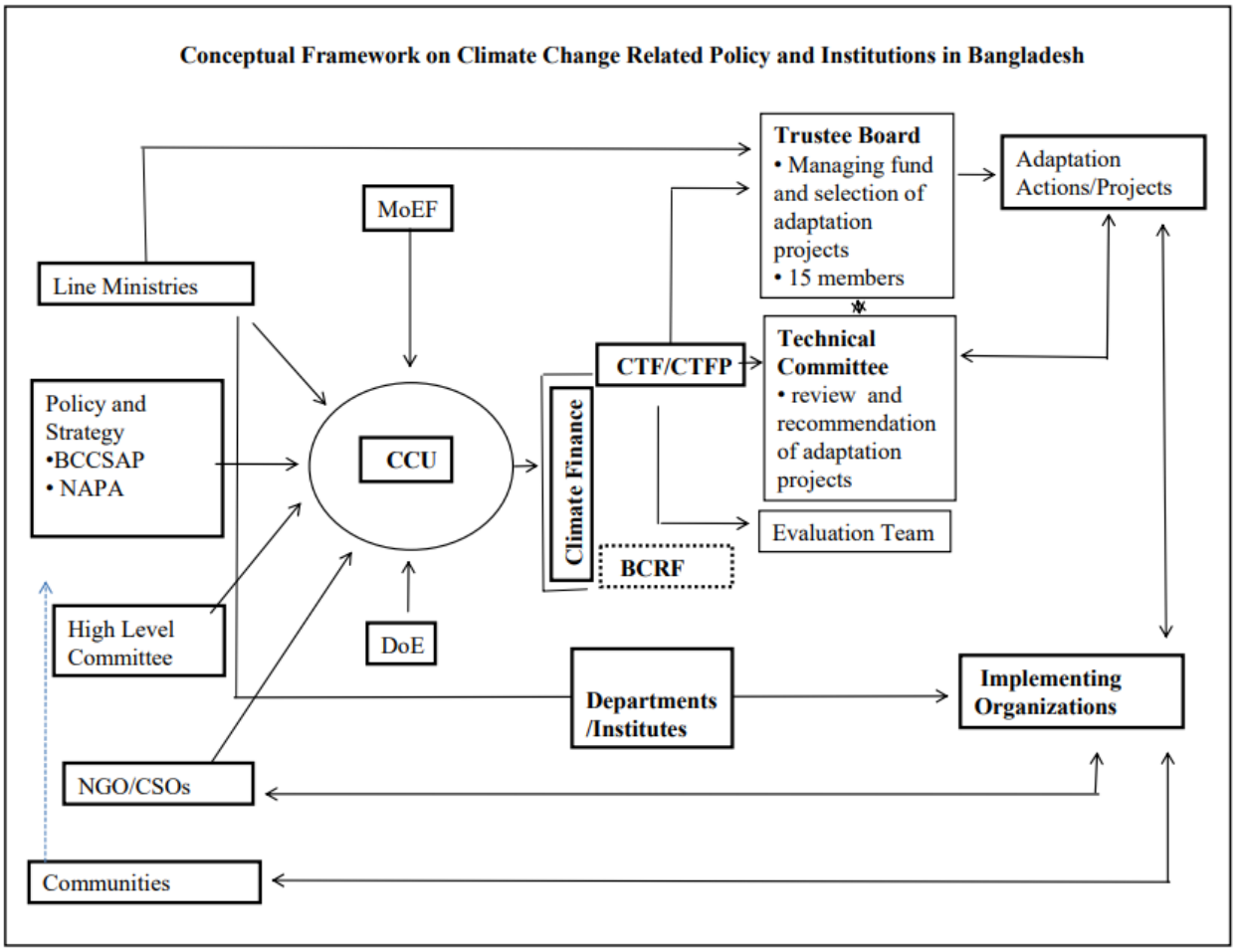


Figure 5: Conceptual Framework on Climate Change related Policy and Institutions in Bangladesh (Huq & Rabbani, 2011)

Even during the pandemic, the government had allocated Tk 24,225.7 crore (7.5% of the total budget) to 25 ministries for preventing the adverse impacts of climate-induced hazards, and for adaptation. According to the Finance Ministry's report, among the thematic areas across Bangladesh Climate Change Strategy and Action Plan (BCCAP), 41.25% has been allocated for food security, social protection, and health; 26% for infrastructure; 16.53% for mitigation and low-carbon development; 7.47% for comprehensive disaster management; 5.23% for capacity building and institutional strengthening, and 3.50% for research and knowledge management in the climate budget.

Among the international treaties, it is worth mentioning that Bangladesh signed the Paris Agreement in 2015. The Paris Agreement is a landmark accord within the UNFCCC. It was adopted by 195 nations including Bangladesh with the aim to address climate change and its negative impacts. Bangladesh, as a signatory, submitted its climate action plan ahead of the agreement's adoption, showcasing its commitment to sustainable development and reducing greenhouse gas emissions. The country's involvement is particularly significant given its vulnerability to climate-related disasters and its status as a developing nation (Toufique & Islam, 2014). By ratifying the Paris Agreement, Bangladesh has pledged to undertake adaptation and mitigation activities to contribute to the global effort of limiting the temperature increase to below 2 degrees Celsius above pre-industrial levels. This commitment is crucial for Bangladesh, as it seeks international support and access to climate finance to implement its climate resilience strategies and protect its population from the adverse effects of climate change.

As a country highly vulnerable to climate change, Bangladesh ranks seventh on the World Climate Risk Index 2021. Despite contributing only a small share of global emissions, it faces climate-induced natural disasters due to its geographic location and flat, low-lying topography. High population density, poverty, and reliance on climate-sensitive sectors such as water resources, agriculture, fisheries, and livestock — further increase its vulnerability (Hadi, 2019). With the aim of improving this situation and curving a viable path toward climate-resilient development, reducing climate risks and vulnerabilities through effective adaptation strategies, the GoB devised the NAP (2023-2050) in October of 2022. The plan focuses on eight key sectors and thematic issues: water resources, disaster management, social safety, agriculture, fisheries, aquaculture, livestock, urban areas, ecosystems, wetlands, biodiversity, policies, institutions, and capacity development (MoEFCC, 2022).

The Plan has been discussed in detail being organized into five chapters. The first chapter sets the context and highlights past efforts towards climate resilience. It also lays down the Plans, Vision, and Goals to be achieved. The second chapter talks about the historical climate trends and the future climate risks and vulnerabilities. The third chapter discusses the entry points for adaptation in various sectors including water resources, agriculture, fisheries, aquaculture, and livestock. It further identifies adaptation preferences and strategies under the 8 identified sectors addressing

adaptation needs for three different time periods, namely short-(2030s), medium-(2041) and long-term (2050s).

The fourth chapter emphasizes the necessity of a well-organized, inclusive and active institutional setup for smooth implementation and identifies action points for policies and regulations; institutional arrangements and coordination; private sector engagement; financing strategies; capacity development; technology transfer; data and knowledge management; gender, disability, youth and social inclusion. The fifth and the final chapter lays down the M&E framework which involves a three-fold system to monitor, evaluate and report adaptation progress (MoEFCC, 2022). These are:

Tier 1: Strategy and policy level M&E;
Tier 2: Planning level M&E;
Tier 3: Programme or project level M&E.

2.6 Climate Change and Dhaka City

Dhaka, the bustling capital of Bangladesh, has been burdened with successive climate-based challenges from gavel to gavel from the very beginning of this century. Dhaka is experiencing rising temperatures due to climate change, coupled with waste heat from vehicles and buildings. The city's extensive concrete surfaces, dark impervious materials, and lack of vegetation contribute to the urban heat island effect, making it even hotter (Varricchione et al., 2024).

According to a newspaper article published in the popular daily 'Dhaka Tribune' in February of 2023, Dhaka is among the top 10% of global cities at risk from climate change and extreme weather. The article mentioned about a report published by the XDI (The Cross Dependency Initiative), a world-leading independent physical climate risk analysis company, which has ranked Dhaka as 101st based on aggregated damage ratio and 236th in the rank based on the average damage ratio (Cross Dependency Initiative, 2023). As per the report, Dhaka falls into the Asia region that experienced the greatest escalation in damage from 1990 to 2050 anywhere in the world. Cyclones, floods, and other natural disasters pose significant threats to the city's population and infrastructure. On that account, adaptation to climate change in Dhaka is an urgent concern. The city's urban governance is complex, but it is crucial to ensure that adaptation efforts are not hindered by politics or top-down approaches.

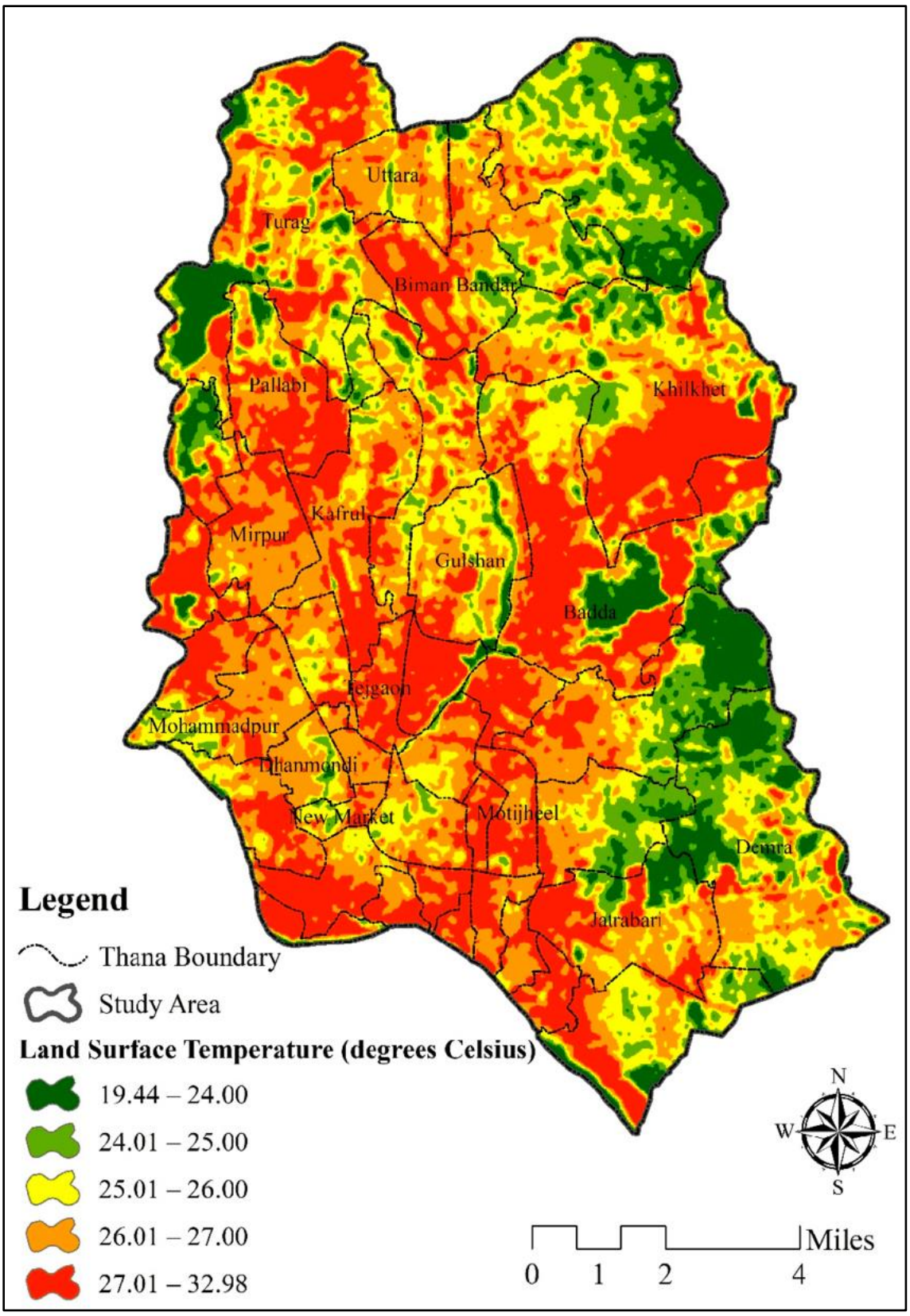


Figure 6: Land surface temperature map of Dhaka Metropolitan Area (Abrar et al., 2022)

Human-induced climate change has significantly increased the likelihood and intensity of humid heat events in Dhaka, which has been reflected by the *figure 6*. These extreme heat conditions impact public health, especially vulnerable groups. Therefore, Dhaka faces a critical need for climate resilience and adaptation measures to protect its residents and enhance its urban environment. However, no study has been conducted so far to determine the ranking of the adaptation options identified in the NAP 2023-2050. So, this paper tried to uncover that missing puzzle piece to assist policy makers at critical moments of crisis.

2.7 Project Prioritization

With the increasing use of resources and continuous degradation of the climatic conditions, there is a pressing need to select projects wisely for climate change mitigation and adaptation. Previous literature in this realm has largely focused on the prioritization and evaluation of flood protection measures in Dhaka city or in other parts of Bangladesh (Acharjee et al., 2020; Haque et al., 2012). Others like Kabir et al. (2018) have rather focused on assessing disaster resilience in Dhaka North using the UDRI model (Kabir et al., 2018).

According to Brooks et al. (2009), multicriteria analysis (MCA) has been defined as, 'any structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives' (Brooks et al., 2009). Since environmental problems are inherently complex, uncertain and multiple scales are involved, and have their impacts on different ranges of people and organizations (Haque, 2016). Therefore, it is imperative that the assessment of climate adaptation measures should be of participatory nature which involves stakeholders from every level in the decision making process.

The UN endorses the multicriteria analysis (MCA) method as the preferred method for assessing adaptation options and policies. The MCA fulfills all the assumptions stipulated by the United Nations Framework Convention for Climate Change for evaluating climate adaptation measures (UNFCCC, 2002). These assumptions are given as follows:

i. Diverse criteria and indicators have to be taken into account;

ii. In many cases, it is not possible to evaluate climate change costs in monetary terms;

iii. Often there is a lack of data to conduct cost benefit analysis (CBA) or cost effectiveness analysis (CEA);

iv. The perspectives of local people must be considered as they are the most affected;

v. The adaptation responses, which have been assessed based on participation of all the relevant stakeholders in the decision making, are most acceptable.

Multi-criteria analysis approach has been deployed for evaluating the adaptation measures in many impactful studies. Haque et al. (2012) has cited real-life examples of successful application of MCA method all over the globe; ranking of climate change adaptation options for the Netherlands (De Bruin et al., 2009), urban flood risk assessment in Germany (Kubal et al., 2009), decision making process for policy planning in Canada (Qin et al., 2008), assessing flood risks and identify flood vulnerable areas by incorporating geographic information systems or GIS in Nigeria (Shuaibu et al., 2022) and so on.

These criteria can be both quantitative and qualitative. Thus, it can accommodate both types without being restricted like Cost Benefit Analysis or Cost Effectiveness Analysis. Moreover, it allows a participatory process for the assessment, i.e., all the stakeholders can participate at different stages of assessment. All things considered, this study has attempted to assess projects under the newly devised National Adaptation Plan 2023-2050 under the scope of an MCA.

Chapter 3: Theoretical and Conceptual Framework

3.0 Theoretical and Conceptual Framework

3.1. Theoretical Framework

Theoretical frameworks are an integral part of research as they help to support theories of the study. These theories explicate the importance of the research. Theories that are relevant to this study are as follows:

I. Theories on climate change policy
II. Eco-city theory
III. Sustainable urban development theory
IV. Theories on community-based adaptation

3.1.1. Theories on Climate Change Policy

While the need for effective solutions in both local and global climate policies is unquestionable, the collective pool of knowledge in this regard can often prove to be quite limited. It is optimistic that most countries appear to agree with the level of threat pose by anthropogenic climate change on both the environment and the economy. The Pew Research Center carried out a survey to measure global attitudes in regard to climate change and found that every 8 out of 10 countries view climate change as a significant and irreversible issue. These countries also appear keen on devising effective policies towards climate action that also consider the urgency of the matter (Moira Fagan & Christine Huang, 2019).

Since the field of climate change policy is so complicated, many different theories may be used to explain why strong climate policies are occasionally but not always implemented. The literature on energy policy (particularly those on renewable energy and energy efficiency), air pollution, and explicit climate change mitigation policies are all pertinent. So are those on environmental policy and results. While the literature on explicit climate policy making is most directly relevant to the research, the most developed of these literatures are those on environmental policy and environmental outcomes, providing a full set of causative elements.

The possible impacts of climate change policies are just as severe as climate change itself. For analysts to assist governments in making informed policy decisions to address these problems, carefully considering the goals of climate change policies is the quintessential first step. The theoretical framework for comparative study of climate change policy proposed by Keeney and McDaniels has been demonstrated in *figure 7* The paradigm emphasizes learning over time as a core priority and acknowledges that typical policy analysis is limited in its capacity to foresee long-term outcomes, partly because of route dependance. The framework focuses on the goals that are important for climate change policy in the near future (e.g., the next 20 years). A mix of core goals for the near term and proxy goals for describing the status of the climate problem and the capacity to address it at the end of that period is recommended for planning and assessing existing climate policy choices. The framework aims to offer a foundation for policy analysis that specifically takes into account the advantages of learning over time to enhance policies related to climate change.

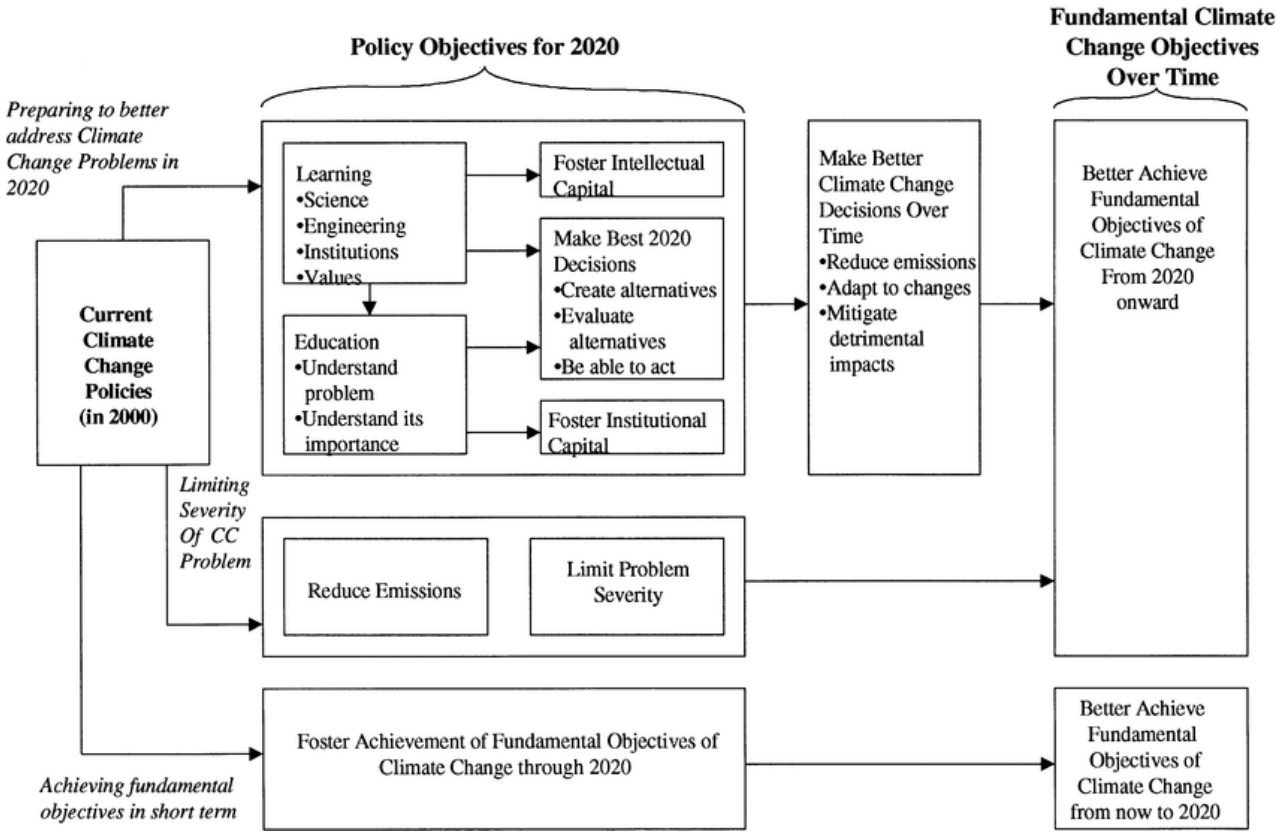


Figure 7: Schematic of a practical model for climate change policy choices (Keeney & McDaniels, 2001)

3.1.2. Eco-City Theory

In the wake of the industrial revolution, the labor force and the surrounding human population were forced into unbearable condition of living, safety, and health. This inspired concepts like the "eco-city" in response in the post-industrial revolution era. In the following decades, this concept matured further in the North American and Western Europe states, and took on five different forms that, in essence, remain true to the same principles, while adding on to its predecessor (Nan Zhou & Christopher Williams, 2013). These forms of the eco-city theory have been discussed below in a chronological manner:

1. Integrating an agrarian settlement mode into city-like settlements to increase health and reduce social discord related to poverty;
2. Protecting human and local environmental and ecosystem health;
3. Protecting global environmental health;
4. Integrating broad concepts of social health, such as economic and social equity;
5. Incorporating climate change resilience and technological advances.

This evolution has yielded a variety of notions, many of which, despite disagreements over the specifics of each or the order of importance of methods to be followed, have been included by proponents into eco-city theory. Generally speaking, an eco-city should include policies, programs, technologies, and operational strategies to improve all facets of the environment, society, and economy. More specifically, these objectives should be primarily achieved through conservation of natural resources, decreased use of fossil fuels, increased density and decreased automobile use, decreased and recycled waste streams, integration of nature into cities, economic shift toward the service sector and the creation of high-value added technologies, construction of diverse spaces that benefit all population subgroups, and aggressive outreach to encourage community involvement in city improvement initiatives (Wong & Yuen, 2011). While there are differences in the concept of an eco-city, during the past 20 years, systems for assessing eco-city success have shifted from depending on qualitative principles to using quantitative performance measures.

Eco-cities can act as experimental grounds for innovative policies that can build the socioeconomic conditions of a community while also pertaining to the principles of environmental protection, health, and climate change. This, as a result, has attracted several countries across the globe to the concept and continues to do so. Numerous eco-city concepts are primarily built on adhering to the

principles of urban ecology or fusing the tactics of smart city solutions with sustainable city strategies. Data-driven smart eco-cities and sustainable integrated districts are the most well-known of these approaches (Bibri, 2021). In light of the recent paradigm shift in science and technology brought about by big data science and analytics, the latter model depicts the extraordinary transformational transformations the eco-city is presently undergoing. This is driven by the increasing demand to address the issues related to eco-cities and their techniques and practices for planning, development, and governance.

There are many models of the eco-city, which can be categorized into three types:

1. Emphasizes passive solar design
2. Combines passive solar design and greening
3. Focuses on green energy technologies and/or smart energy and environmental technologies

Classification of these three types of models have been shown in *table 3.* The examples listed in 'Type 3' signify smart eco-cities which adhere to the innovative ideas of urban development being devised today, promoting green technology and net-zero emission practices.

Table 3: Types of Eco-City Models (Bibri, 2021)

Type 1	Type 2	Type 3
• Eco-village	• Eco-city	• Symbiotic city
• Solar city	• Eco-district	• Carbon neutral city
• Solar village	• Environmental city	• Zero energy city
• Cohousing	• Green city	• Zero carbon city
• Sustainable housing	• Garden city	• Net zero carbon community
	• Sustainable neighborhood	• Low carbon city
	• Sustainable community	• Energy efficient city
	• Sustainable urban living	• Ubiquitous eco-city
	• Living machines	• Smart eco-city
	• Techno-city	• Data-driven smart eco-city
	• New town	

3.1.3. Theories on Sustainable Urban Development

Sustainability has been the focus of development discussions for the past several decades, with quality of life being discussed as a right that even applies to vulnerable people. Thus, advocating a more holistic approach to urban development. Though complete indices to score or quantify the sustainability of urban agglomerations have only recently been produced, theories related to sustainable urbanism have been evolving over the past twenty years or so (Khalil, 2012).

According to the Circles of Sustainability concept, resilience, livability, adaptation, innovation, and reconciliation are among the fundamental requirements of a healthy social life that sustainability intersects with. When sustainability is viewed in this broader perspective, it challenges both the traditional propensity for sustainability to be seen as an end in and of itself, and the search for a new terminology to replace it, such as resilience.

Figure 8 signifies the "Circle of Sustainability", which can be praised for its simplistic nature in viewing sustainable urban development. The figure is separated into four domains; economics, politics, culture, and environment. These parts further divide into 7 sub-domains as seen in the figure. Each quadrant of the circle represents the four domains and the sections within each quadrant represent the sub-domains. These elements are then assessed based on the nine-point-scale shown in the middle, with the first and best option being 'vibrant sustainability', and the ninth and relatively worst option being 'critical sustainability'. The simple color gradient transitioning from green to red for each of the domain and sub-domains can provide a quick snapshot of a city's condition in terms of sustainability.

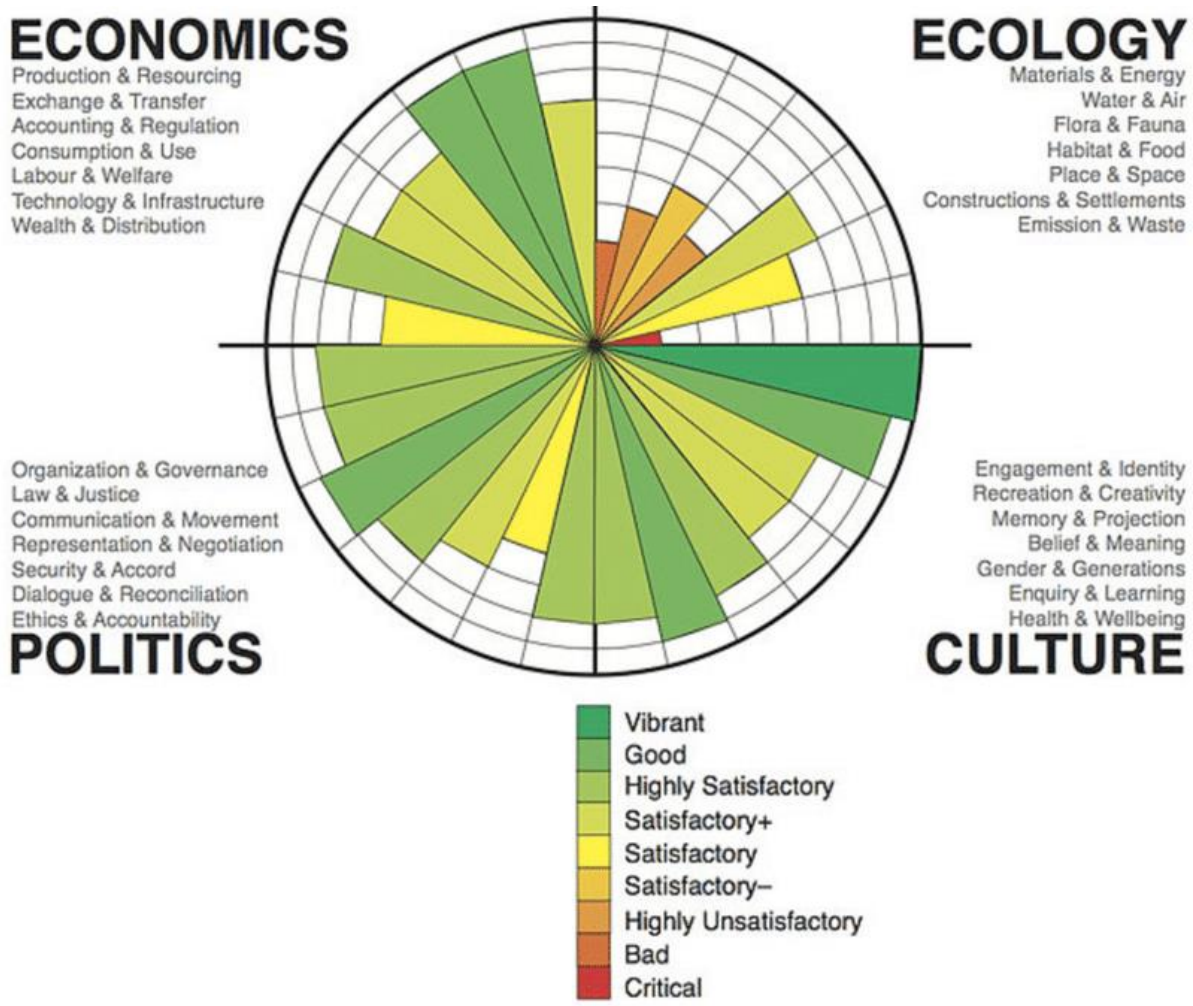


Figure 8: Circles of Sustainability: Urban Profile Process (James, 2015)

3.1.4. Theories on Community-based Adaptation

The effects of climate change are unevenly distributed and pose substantial hazards to survival and wellbeing due to bio-geophysical variables, demographic vulnerabilities, and other reasons. Everyone is vulnerable to the effects of shifting weather patterns, changes in the frequency and geographic distribution of climate-sensitive health outcomes, and other factors, although certain groups and geographic areas are more susceptible than others. Vulnerable populations that include the elderly, pregnant women and children, persons with chronic medical illnesses, people with mobility and cognitive limitations, and the impoverished in both urban and rural areas are disproportionately represented by low-income communities and communities of color.

Collaboration between these groups and other pertinent stakeholders in the design and implementation of public health programs enhances acceptance of the intervention by the community and individuals, as well as lowering barriers to its success (Ebi, 2009). Community resilience to climate change and other stressors is enhanced by community-based adaptations that address the sociological, cultural, environmental, political, and economic settings that increase susceptibility. These adaptations have several advantages. There are several chances to improve the present initiatives to address the hazards of climate change rather than developing new ones for community-based adaptation.

Ebi (2009) developed a framework for enabling community-based adaptation to the health impacts of climate change as demonstrated in *figure 9.* This model consists of eight steps where each step is designed to enhance components of social capital. Ideally, individuals, communities, and government would collaborate to guarantee that adaptation efforts receive the greatest amount of support. The complex nature of climate change concerns necessitates addressing them at multiple scales, with communities being the most effective place to implement many of the solutions. It is crucial that social justice concerns be taken into account when developing and implementing climate-oriented initiatives, as the poor and disadvantaged populations are most vulnerable to the effects of climate change.

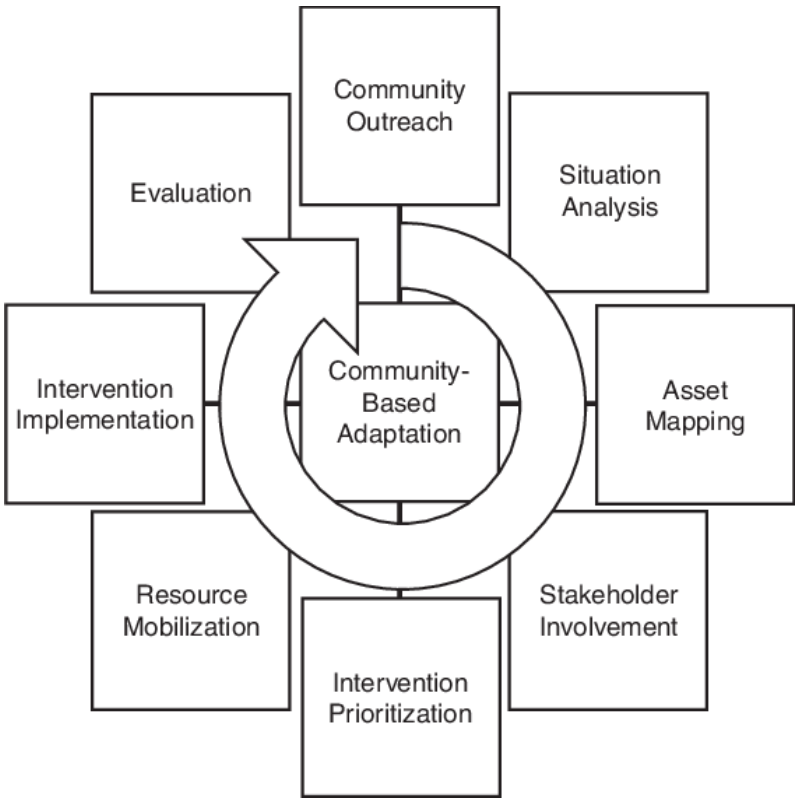


Figure 9: Framework for Community-based Adaptation (Ebi, 2009)

3.2. Conceptual Framework

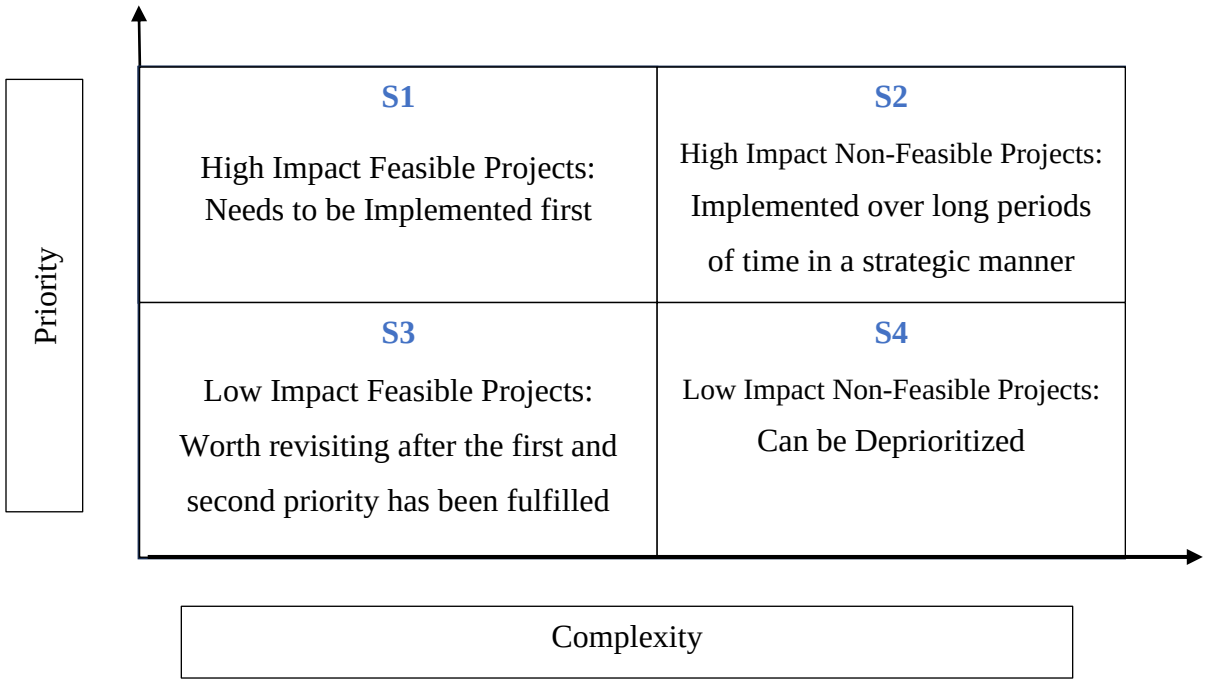


Figure 10: Priority/Complexity Matrix for Prioritizing Adaptation Options

Prioritizing urban adaptation options properly is extremely crucial for navigating the current climate challenges. In the face of escalating climate change impacts, urban areas are increasingly vulnerable to a range of environmental stresses. Therefore, prioritization of the urban adaptation options has become a critical task for policymakers and urban planners who aim to enhance the resilience of cities. The added pressure of time and budget constraints makes the decision making process even more difficult and stresses the significance of prioritizing urban adaptation strategies effectively to mitigate climate risks. And the already degraded state of Dhaka city leaves even less room for any kind of delay or errors. So, this study has been designed to help the policymakers decide which adaptation options under the newly devised NAP 2023-2050 need to be implemented first. The Ministry of Environment, Forest, and Climate Change formulated the latest national adaptation strategy for the People's Republic of Bangladesh in October, 2022 (MoEFCC, 2022). The adaptation options pertinent to Dhaka metropolitan have been assessed by the academicians and development practitioners. They have scored the adaptation options based on their complexity and priority level. On the basis of this scoring, it will be possible to realize the extent of urgency for implementation of the adaptation options.

Figure 10 shows the conceptual framework of this study, which essentially depicts a priority-complexity matrix. Priority has been taken along the Y-axis and Complexity along the X-axis. S1, S2, S3 and S4 refers to the four different types of priority-complexity combinations. For S1 where priority is high but and complexity is low, those will be considered as first priority project and should be implemented first, which would not be difficult given the feasible nature of the project. For S2, both priority and complexity are high. Thus, implementation would be crucial and challenging simultaneously. So, they can be considered as second priority projects that needs to be handles strategically. S3 signifies low complexity and low priority projects. Hence, they can be considered third level priority in terms of implementation since they are low- impact with high feasibility. They can be implemented on an ad-hoc basis. Lastly, S4 represents low priority projects with high complexity. Due to low impact nature of the projects, they can easily be overlooked since implementing them would be render unnecessary complications.

Thus, the conceptual framework of the study would be a great help to narrow down the necessary adaptation options' and remove the 'excess fat' so that the policymakers can concentrate on the core matters for developing resilience in the Dhaka metropolitan.

Chapter 4: Methodology

4.0 Methodology

4.1 Research Design

This study follows a methodological approach commonly regarded as the Multi-Criteria Analysis (MCA) or Multi-Criteria Decision Analysis (MCDA). The MCA can utilize both qualitative and quantitative data. However, in this study, the criteria are measured using expert opinions through key-informant interviews. Therefore, it can be suggested that the study is mostly qualitative in nature. The expert opinion is, however, described numerically and the final priority and complexity scores derived to establish a ranking was also done in a numeric fashion.

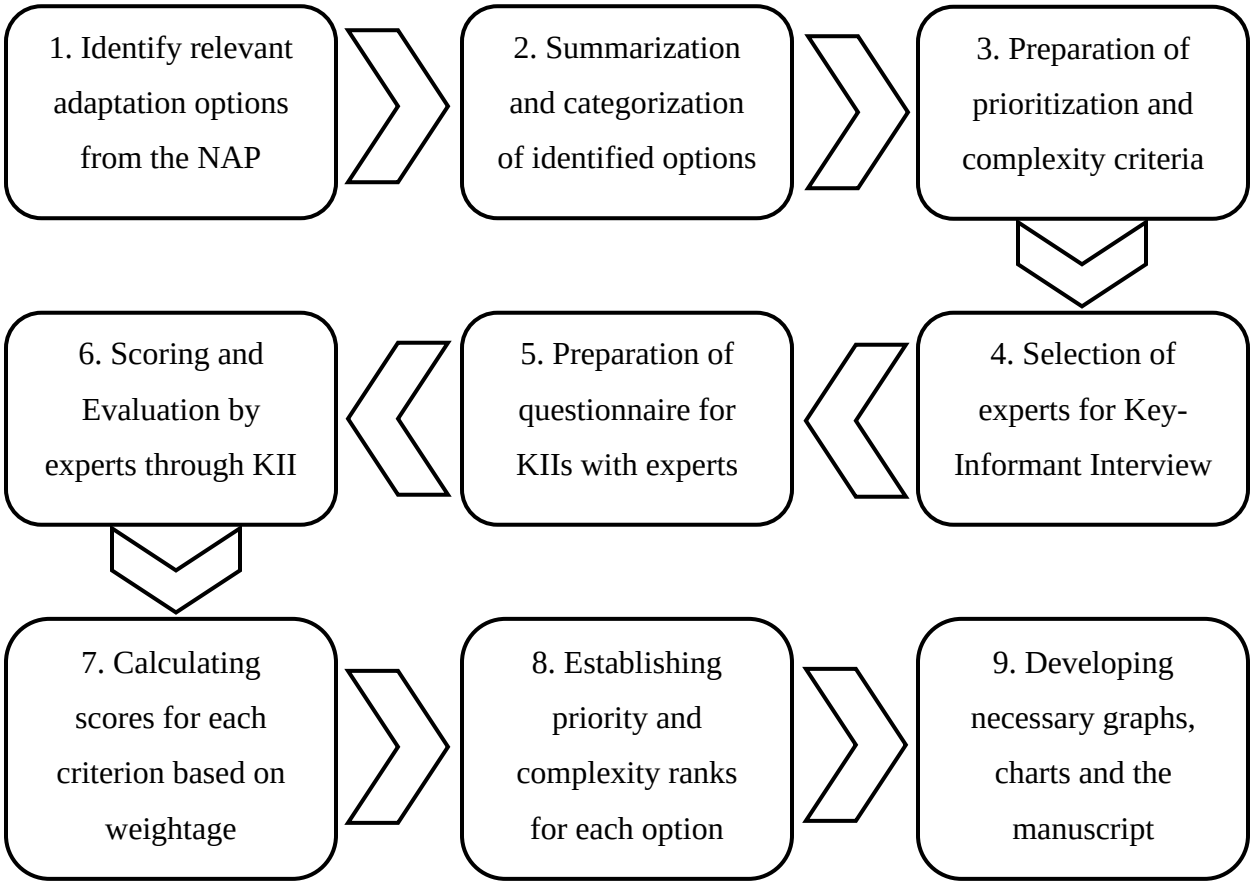


Figure 11: Methodological steps followed in this study

Figure 11 accurately displays the steps that were followed in this study. Adaptation options were first selected based on their relevance with urban development. The selected options were then carefully summarized and categorized. In the next step, 4 criteria were developed for prioritization and 3 for complexity. Experts (sample) were then identified for key-informant interviews using a

mix of purposive method and snowball method. Afterwards, a proper questionnaire was developed with the summarized options and criteria. Using this questionnaire, experts were able to attach scores to each adaptation option for each criteria on a scale of 1 – 5. They further attached weightages to the criteria they are judging the options on, all of which was later calculated to establish priority and complexity rankings for each option. And finally, using the final results, the complete manuscript was developed along with the necessary graphs and charts.

4.2 Identification of Adaptation Options

The adaptation activities chosen for this study are all a part of the NAP 2023 – 2050. The policy consists of 113 interventions in total spread across 11 stress areas, each intervention having a number of activities planned. The stress areas include *South-western coastal area and Sundarbans (SWM), Chattogram Hill Tracts (CHT), Drought Prone and Barind Area (DBA),* etc. However, as our study primarily focuses on Dhaka, which is an urban area, only the interventions that included the *Urban Areas (URB)* stress area signature were considered. Applying this exclusion criteria, the study became focused on 12 out of the 113 total interventions (Appendix 1), which boasted a total of 86 adaptation activities between them (Appendix 2). In order to avoid repetition and ambiguity, as is often prevalent in national policies, the 86 activities were abridged to a list of 47 activities, and the 12 intervention areas were abridged to a total of 7 themes. These 7 themes include –

1. Drainage and Waste Management
2. Green and Blue Infrastructure Development
3. Capacity Building through Planning and Implementation
4. Inclusive and Advanced WASH technologies
5. Youth Development and Well-being
6. Private Sector Engagement through Eco-friendly Interventions
7. Climate Resilient Healthcare Facilities (HCF)

The distribution of adaptation options between these 7 categories are detailed in *figure 12*, and the final list of 47 identified adaptation options belonging to the 7 individual categories are available in *Appendix 3*.

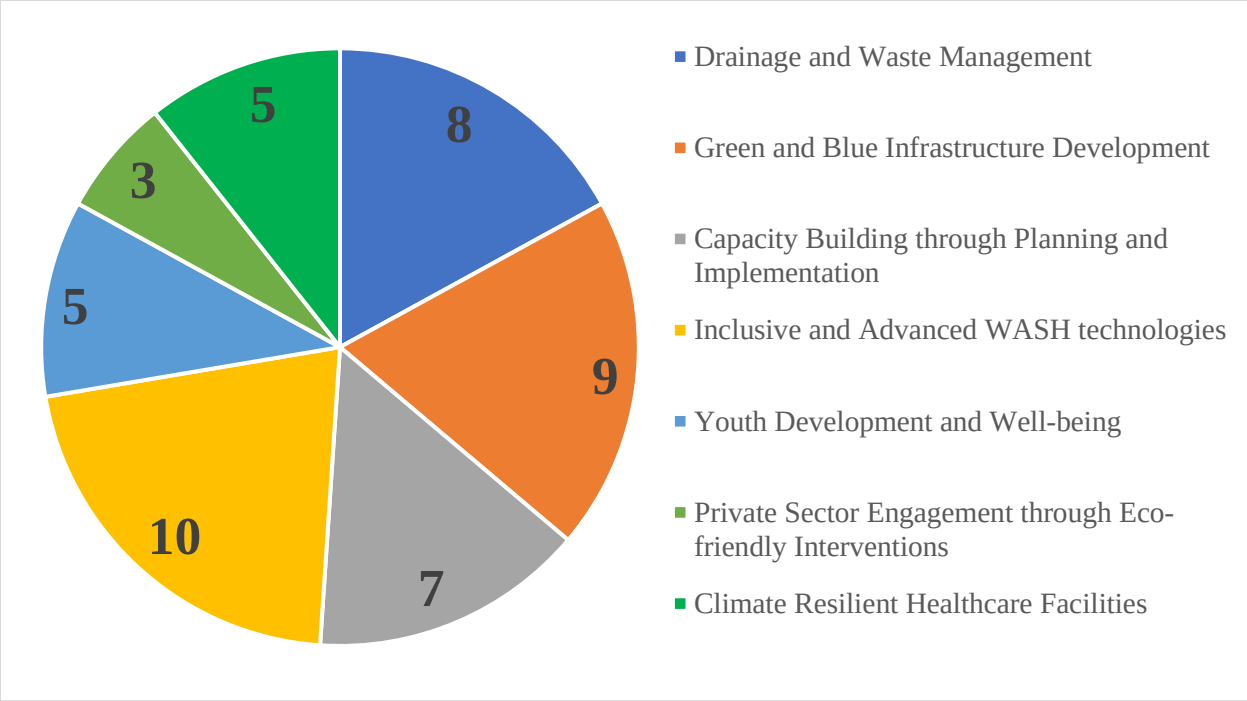


Figure 12: Category-wise distribution of adaptation options (Frequency)

4.3 Study Area

As this study is purely based on expert opinions, there was no exact location targeted. However, it is clear that the study only focuses on the urban adaptation options devised in the NAP 2023-2050. The policy does indicate to the fact that local adaptation plans are also being devised, no such localised plan could be found in the public domain. That being said, although the 47 selected options can refer to any urban location in Bangladesh, as our selected experts are mostly from Dhaka, and specialise within this area, our selected study area can also be identified as Dhaka city or metropolitan. *Figure 13* accurately displays the bounds of the study area, which lies in the heart of the country, nestled within a number of waterbodies, most prominently the Buriganga, Shitalakshya, and Turag rivers.

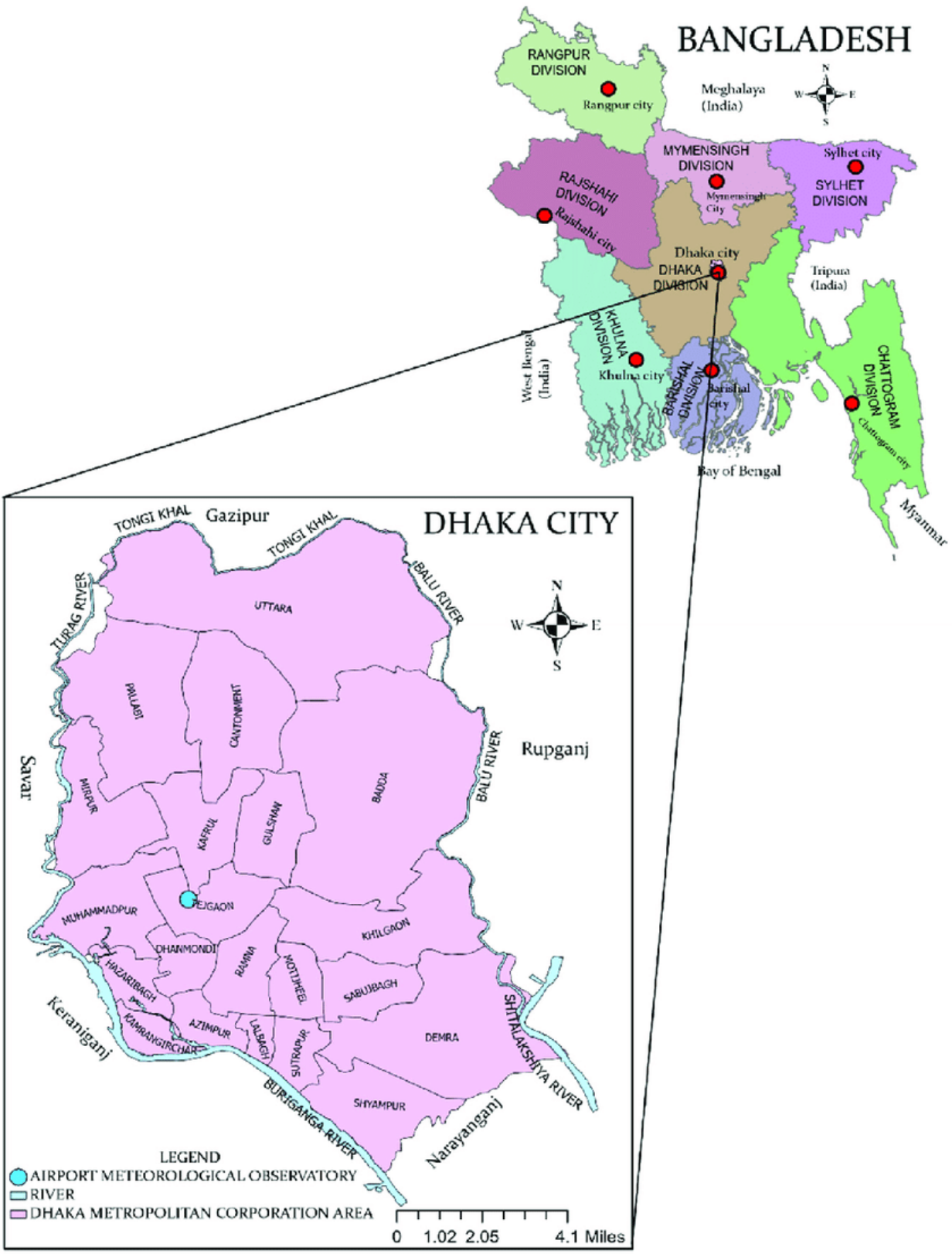


Figure 13: Study Area; Dhaka Metropolitan (S. Islam et al., 2021)

4.4 Selection of Experts and Stakeholders

The experts and stakeholders selected for this study, and therefore, the sample units, were all selected through a mix of purposive sampling and snowball sampling method. A total of 20 individuals were chosen for Key-Informant Interviews, all of whom are experts in the fields of climate change and/or urban development. The author initially relied on their existing network of academics and practitioners that hold particular expertise in the subject matter. These professionals were able to establish communication links with other experts in the field allowing the study to reach a wide variety of experts. The interviews all lasted approximately 60 minutes, and the experts were carefully reminded not to generalize their answers. It requires mentioning that each individual expert in this study belongs to a unique institution or department. This was done to include as many perspectives into the study as possible. With respect to the privacy of the experts, their personal information was omitted, however, it can be assumed that they belong to highly established academic institutions and non-governmental organizations. *Figure 14* shows the distribution of experts on the basis of the respected industries in which they currently belong.

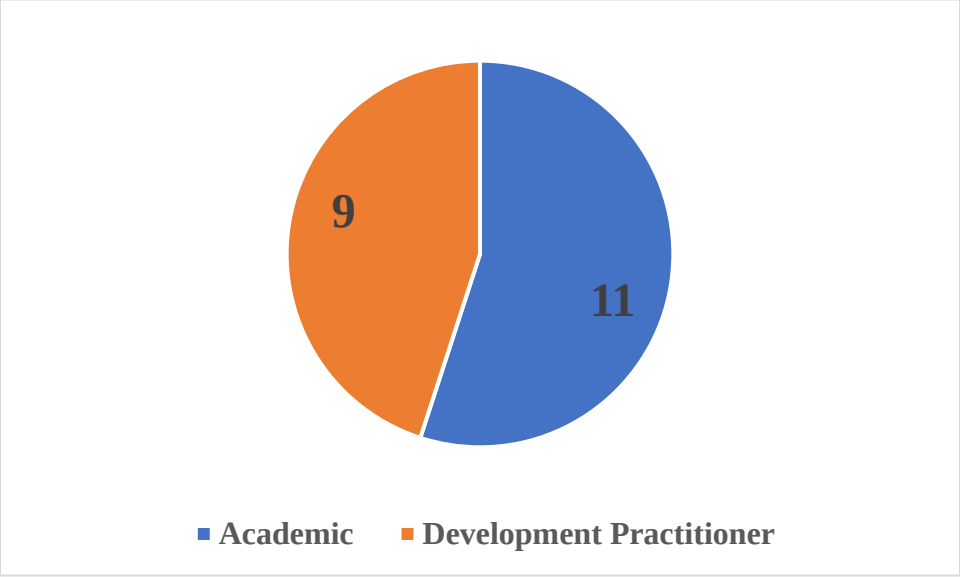


Figure 14: Distribution of Experts in the Study According to their Organizational Affiliation (Frequency)

4.5 Assessment Criteria

In this step, 7 individual criteria were developed to measure the priority and complexity of the 47 selected adaptation options. 4 of these criteria were designed to measure the ***"priority"*** of each option while the other 3 measured the ***"complexity"***. These criteria are defined below –

Prioritisation Criteria –

1. Importance: The importance of an adaptation option is defined as the total benefit that can realistically be expected from the measure through its life-cycle. It is an indication of just how crucial it is to avoid negative impacts, such as significant infrastructural or socioeconomic damages as a result of climate change. It is a measure off the benefits an adaptation option can have through avoided damages, even if they come with high initial costs.

2. Urgency: Urgency refers to whether the adaptation option needs to be implemented immediately given the existing conditions in the urban site, or if they can be delayed and pushed back to a later time without causing further damages or sacrificing the benefits significantly. A point to be noted is that adaptation options that require a long lead time or a long processing time to implement may be rendered redundant if they are delayed, and thus may be prone to receiving a high urgency score, however, that does not necessarily imply that they will receive a high final priority score.

3. No-regret: The no-regret characteristic refers to the quality of an option being good to implement despite the advent of climate change. If an adaptation option is projected to have significant non-climate related benefits, such as improved quality of life, livelihood diversification, etc., and these benefits exceed the cost of implementation, then the option may have a high no-regret score. The United Kingdom Climate Impacts Programme (UKCIP) defines no-regret adaptation options as: "options (or measures) that would be justified under all plausible future scenarios, including the absence of human-induced climate change"

4. Co-benefits: The co-benefits element refers to an option having direct or indirect benefits in sectors outside of the one that it is primarily targeting. If a devised adaptation option has the intended effects and benefits relevant to climate change, but has further benefits across sectors that may not entirely be related to climate change, that option would deserve would deserve a high scoring in the co-benefits criteria.

Complexity Criteria –

The complexity dimension allows policymakers to identify the feasibility of a particular option. In this case, there may be adaptation options that are highly ambitious from the perspective of a developing country. Ranking the complexity of the individual options will establish a ranking for the options, distinguishing between the feasible options and the more complex ones.

1. Technical Complexity: This criterion measures whether an adaptation option is technically challenging or feasible to implement based on the existing and accessible resources. This may include the uniqueness of operations and risks of an adaptation option, as well as the technological challenges and uncertainties.

2. Social Complexity: This criterion is measured on the basis of the expected social pushback or acceptance of a particular adaptation option. It considers the diverse range of values present in the society where the option is to be implemented. It also considers changes that need to be made in the collective social thought process, and the need for people's collaboration, consensus, the degree to which an option is controversial, etc.

3. Institutional Complexity: This criterion is measured on the basis of the existing institutional structures, and whether they support the implementation of an adaptation option or acts as a hindrance to it. Some components of this criteria include: friction between institutional policies, consequences of an implemented option on the existing institutions, and the cooperation that is required between organizations for the option to be successful.

These criteria have been developed in such a particular manner that they are **complete**, meaning all of the relevant criteria in this case have been considered. They are also **operational**, meaning that each criterion can be measured and compared against each other. Furthermore, they are **mutually exclusive** of each other, meaning that each criterion of each adaptation option is independent of one another. They are also not susceptible to **double counting**, and remain consistent over time (De Bruin et al., 2009).

This criteria model has been developed based on a previous study conducted by De Bruin et al. (2009). In the original paper, the authors added another criterion for prioritization; that being the effect on mitigation of the individual adaptation options. However, in pursuit of simplicity and

avoiding confusion, this fifth criterion was omitted from this study as was done in some previous studies (Acharjee et al., 2020).

4.6 Scoring and Assessment

Upon developing a suitable list of criteria, a questionnaire was drafted that listed the 47 selected adaptation options and attached the 4 prioritization criteria and 3 complexity criteria beside them (Appendix 7). The options were then scored on a scale of **1 to 5** for each criterion by selected experts and stakeholders over a detailed key-informant interview (KII) session that lasted approximately 60 minutes each.

The scales used for scoring priority and complexity are given below –

Priority	**Complexity**
1 = Very Low Priority	1 = Very Low Complexity (Highly Feasible)
2 = Low Priority	2 = Low Complexity (Feasible)
3 = Moderate Priority	3 = Moderate Complexity
4 = High Priority	4 = High Complexity
5 = Very High Priority	5 = Very High Complexity

4.7 Calculation and Ranking

The calculation and ranking of the options was done using the multi-criteria analysis method. MCA ranks the options based on the weights assigned to the various criteria by using the opinions of decision makers, experts, or stakeholders regarding the significance of the various criteria. Our approach is essentially participatory: everyone, or any combination of people, decision makers, or groups of decision makers (or experts) can indicate which pertinent weights to apply, and the ranking will be changed as a result. We report on a criterion-weighted ranking in this study. For the results provided in this paper, the scores and weights are based on expert opinion to enable cross-sector comparisons. The ranking is based on a weighted summing of the scores on the various criteria. Each criterion is assigned a weight in criteria weighting, which is intended to represent

the decision makers' preferences. The options are ranked using the weighted total of the various criteria.

Selecting the proper weights is the first issue. Equal weights is one option; this simulates an unweighted total of the scores. Giving importance and urgency higher weights, which implies that these are necessary requirements, is another pertinent way to weigh things. Our approach enables the interactive application of a broad spectrum of weights to analyze the ranking under a large range of weights. Focusing on a small set of criteria is also achievable by setting the weights of some criteria to zero.

In the case of this study, the experts were directly asked to provide weightage to each criteria before they were asked to score the individual options. The weighted were later calculated using the following formula –

$$WSxi = Wi \times Sxi$$

Here,

- *WSxi* is the weighted score of option *x* under criterion *i*,
- *Wi* is the weight of criterion *i* assigned by an individual expert/stakeholder
- and *Sxi* is the score for option *x* under criterion *i* assigned by an individual expert/stakeholder

The final score under each criterion was calculated as follows:

$$FSxi = \sum WSxi \,/\, \sum Wi$$

Here, *FSxi* is the final score for option *x* under criterion *i*.

In order to develop the final ranking of adaptation options, the average score for four of the criteria was used. This data was digitized and calculated using Microsoft Excel and the functionalities available in the Microsoft Office suite. Both priority and complexity ranks were developed for the identified 47 adaptation options using this model.

4.8 Ethical Considerations

Studies and information pertaining to the climate crisis are vital for the global community. As a result, our work adheres closely to the ethical concerns that are essential for any research involving humans and climate information.

As this study contained primary data collected through KIIs from experts in the field of urban development and climate change adaptation, the privacy, consent, convenience, and comfort of the interviewees were always given high priority. When the experts were initially contacted, the enumerators always provided a brief of the study along with its goals and objectives. They also provided complete assurance that the collected data would not be used for any purpose outside of this study. Only when the experts provided full consent to participate did the enumerators proceed.

An estimate of the length of the interview was given to the experts and they were given complete authority to choose the time of the interview as to not create conflicts in their schedule. In many cases, the enumerators would have to visit the experts multiple times, and the participants also held the right to withdraw from the study at any time.

The identities and personal information of the 20 experts that participated have been kept confidential and will only be disclosed with permission if necessary. They have not been given any incentive to report dishonestly and only their true opinions were captured with the KIIs.

The respondents' rights, and the rights of the people affiliated in the development of this study have been upheld throughout the study process. No animals or plants were hurt during the course of this investigation.

This study intended to deliver solid and impactful messages that will support Bangladesh's climate action efforts. There were be no instances of plagiarism or research misconduct in the study's report. The study findings will be accurately reported to the relevant bodies upon the author’s needs.

Chapter 5: Findings and Discussion

5.0 Findings and Discussion

After carefully calculating the values using the 4 prioritization criteria, the data shows that the prioritization scores range from **3.1037** to **4.4057**. This score is on a scale of 1 to 5 where a lower score indicates low priority for an adaptation option, and a higher score indicates high priority. It further requires mentioning that the scores in the study tables have been rounded up to the fourth decimal.

Complexity scores have been calculated in a similar manner with 3 distinct criteria as well. The scores, in this case, range from **2.4301** to **3.8364**. This variable also exists on a scale of 1 to 5 with a high score suggesting that the adaptation option is significantly complex to implement, and a low score suggesting that the options are relatively feasible to implement in the country context.

The ranges for the individual criteria, along with the full list of ranked adaptation options are available on *Appendix 4* for ***Priority*** and *Appendix 5* for ***Complexity***.

5.1 Highest Priority Rankings

Our established ranking of adaptation options reveals the top 10 options based on prioritization scores, as can be seen in **Table 4.** Here we find that *"Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks"* takes the crowning rank with a priority score of **4.4057**. Breaches in Dhaka's water supply lines have often been the cause of dangerous disease outbreaks affecting the community at large. In 2022, the city suffered from a cholera outbreak that was unlike anything it had faced in the past decades (The Business Standard, 2022; Zyma Islam & Moudud Ahmmed Sujan, 2022). The public authority responsible for meeting drinking water and sanitation demands, Dhaka Water Supply and Sewerage Authority (DWASA), not only fails to provide water on dry seasons but reportedly also suffers from 40% system failures regularly. A majority of areas in the city, as a result, suffer from insufficient water, sanitation, and waste disposal facilities. This condition makes communities vulnerable to disease outbreaks (Mollah & Aramaki, 2010).

The 2nd ranked option, which held the highest score in the *importance* criteria and a final weighted score of **4.3901**, was *"Maintaining a 25% green space ratio in cities to reduce the heat-island*

effect (rooftop gardening, urban landscaping)". The urban heat island effect has garnered a lot of attention in the international community in recent years. Owing to it, heatwaves are becoming a larger threat in metropolitans all over the world, including Dhaka, with every passing year (Ella Kim & Monica Jain, 2023). In order to offset this effect, a recent study on the tropical megacities Dhaka, Kolkata, and Bangkok have found the effectiveness of developing urban green spaces unparalleled (Li et al., 2022). Given this information, it is clear why this adaptation measure ranked so highly.

The 3rd ranked option *"Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)",* with a **4.3274** score, reveals that experts prefer the maintenance of existing urban waterbodies rather than spending efforts and budget in developing or constructing new channels, as the option titled *"Constructing and rehabilitating artificial drainage networks through water modelling under extreme climate change scenarios"*, in contrast, took the 22nd ranking out of the 47 options, with a score of **3.8611** (Appendix 4). While Bangladesh does seem to follow an Integrated Water Resources Management (IWRM) approach, the country has been continuously failing to address many of the social issues including equity, which may yield significantly positive results (Gain et al., 2017). The study participants may, therefore, also feel that these issues hold more priority over new structural measures.

"Strict monitoring and enforcement to reduce encroachment on permeable open lands, khash lands, or green areas" and held the 4th ranking with a score of **4.2114**. The study participants vehemently stressed on the historical prevalence of land encroachment in Dhaka as well as its prevalence in the present day. Studies also indicate towards historical encroachment of wetlands, and waterbodies in the past decades being responsible for dramatically increasing the inundation rates of Dhaka city (Alam, 2014; Dewan et al., 2006, 2007). More recent reports have shown the recent prevalence of land encroachment, especially around the city's rivers and canals, leading to floods and waterlogging (Md Ashraful et al., 2016). Sultana (2009) shows how low-lying marshlands decreased from 133 square kilometers in 1968 to 67 square kilometers in 2001 (M. S. Sultana et al., 2009). Mahmud (2011) also reported a 60% loss of wetlands and a 65% loss of rivers and canals in the Dhaka metropolitan area during the preceding 30 years (Mahmud et al., 2011).

"Awareness raising to avoid illegal waste dumping into drains or khals" scored **4.2033** and held the 5th ranking. This can be easily rationalized with recent reports indicating how a majority of

home owners have bypassed the law to connect their sewerage lines to surface drains rather than the sewage management network (Dhaka Tribune, 2023). Studies have also shown that these wastes being illegally channeled to the Buriganga river is significantly deteriorating the river's health (Reza & Yousuf, 2016).

"Promoting environmentally friendly vehicles and mass transport" taking such a high position at 6th rank is not beyond understanding either as studies have been pushing for Dhaka city being more energy efficient in their transport system through introducing large-scale public bus systems, signal optimization, mileage taxation. They have also called for the city needing to be more walkable with proper footpaths and bicycle lanes (Labib et al., 2014)

The ten adaptation options with the highest priority scores predominantly belonged to the categories, *Drainage and Waste Management (3)* and *Green and Blue Infrastructure Development (3).* They also included the categories *Inclusive and Advanced WASH technologies (1), Youth Development and Well-being (1), Climate Resilient Healthcare Facilities (1), and Capacity Building through Planning and Implementation (1),* as can be seen in **Table 4**.

Table 4: Ten adaptation options with the highest priority scores

Rank	Adaptation Option	Category	Importance (34.00)*	Urgency (31.5)*	No-regret (14.5)*	Co-benefits (20)*	Weighted Score**
1	Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks	Inclusive and Advanced WASH technologies	4.2820	4.5472	4.5436	4.25	**4.4057**
2	Maintaining a 25% green space ratio in cities to reduce the heat-island effect (rooftop gardening, urban landscaping)	Green and Blue Infrastructure Development	4.5329	4.4351	4.2394	4.3529	**4.3901**
3	Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)	Drainage and Waste Management	4.5156	4.5939	4.0974	4.1029	**4.3274**
4	Strict monitoring and enforcement to reduce encroachment on permeable open lands, khash lands, or green areas	Green and Blue Infrastructure Development	4.3772	4.4164	4.3813	4.0147	**4.2974**
5	Awareness raising to avoid illegal waste dumping into drains or *khals*	Drainage and Waste Management	4.1003	4.3978	4.0974	4.25	**4.2114**
6	Promoting environmentally friendly vehicles and mass transport	Green and Blue Infrastructure Development	4.3426	4.2297	4.1379	4.1029	**4.2033**
7	Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)	Youth Development and Well-being	4.2907	4.2578	4.0568	4.1618	**4.1917**
8	Increasing the number of community clinics and ensuring coordination across all healthcare agencies to improve resilience, especially during disaster events	Climate Resilient Healthcare Facilities	4.2561	3.9776	4.3205	4.1324	**4.1716**
9	Maintaining adequate machineries and infrastructure for garbage cleaning	Drainage and Waste Management	4.4896	4.4258	3.9959	3.7647	**4.1690**
10	Climate risk assessment and mapping	Capacity Building through Planning and Implementation	4.4637	4.3417	3.8337	3.9118	**4.1377**

*The average weight of each criterion are indicated within parenthesis (Qualitative Survey, 2024)

**The scores determine the final rank of the adaptation options

Table 5: Ten adaptation options with the lowest priority scores

Rank	Adaptation Option	Category	Importance (34.00)*	Urgency (31.5)*	No-regret (14.5)*	Co-benefits (20)*	Weighted Score**
38	Expanding urban agriculture through vertical farming	Green and Blue Infrastructure Development	3.6678	3.3520	3.5700	3.1912	**3.4452**
39	Climate-proofing of water management infrastructure	Drainage and Waste Management	3.6678	3.8469	3.2252	2.9706	**3.4276**
40	Introducing incentives and tax rebates to develop investment ecosystems for the private sector	Private Sector Engagement through Eco-friendly Interventions	3.7111	3.4734	3.0629	3.4412	**3.4221**
41	Understanding and assessing the impacts of climate change and extreme climatic events on mental health in varying demographics	Youth Development and Well-being	3.5554	3.3987	3.4483	3.2794	**3.4204**
42	Awareness raising campaigns for integrated water management	Inclusive and Advanced WASH technologies	3.6851	3.4547	3.2860	3.1029	**3.3822**
43	Installing lightning arresters in residential and commercial buildings	Green and Blue Infrastructure Development	3.5813	3.4360	3.5700	2.8824	**3.3674**
44	Wide-scale installation of sheds with improved WASH facilities across the city to reduce heat stress and lightning risk	Inclusive and Advanced WASH technologies	3.4343	2.9505	3.4483	3.2500	**3.2708**
45	Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)	Drainage and Waste Management	3.5640	2.9692	2.8195	3.3676	**3.1801**
46	Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services	Climate Resilient Healthcare Facilities	3.3045	3.1746	2.9209	3.3088	**3.1772**
47	Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic	Climate Resilient Healthcare Facilities	3.2353	3.0906	3.1034	2.9853	**3.1037**

*The average weight of each criterion are indicated within parenthesis (Qualitative Survey, 2024)

**The scores determine the final rank of the adaptation options

5.2 Lowest Priority Rankings

As for the ten options with the least priority scores, and therefore, ranked 38th to 47th, **Table 5** presents a detailed view. Here, we find *"Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic"* as the option with the lowest priority score at **3.1037**. Experts have claimed during live interviews for this study that it is clearly evident how the country's resources and training, when it comes to healthcare during widescale shocks, is extremely limited, and therefore, stress tests may not be as effective a measure as directly improving these facilities. Reports by the UNDP and WHO claim that Bangladesh has a doctor-to-patient ratio of 5.26 per 10,000 people, which is the second lowest in South Asia (UNDP Bangladesh Research Facility, 2020). The option titled *"Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services"* holds the rank preceding the last with a score of **3.1772**. In this regard, the study participants have also expressed that reports and academic papers partially attributing heatwaves to disease outbreaks such as the recent dengue outbreak in Bangladesh during 2022 and 2023 are already available (J. Islam & Hu, 2023). Therefore, this activity may not be as useful.

"Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)" holds the third lowest rank with a score of **3.1801**, as the study participants believe the existing system needs to be made effective rather than redesigning the entire system (Jakariya et al., 2023). Unsurprisingly then, this option also holds the highest rank in terms of complexity.

The study participants also found wide-scale installation of sheds with improved WASH facilities to be redundant as the existing sheds fail to be maintained properly (Hasan & Shuvo, 2023). They also claimed that there is no one-size-fits-all solution to people's sanitation requirements and policymakers should take that into account before applying such wide scale measures (M. M. Rahman et al., 2014). This may explain why the associated adaptation option ranked 44th.

They also claimed that installing lightning arresters is already common practice in Dhaka city, which may explain its 43rd position in the complete list. Even then, lightning deaths are quite uncommon in Dhaka city as much they are in rural areas (Biswas et al., 2020). There also exists a recent trend of installing lightning arresters unnecessarily that have been criticized as sinks for public funds (Daily Observer, 2024; A. Rahman, 2023).

The ten options with the least priority scores belonged to *Drainage and Waste Management (2), Green and Blue Infrastructure Development (2), Inclusive and Advanced WASH Technologies (2), Climate Resilient Healthcare Facilities (2), Private Sector Engagement through Eco-friendly Interventions (1), and Youth Development and Well-being (1).* They can be observed in detail on *table 5*, and the complete list of priority ranking is available in *Appendix 4*.

5.3 Highest Complexity Rankings

As mentioned in the previous section (5.2), the adaptation option holding the first rank in terms of complexity is "*Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)"* with a weighted complexity score of **3.8364**. Redesigning the entire system may introduce significant challenges in training the workforce that can be avoided if incremental improvements are made in the existing system instead. Furthermore, previous attempts at introducing ICT-based solutions to fecal sludge management has been extremely challenging as significant knowledge gaps exist among the local administrators (Jakariya et al., 2023). Therefore, the high degree of complexity in this regard is entirely plausible.

With a score of **3.5826**, the second highest position, in terms of complexity, is held by *"Decentralisation of development initiatives by LGIs where necessary"*. The institutional complexity (4.1278) for this particular option was significantly higher than the other two criteria, as can be seen in *figure 15.* This might be in indication to the lack of coordination and prevalence of corruption in the local government institutions. For example, decentralized dengue management projects and WASA projects in recent years have seen an alarming rate of corruption that have become public knowledge. The experience of people outside of Dhaka in regards to the local government have also been less than ideal in many instances (R. Islam et al., 2017).

A similar imbalance can be found with the 3rd most complex option, *"Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies"*. In this case, the social complexity of the option recorded significantly lower (2.8096), as visualized in *figure 16*, but the technical and institutional complexity scored quite high. The experts have suggested that artificial groundwater recharge may be too technically challenging to maintain for

the existing personnel and local institutions. Previous studies have also highlighted many of the challenges of MAR implementation, mainly that it requires a number of technically challenging preconditions to be met (Pervin, 2015).

The argument of cost can be applied to the option "*Climate-proofing of water management infrastructure"*, which holds the 4th ranking for complexity. Based on the IPCC predictions for the year 2050, a recent study has suggested that climate proofing the infrastructure in Bangladesh may cost 2,671 million USD with an annual recurring cost of another 54 million USD, a majority of which falls under urban infrastructure, namely in Dhaka city (Dasgupta et al., 2011). The social and institutional pushback that would come to pass given this significant cost may prove incredibly challenging.

"Maintaining adequate machineries and infrastructure for garbage cleaning" holds the 5th most complex ranking with a score of **3.4893.** The scale of Dhaka city may make it difficult for proper inventory management and maintaining stock as it would require a well maintained database that depends on large-scale coordination (M. Sultana, 2022).

Further adaptation options among the ten most complex can be found in *table 6*. These options predominantly belonged to the Drainage and Waste Management (4) category, with *Capacity Building through Planning and Implementation (2), Inclusive and Advanced WASH technologies (2),* and *Climate Resilient Healthcare Facilities (2)* also being relevant. The total list of complexity rankings with all 47 options can be found in *Appendix 5*.

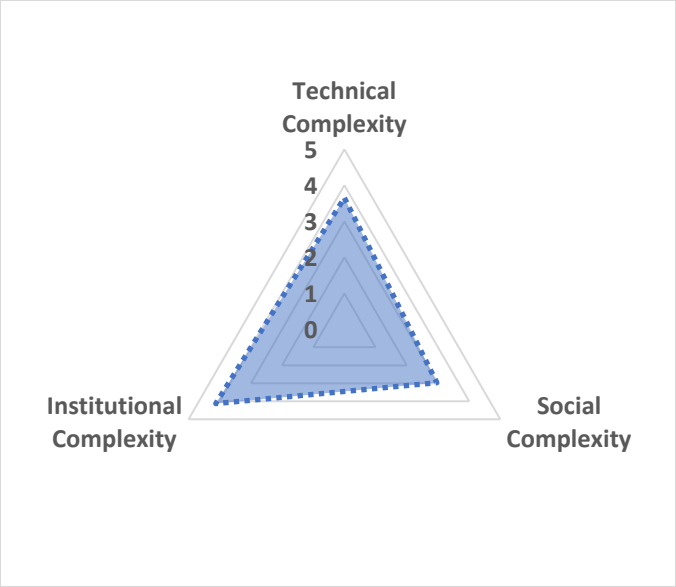


Figure 15: Scores on individual complexity criteria of the option *"Decentralisation of development initiatives by LGIs where necessary"*

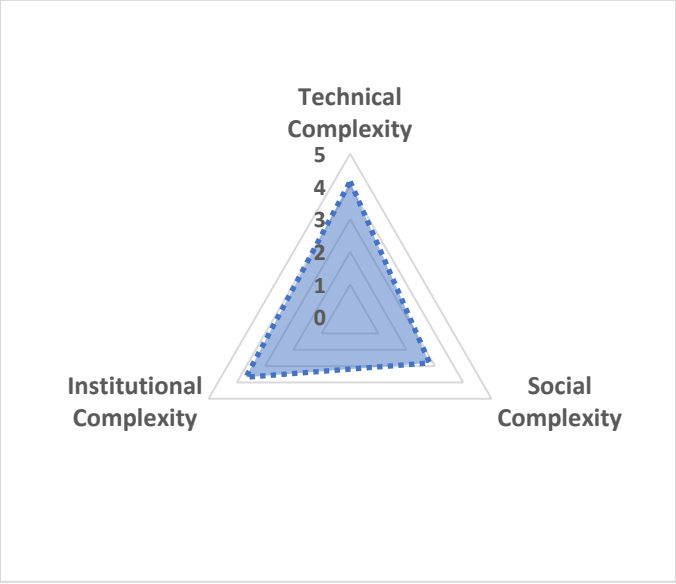


Figure 16: Scores on individual complexity criteria of the option *"Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies"*

Table 6: Ten adaptation options with the highest complexity scores

No.	Adaptation Option	Category	Technical Complexity (36.39)*	Social Complexity (28.06)*	Institutional Complexity (35.56)*	Weighted Score**
1	Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)	Drainage and Waste Management	4.0736	3.5644	3.8713	**3.8364**
2	Decentralisation of development initiatives by LGIs where necessary	Capacity Building through Planning and Implementation	3.6533	2.9668	4.1278	**3.5826**
3	Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies	Inclusive and Advanced WASH technologies	4.1545	2.8096	3.6811	**3.5484**
4	Climate-proofing of water management infrastructure	Drainage and Waste Management	3.9605	3.3128	3.3667	**3.5467**
5	Maintaining adequate machineries and infrastructure for garbage cleaning	Drainage and Waste Management	3.5564	3.1974	3.7142	**3.4893**
6	Developing one-stop solutions for re-emerging diseases (COVID-19, Zika, SARS) and maternity/neonatal services	Climate Resilient Healthcare Facilities	3.7746	2.7047	3.8300	**3.4364**
7	Smart metering systems and assessment to address shadow water prices	Inclusive and Advanced WASH technologies	3.5321	3.3442	3.3006	**3.3923**
8	Adopting climate and disaster risk recovery mechanisms for urban slum dwellers, the urban poor, and climate migrants	Capacity Building through Planning and Implementation	3.7261	3.0507	3.3915	**3.3894**
9	Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services	Climate Resilient Healthcare Facilities	3.8716	2.8620	3.4329	**3.3888**
10	Impact assessments of upstream water and hydrological systems to avoid consequences downstream	Drainage and Waste Management	3.8392	2.7676	3.5404	**3.3824**

*The average weight of each criterion are indicated within parenthesis (Qualitative Survey, 2024)

**The scores determine the final rank of the adaptation options

Table 7: Ten adaptation options with the lowest complexity scores

No.	Adaptation Option	Category	Technical Complexity (36.39)*	Social Complexity (28.06)*	Institutional Complexity (35.56)*	Weighted Score**
38	Taking stock of baseline information and adaptation needs of communities	Capacity Building through Planning and Implementation	2.8289	2.8410	2.6636	**2.7778**
39	Developing leadership/entrepreneurship programs, innovation labs, and psychosocial telehealth services	Youth Development and Well-being	2.8774	2.3063	3.1103	**2.7647**
40	Introducing incentives and tax rebates to develop investment ecosystems for the private sector	Private Sector Engagement through Eco-friendly Interventions	2.6269	2.2749	3.2592	**2.7203**
41	Awareness raising to avoid illegal waste dumping into drains or *khals*	Drainage and Waste Management	2.2227	2.7467	3.0689	**2.6794**
42	Developing walkways and recreational facilities along the banks of urban waterbodies	Green and Blue Infrastructure Development	2.9663	1.8346	3.1103	**2.6371**
43	Installing lightning arresters in residential and commercial buildings	Green and Blue Infrastructure Development	2.8612	2.2644	2.7215	**2.6157**
44	Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)	Youth Development and Well-being	2.7238	1.8136	3.2426	**2.5934**
45	Assessment of climate change impacts on children and youth	Youth Development and Well-being	2.4975	2.4112	2.7050	**2.5379**
46	Integrating climate change and adaptation studies in children's education	Youth Development and Well-being	2.1176	2.2120	2.9697	**2.4331**
47	Awareness raising campaigns for integrated water management	Inclusive and Advanced WASH technologies	2.0207	2.6418	2.6305	**2.4310**

*The average weight of each criterion are indicated within parenthesis (Qualitative Survey, 2024)

**The scores determine the final rank of the adaptation options

5.4 Lowest Complexity Rankings

In terms of adaptation measures with the least recorded amount of complexity in this study, *table 7* shows us that *"Awareness raising campaigns for integrated water management*" held the 47th and last position with a score of **2.4310**, meaning that the experts collectively found this to be the most feasible and easy to implement measure out of the total 47. Awareness raising campaigns often do not require highly technical methods, urban society is relatively welcoming of them, and local institutions in Dhaka and Bangladesh have historically had experience with this particular measure (Parveen, 2024). It may, therefore, be unsurprising to see this option occupy this position in the rankings.

"Integrating climate change and adaptation studies in children's education", ranking 46th with a score of **2.4331** may also be considered relatively feasible as there is a vast library of climate change and adaptation studies available internationally. The acceptability of this subject matter in children's education can also be expected as it is generally viewed positively. Many schools have already started providing supplementary education for climate adaptation, and therefore, would welcome its addition in textbooks (Zami, 2023). The only challenge may come in the form of passing through the required institutional channels and the coordination that is required for its implementation.

Assessing the impact of climate change on the younger demographics can be achieved through simplified qualitative studies and investigations. Recent studies in this matter have linked the effects of climate change, namely salinity intrusion, with increasing rates of child marriage (Asadullah et al., 2021). The lack of technical complexity in this matter may have placed *"Assessment of climate change impacts on children and youth"* in the 45th complexity ranking.

It can also be assumed that the local government and public authorities are equipped with the knowledge and resources required to install new parks, playgrounds, bicycle lanes, as well as lightning arresters, since they have previous experience with such activities (Labib et al., 2014). Therefore, the adaptation options in the 43rd, 44th ranking of the complexity standings can also be rationalized.

The majority of the most feasible options belong in the *Youth Development and Well-being (4)* category. Other categories include *Green and Blue Infrastructure Development (2), Capacity*

Building through Planning and Implementation (1), Private Sector Engagement through Eco-friendly Interventions (1), Drainage and Waste Management (1), and Inclusive and Advanced WASH technologies (1). The complete list of complexity ranking is available in *Appendix 5*.

5.5 Priority to Complexity Ratio Measurement

The options were further calculated to find the ratio when dividing their final priority scores with their final complexity scores in *table 8* and *table 9*. A higher score in this measure would suggest that the adaptation option is both feasible and holds high priority, whereas a lower score would suggest that it should neither be prioritized nor is it feasible to implement. In this regard, the scores ranged from **0.8289** to **1.6163**.

A close observation of *table 8* reveals that only 4 adaptation options held a ratio **above 1.5**. These were –

- Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)
- Awareness raising to avoid illegal waste dumping into drains or *khals*
- Developing walkways and recreational facilities along the banks of urban waterbodies
- Integrating climate change and adaptation studies in children's education

Furthermore, on *table 9* we find that only 4 adaptation options scored **below 1** in this measurement. These were –

- Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)
- Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services
- Climate-proofing of water management infrastructure
- Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies

These adaptation options have been discussed in details in previous sections, but this added layer of calculation can express the study participants' idea of their effectiveness, or lack thereof, even more clearly.

Table 8: Ten adaptation options with the highest priority to complexity ratio

No.	Adaptation Option	Category	Priority	Complexity	Ratio*
1	Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)	Youth Development and Well-being	4.1917	2.5934	**1.6163**
2	Awareness raising to avoid illegal waste dumping into drains or *khals*	Drainage and Waste Management	4.2114	2.6794	**1.5717**
3	Developing walkways and recreational facilities along the banks of urban waterbodies	Green and Blue Infrastructure Development	4.1279	2.6371	**1.5653**
4	Integrating climate change and adaptation studies in children's education	Youth Development and Well-being	3.6761	2.4331	**1.5109**
5	Climate risk assessment and mapping	Capacity Building through Planning and Implementation	4.1377	2.8344	**1.4598**
6	Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)	Drainage and Waste Management	4.3274	2.9843	**1.4501**
7	Assessment of climate change impacts on children and youth	Youth Development and Well-being	3.6033	2.5379	**1.4198**
8	Increasing the number of community clinics and ensuring coordination across all healthcare agencies to improve resilience, especially during disaster events	Climate Resilient Healthcare Facilities	4.1716	2.9757	**1.4019**
9	Awareness raising campaigns for integrated water management	Inclusive and Advanced WASH technologies	3.3822	2.4310	**1.3913**
10	Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks	Inclusive and Advanced WASH technologies	4.4057	3.1813	**1.3849**

*The scores determine the final rank of the adaptation options (Qualitative Survey, 2024)

Table 9: Ten adaptation options with the lowest priority to complexity ratio

No.	Adaptation Option	Category	Priority	Complexity	Ratio*
1	Wide-scale installation of sheds with improved WASH facilities across the city to reduce heat stress and lightning risk	Inclusive and Advanced WASH technologies	3.2708	2.9605	**1.1048**
2	Impact assessments of upstream water and hydrological systems to avoid consequences downstream	Drainage and Waste Management	3.6629	3.3824	**1.0829**
3	Expanding urban agriculture through vertical farming	Green and Blue Infrastructure Development	3.4452	3.2069	**1.0743**
4	Advanced water storage and collection through solar-powered water networks, small-scale retention structures, climate-resilient latrines to increase resilience	Inclusive and Advanced WASH technologies	3.5061	3.3679	**1.0410**
5	Smart metering systems and assessment to address shadow water prices	Inclusive and Advanced WASH technologies	3.5155	3.3923	**1.0363**
6	Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic	Climate Resilient Healthcare Facilities	3.1037	3.0229	**1.0267**
7	Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies	Inclusive and Advanced WASH technologies	3.4824	3.5484	**0.9814**
8	Climate-proofing of water management infrastructure	Drainage and Waste Management	3.4276	3.5467	**0.9664**
9	Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services	Climate Resilient Healthcare Facilities	3.1772	3.3888	**0.9376**
10	Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)	Drainage and Waste Management	3.1801	3.8364	**0.8289**

*The scores determine the final rank of the adaptation options (Qualitative Survey, 2024)

5.6 Average Scores by Category

Until this point, the adaptation options have been discussed individually. However, in this section, we will be focusing on each of the 7 categories as a whole. In order to do this, the final weighted scores of all of the adaptation options in a particular category (as available in *Appendix 3*) were averaged to find the average priority, complexity, and ratio scores of each of the 7 categories.

Taking a closer look at *figure 17*, we find that the average priority scores for the categories ranged from 3.61 to 3.94, and therefore, were quite close to each other. However, the categories *Capacity Building through Planning and Implementation, Green and Blue Infrastructure Development,* and *Drainage and Waste Management* held marginally higher scores in terms of priority, whereas *Climate Resilient Healthcare Facilities* scored the least. This suggests that the adaptation options related to healthcare facilities may require a revision.

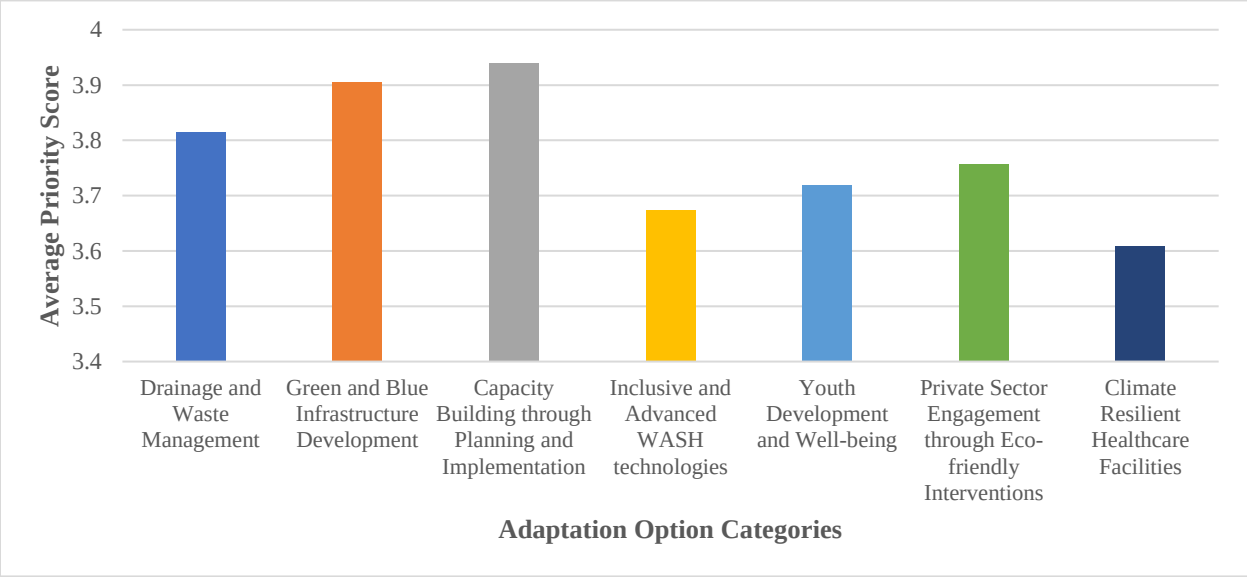


Figure 17: Average Priority Scores by Category

Figure 18 presents us with the average complexity scores for each of the categories. Here, we find a clear distinction between the categories, with *Youth Development and Well-being* having a complexity score of **2.65** and the others all ranging from **3.01** to **3.28**. This can be a clear indication that the experts in this study find the adaptation options under that particular category to be more feasible than the options in other categories.

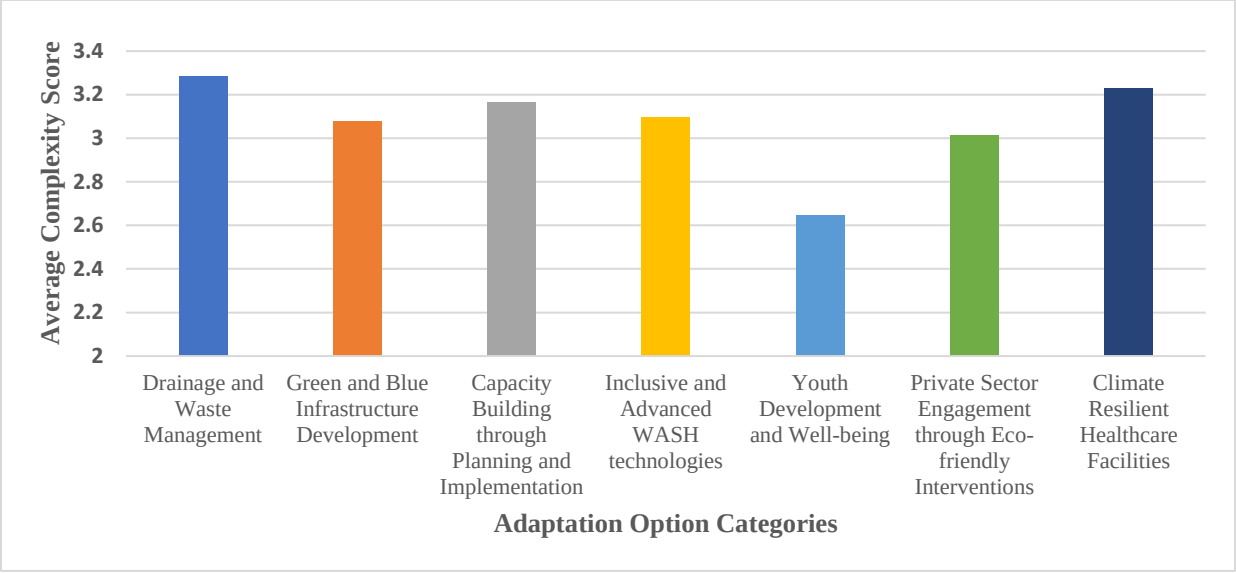


Figure 18: Average Complexity Scores by Category

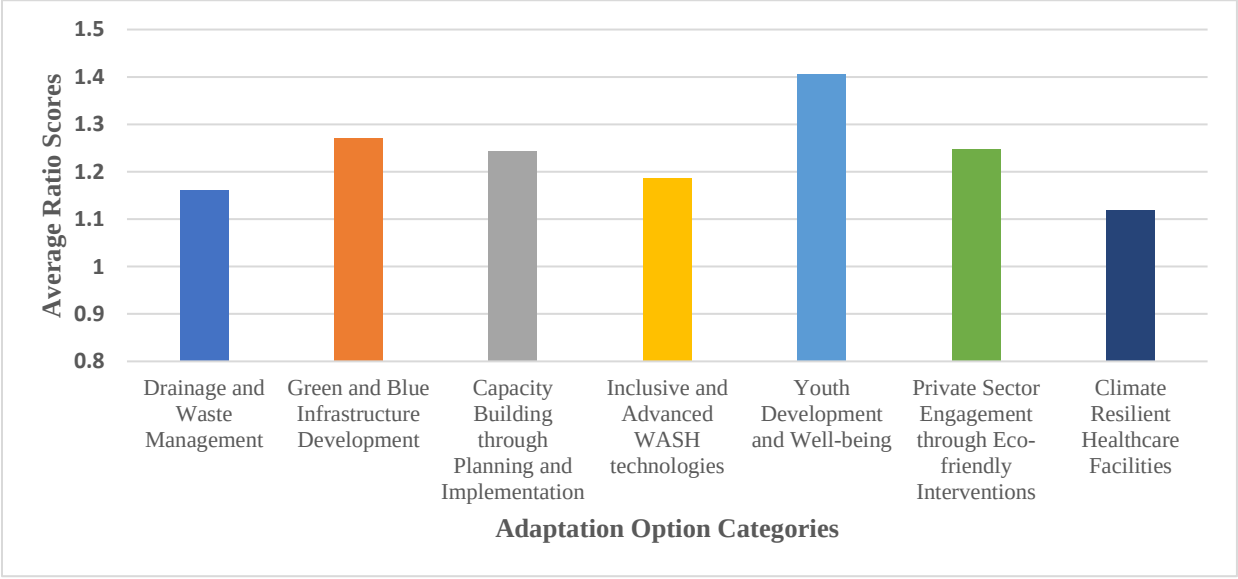


Figure 19: Average Priority to Complexity Ratio Scores by Category

Similarly, *figure 19* displays the average priority to complexity ratio scores of all 7 categories. The Youth Development and Well-being category here also shows distinct results with a score of **1.41** while the other ratio scores all range from **1.12** to **1.27**. This further suggests that the options in this category are not only feasible but also hold relatively high priority.

5.7 Average Scores by Criterion

In this section, the average scores for each adaptation option has been broken down into the weighted scores they received for each criterion. They have then been visualized into line charts, and presented as a part of their category.

Figure 20 and *figure 21* present us with the individual priority criteria scores and individual complexity criteria scores for all eight options in the *Drainage and Waste Management* category. Taking a closer look at *figure 20*, we find that all of the options have relatively balanced scores for each criterion. The scores do not vary significantly for any one criterion. However, with the individual complexity scores in *figure 21*, we can observe that the options consistently record having significantly lower social complexity in comparison to the other two criteria, which is visualized in the observable dip in the middle section.

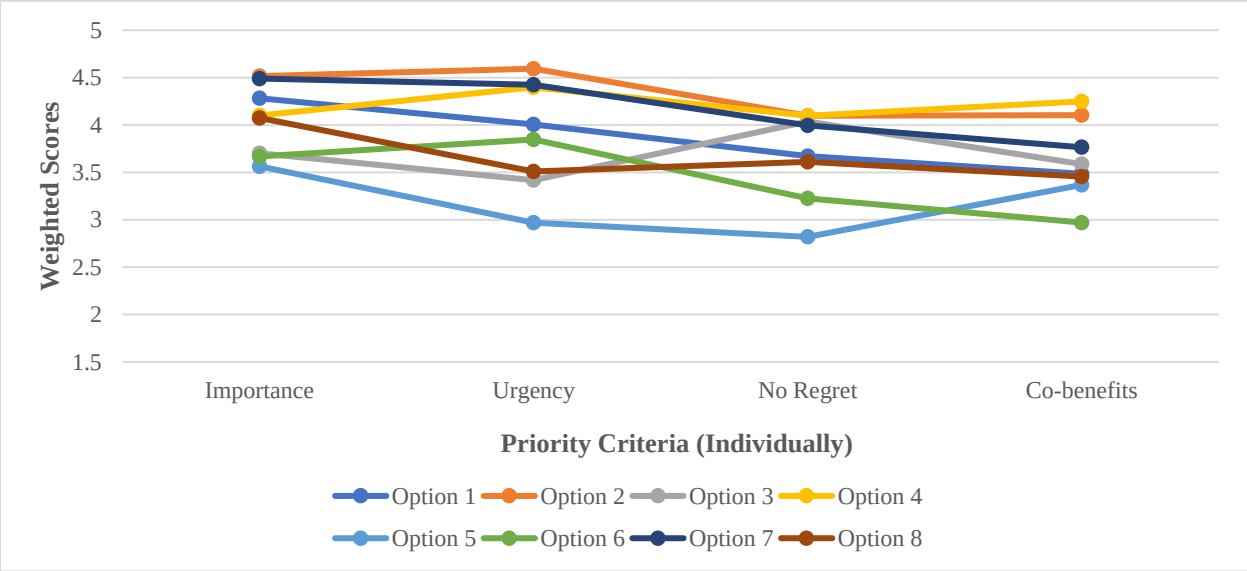


Figure 20: Score Distribution of Each Priority Criterion (Drainage and Waste Management)

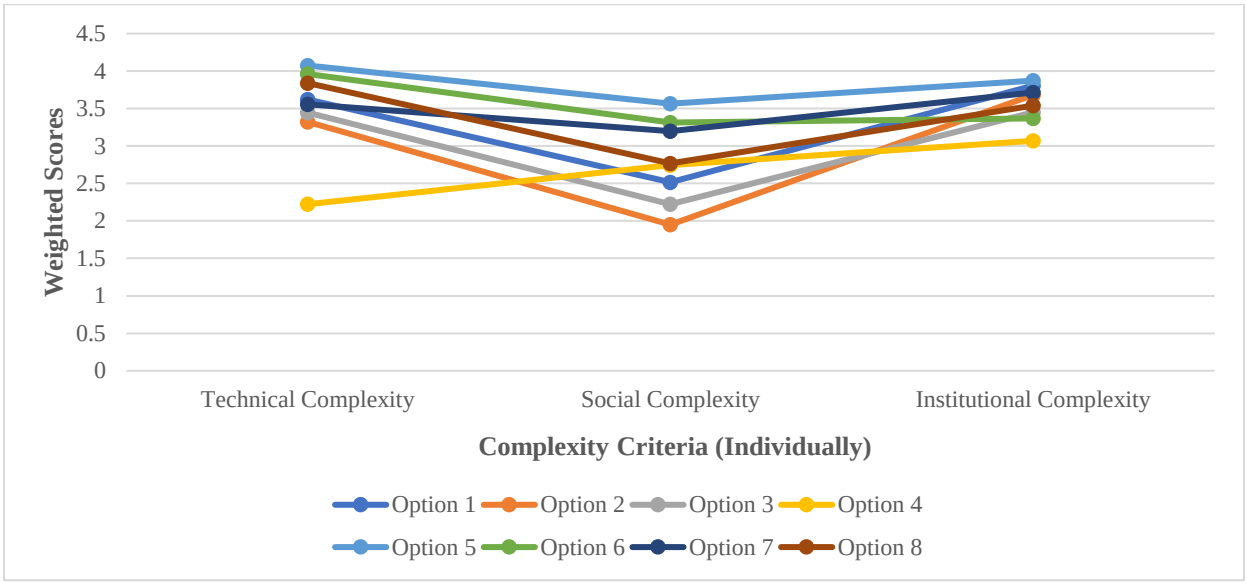


Figure 21: Score Distribution of Each Complexity Criterion (Drainage and Waste Management)

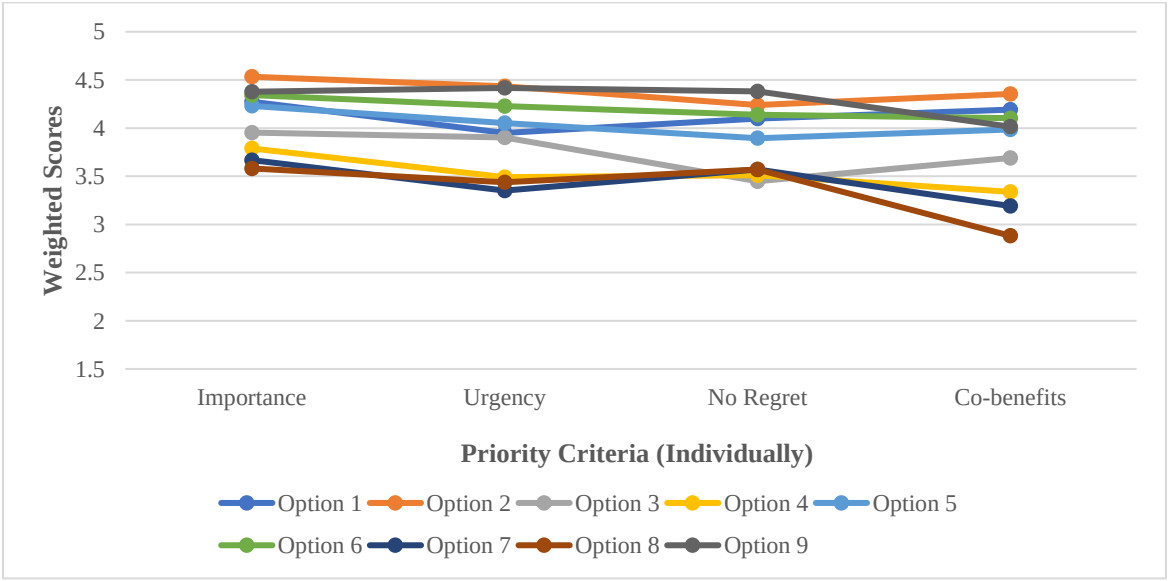


Figure 22: Score Distribution of Each Priority Criterion (Green and Blue Infrastructure Development)

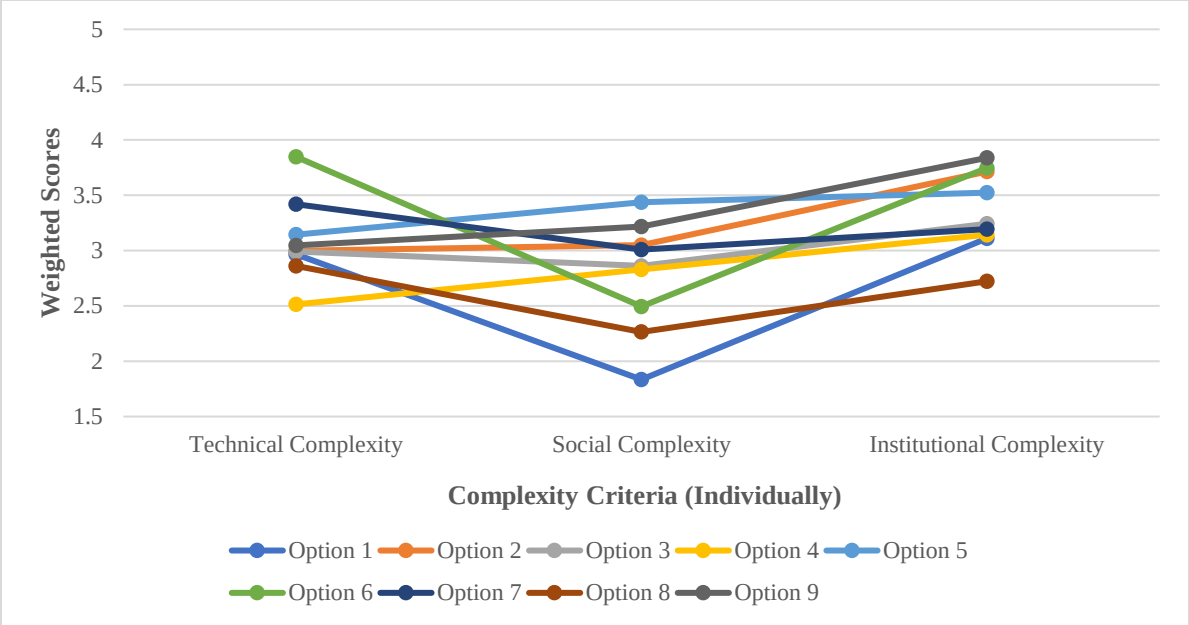


Figure 23: Score Distribution of Each Complexity Criterion (Green and Blue Infrastructure Development)

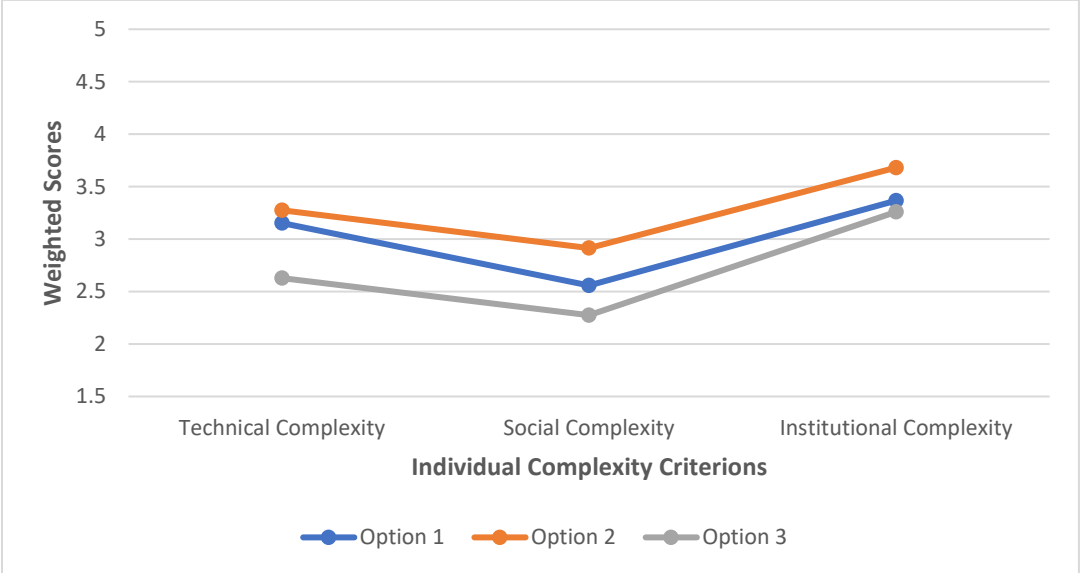


Figure 24: Score Distribution of Each Complexity Criterion (Private Sector Engagement through Eco-friendly Interventions)

Similarly, *figure 22* and *figure 23* visualize the individual criteria scores of the nine adaptation options under the category *Green and Blue Infrastructure Development*. The priority scores follow similar scoring trends across each of the option, and again we find that the social complexity often drops with certain adaptation options, though not as consistently as with the previous category.

Most of the options in the other categories showed similar results and did not necessitate their own charts. However, it is only with the category *Private Sector Engagement through Eco-friendly Interventions* that we find a new and interesting trend. There we find the institutional complexity of the adaptation options to be significantly more than the technical and social complexities, which is observable with the sharp rise at the end of the X axis on *figure 24*.

This suggests that the options in every category are socially acceptable, but the complexities and challenges are mainly technical or institutional, except for the options related to *Private Sector Engagement through Eco-friendly Interventions* where institutional complexity peaks above the rest.

Chapter 6: Conclusion and Recommendations

6.0 Conclusion and Recommendations

6.1 Recommendations

This study attempted to measure the priority and complexity of the urban adaptation measures mentioned in the NAP 2023-2050 and developed a complete ranking of the identified 47 options. This task has been achieved while considering all possible constraints and limitations as the methods are mostly subjective (expert opinion). The findings of this study can not only be utilized by policymakers in revising the existing policies or drafting new ones, but they may also act as a resource for the awareness of civil society.

That being said, there are a number of clear recommendations for policymakers that can be drawn from the findings of this study –

1. Investing on adaptation options that focus on developing the youth demographic can have high benefits while requiring very little effort. This may include structural measures such as developing new green areas, parks, bicycle lanes, playgrounds, etc., as well as non-structural measures like integrating climate adaptation education in school textbooks, and engaging the youth in leadership/entrepreneurship programs.
2. The policymakers must consider the technical limitations of the relevant personnel prior to applying highly advanced and IT-based mechanisms. In many cases, it may yield better results to improve the current system rather than wholly redesigning it. However, thorough training programs are required for the personnel if more advanced mechanisms are developed.
3. Strict measures need to be applied to revive the previously existing waterbodies within the city that acted as natural drainage for excess precipitation before constructing newer channels.
4. Existing literature on the resources and conditions of the city need to be considered before undertaking newer investigations.
5. Risk assessment studies on Dhaka need to be considered in policymaking so as to not give prevalence to hazards with limited risk. For example, safety from lightning strikes may not hold much significance in Dhaka city as there are limited lightning casualties here.

6.2 Conclusion

It is a certainty that the developing world will be more severely affected by climate change, even if there is debate over how it will affect the world as a whole. Extreme weather events will occur more frequently and with greater severity in the age of climate change. However, well-coordinated planning, administration, and implementation will determine whether these incidents become disasters.

Adapting to the growing climate variabilities is critical for a sustainable future and the survival of the people both in developing countries and small-island nations. Bangladesh is still regarded as a least developed country. Its available resources are scarce while the risk of climate change is high. Therefore, the appraisal of adaptation measures conducted in this study offers substantial assistance to policy formulation and decision making.

Scientific studies may always contain ambiguity, therefore, it should be remembered that the people, or end users, should only partially rely on environmental researchers to provide them with the answers. Ultimately, it is up to the end users to behave and make decisions in their daily lives that take the effects of climate change into account. Then and only then will the data that the researchers are gathering be able to be utilized as effectively as possible.

6.3 Further Research Potential

Applying an adaptation option doesn't have to be a one-time choice or based just on lowering exposure to a particular climate danger. Other issues that are taken into consideration within the context of the study include a restricted budget, limited institutional and technical ability, etc., which might limit the option's implementation. MCA can produce information on the relative merits of the alternatives under consideration, but it cannot be a stand-alone tool for discovering and ranking the adaptation possibilities. Therefore, further studies in this matter that utilize techniques like CBA and CEA can support (or confirm) the findings of this study. Another avenue for future study may be a more comprehensive MCA evaluation approach that includes risk management since climate change is a delicate field with many unknowns.

Chapter 7: References

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Chapter 8: Appendices

8.0 Appendices

Appendix 1: List of Interventions in the NAP 2023-2050 for *Urban Areas (URB)*

Sl.	Title of Intervention	Cost (Billion BDT)	Lead Organization
1	Improvement of natural and artificial stormwater drainage networks for reducing vulnerabilities to urban flooding and drainage congestion	1914	LGD
2	Expansion and conservation of green and blue infrastructure for improvement of urban environments and drainage systems	189	LGD
3	Stormwater management in cities through attenuating peak flow and allowing infiltration in line with the concept of low-impact development	37	LGD
4	Development of city climate action plans for major urban and peri-urban areas emphasizing the resilience of urban-poor communities and climate migrants	4	LGD
5	Expand innovative climate resilient, gender-, age and disability sensitive WASH technologies and facilities for urban communities	65	LGD
6	Increase access to water supply, sanitation and hygiene services in cities for reducing exposure to flooding and waterborne diseases during or after extreme weather events	593	LGD
7	Adopt integrated water management for urban and peri-urban areas	13	LGD
8	Carry out initiatives to improve the well-being of children and youth and reduce the effects of climate stress	138	LGD, DYD

9	Improvement of surveillance, early warning systems and monitoring of psychosocial impacts and mental health risks from extreme weather events	52	DGHS
10	Extension of resilient and eco-friendly materials and engagement of the private sector through incentives and tax rebates for climate resilient infrastructure development in urban areas	58	LGD
11	Establishment of climate resilient health-care facilities in urban areas	214	HED
12	Development of heatwave and disease outbreak advisory services for city dwellers	30	DGHS

Appendix 2: List of Activities in the Selected *URB* Interventions of the NAP 2023-2050

Sl.	**Title of Activity**
1	Construct and rehabilitate adequate coverage of artificial drainage networks in all major cities through water modelling under extreme climate change scenarios
2	Maintain enough room for rivers flowing through cities for accommodating excess flood volume during an extreme event
3	Revitalization of rivers or wetlands flowing inside or surrounding any city through regular dredging or re-excavation
4	Integrated solid waste and urban drainage management for sustainable drainage system development following 3R (reduce, recycle, recovery) principles

5	Awareness raising and citizen behavior change to avoid illegal waste dumping into drains or *khals*
6	Regular cleaning of *khals* or canals inside the city to maintain adequate drainage capacity, navigability and connectivity with rivers (where appropriate)
7	IT-based monitoring mechanisms for urban drainage clogging, reporting, evaluation and rehabilitation
8	Improvement of storm water drainage system using smart warnings and pumping stations
9	Climate-proofing of water management infrastructure supporting improved drainage
10	Develop required infrastructures and purchase machineries for garbage cleaning on a regular basis and during extreme rainfall events
11	Conservation of urban wetlands or *khals*; develop walkway and recreational facilities along the banks of *khals* or wetlands
12	Urban landscaping through green and blue infrastructure to reduce the heat island effect, pollution, human health discomfort, etc.
13	Expansion of green building and green roofs to reduce the urban heat island effect and enhance cooling, carbon sequestration and energy efficiency
14	Support rooftop gardening or plantations, installation of solar energy, and biodiversity conservation through tax instruments
15	Design smart villages and smart cities with a 10 percent provision for protected areas

16	Community conservation area or OECM and 25 percent of area as green space (rooftop garden, hanging garden, greening office and academic compounds, greening military compounds, urban green parks or garden development, etc.) along with water-sensitive planning
17	Plant suitable species of trees or grass on roadsides or road islands
18	Promote environmentally friendly vehicles and mass transport to reduce emissions and pollution
19	Expansion and commercialization of urban agriculture through rainfed rooftop and vertical farming for boosting leafy vegetable production and food security
20	Development of climate-smart solar energy-based utilities and installation of lightning arresters in residential and commercial buildings
21	Strict monitoring and enforcement of land cover change per DAP or structural plan to reduce encroachment on permeable open land, khash lands or green areas
22	Preparation of stormwater management guidelines based on low-impact development concepts and operationalization
23	Feasibility study and implement different low-impact development (LID) measures such as permeable pavement, rooftop rainwater harvesting and use for households, disconnecting direct runoff, green parks or playgrounds, bioswale or bioretention cells, reservoirs, green rooftops, etc.
24	Develop the capacity of city managers to understand low-impact development and its operation
25	Take stock of baseline information and needs of city dwellers in all 43 major urban areas for preparing city climate action plans

26	Develop climate action plans for municipalities
27	Climate risk and vulnerability assessments and mappings for cities
28	Stocktaking of resilient Infrastructure and other adaptation need from the urban areas
29	Integrate water and climate-smart city development concepts into DAP or other required urban development policy
30	Adopt climate and disaster risk recovery mechanisms for urban slum dwellers, the urban poor and climate migrants
31	Adopt low-impact development principles, 3R principles, and urban green and blue conservation and expansion
32	Develop implementable actions for the short, medium and long term for climate resilient city development that enhances the resilience of the urban poor and climate migrants along with implementation mechanisms and financing modalities
33	Expand the use of deeper groundwater reserves through solar-powered water networks, advanced water storage through small-scale retention structures and rainwater harvesting, climate-resilient latrines, and gender-sensitive drinking water points for marginal urban communities to reduce the health risks of climate change
34	Establish sheds with improved gender- and disability-sensitive WASH facilities for reducing heat stress and lightning risk and supporting physical well-being
35	Introduce community-based low-cost desalination techniques and freshwater management for mass drinking water supplies among coastal city communities
36	Operationalize new WASAs for climate-sensitive water supply services

37	Development of climate-smart WASH (Water, Sanitation and Hygiene) technologies and infrastructure to increase the resilience of urban citizens
38	Expand coverage of piped water supplies and improved sanitation in all major cities
39	Develop smart metering systems for water services through assessments of shadow water prices
40	Managed aquifer recharge (MAR) and rainwater harvesting for artificial groundwater recharge in urban areas
41	Ensure implementation/enforcement of the Bangladesh National Building Code (BNBC) and MAR strategy
42	Establishment of dense pedestrian sheds in urban areas with improved gender-sensitive WASH facilities for reducing heat stress and lightning risk and supporting physical wellbeing
43	Increase the efficiency of water use through sustainable management of water resources and locally led adaptation practices
44	Reduce leakage, repair and provide O&M regularly to halt outbreaks of waterborne diseases from WASH-related service infrastructure
45	Develop climate-resilient and portable public sanitation facilities for marginal people and slum communities
46	Encourage the private sector to invest in expansion of the city water supply and sanitation services through PPP modalities
47	Gender- and disability-responsive WASH service expansion
48	Impact assessments of climate change and interventions in water and hydrological systems in the upstream and downstream of urban and peri-urban areas to avoid any consequences downstream

49	Maintain coordination and collaboration among development initiatives in urban and peri-urban areas
50	Decentralize management adaptation by LGIs
51	Management of water resources, urban drainage system and waste in an integrated fashion
52	Raising awareness among city dwellers and other relevant stakeholders regarding the importance of integrated water and urban development plans
53	Assess impacts of climate change on the well-being of children and youth
54	Expansion of green area, biodiversity or green parks, walkways or bicycling facilities with separate lanes, sports playground and recreational facilities for improvement in the physical health of children and youth
55	Update education for children to understand climate change and adaptations for building proactive coping mechanisms
56	Initiatives for children and youth in sports, cycling, swimming and other physical exercise
57	Expand development programmes for children and youth
58	Expand youth entrepreneurship programmes and innovation labs
59	Youth leadership development programmes
60	Engage youth in the nursery development programme

61	Understand and regularly assess the adverse impacts of extreme climate events on mental health inclusive of gender and disability issues
62	Development of advanced and web-based surveillance and early warning systems and monitoring of psychosocial impacts and mental health risks under extreme climatic event
63	Extension of telehealth services for accessing health services
64	Mental health-boosting programme through the development of pollution-free cities and expanding green and blue infrastructure
65	Implementation of feasibility assessments of eco-engineering and environmentally friendly measures for infrastructure and communication
66	Preparation of guidelines for implementing eco-engineering measures and updating relevant building code like BNBC
67	Implement the eco-engineering measures as per developed guidelines
68	Develop proper policy support for producing resilient and eco-friendly brick and other construction materials
69	Preparation of guidelines for use of eco-friendly materials
70	Introduce incentives and tax rebate mechanisms to develop investment ecosystems for the private sector
71	Popularize and extend eco-friendly materials for climate-resilient infrastructure development
72	Operational framework development for building climate-resilient health-care facilities (HCFs) as per WHO guidelines and ensuring the inclusion of women, people with diverse gender identities, children, the elderly and persons with disabilities

73	Establish climate-resilient Health Care Facilities (HCFs), including infection prevention and control (IPC)
74	Scenario-based stress test assessments for the health-care system, including in light of the COVID-19 pandemic or sudden shocks, to formulate adaptations
75	Develop and plan a one health approach to address emerging and re-emerging diseases and infections (COVID-19, SARS, zika, etc.) due to climate calamities
76	Identify and initiate climate-smart approaches including WASH interventions to combat cholera and other neglected diseases (filaria, kalazar, etc.) and to minimize risks from antimicrobial resistance (AMR)
77	Develop special arrangements for emergency neonatal and post-neonatal services
78	Initiatives for dense community clinics with local health workers helping women, children, the physically challenged and pregnant women during climatic hazards
79	Expand renewable energy-based power supplies and green buildings for hospitals or clinics through the private sector
80	Develop specific emergency health-care facilities and infrastructure based on spatial vulnerability
81	Improve accessibility and communication facilities to obtain emergency services from health-care facilities
82	Establish a correlation between heatwaves and disease outbreaks through extensive research
83	Develop climate and health data sharing protocols and MoUs with relevant agencies, research and knowledge institutes
84	Review existing health-related advisory services and develop a framework for heatwave and disease outbreak advisory services with health improvement guidelines

85	Establish ICT-based dynamic heatwave and disease outbreak advisory services with PPP modalities
86	Popularize and extend advisory services to citizens

Appendix 3: Final List of Activities Selected for the Study

Sl.	Category	Title of Activity
1	Drainage and Waste Management	Constructing and rehabilitating artificial drainage networks through water modelling under extreme climate change scenarios
2		Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)
3		Integrating solid waste management with urban drainage management
4		Awareness raising to avoid illegal waste dumping into drains or *khals*
5		Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)
6		Climate-proofing of water management infrastructure
7		Maintaining adequate machineries and infrastructure for garbage cleaning

8		Impact assessments of upstream water and hydrological systems to avoid consequences downstream
9	Green and Blue Infrastructure Development	Developing walkways and recreational facilities along the banks of urban waterbodies
10		Maintaining a 25% green space ratio in cities to reduce the heat-island effect (rooftop gardening, urban landscaping)
11		Improving and adopting solar energy systems at a higher rate
12		Introducing tax instruments for green initiatives like rooftop gardening, installation of solar energy, and biodiversity conservation
13		Maintaining a 10% provision for protected areas
14		Promoting environmentally friendly vehicles and mass transport
15		Expanding urban agriculture through vertical farming
16		Installing lightning arresters in residential and commercial buildings
17		Strict monitoring and enforcement to reduce encroachment on permeable open lands, khash lands, or green areas
18	Capacity Building through Planning and Implementation	Mainstreaming Low-Impact Development (LID) principles and 3R principles through policies, feasibility studies, and capacity building
19		Implementing LID measures such as permeable pavement, rainwater harvesting, green parks and rooftops, bioswales, reservoirs, etc.

20		Taking stock of baseline information and adaptation needs of communities
21		Developing city specific and smart climate action plans for the short, medium, and long term
22		Climate risk assessment and mapping
23		Adopting climate and disaster risk recovery mechanisms for urban slum dwellers, the urban poor, and climate migrants
24		Decentralisation of development initiatives by LGIs where necessary
25	Inclusive and Advanced WASH technologies	Advanced water storage and collection through solar-powered water networks, small-scale retention structures, climate-resilient latrines to increase resilience
26		Wide-scale installation of sheds with improved WASH facilities across the city to reduce heat stress and lightning risk
27		Expansion of WASA, piped water supplies, and gender/disability sensitive WASH facilities
28		Smart metering systems and assessment to address shadow water prices
29		Encouraging private investment in WASH infrastructure and services through Public Private Partnerships (PPP)
30		Addressing the needs of marginal people and slum communities through smart and portable sanitation facilities

31		Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks
32		Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies
33		Ensuring proper adherence to policies like the Bangladesh National Building Code and Managed Aquifer Recharge (MAR)
34		Awareness raising campaigns for integrated water management
35	Youth Development and Well-being	Assessment of climate change impacts on children and youth
36		Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)
37		Integrating climate change and adaptation studies in children's education
38		Developing leadership/entrepreneurship programs, innovation labs, and psychosocial telehealth services
39		Understanding and assessing the impacts of climate change and extreme climatic events on mental health in varying demographics
40	Private Sector Engagement through Eco-friendly Interventions	Preparation of guidelines, feasibility assessments, and ensuring policy support for eco-friendly solutions in the private sector
41		Implementing the prepared eco-friendly guidelines for construction materials (brick) and the private sector at large

42		Introducing incentives and tax rebates to develop investment ecosystems for the private sector
43	Climate Resilient Healthcare Facilities (HCF)	Establishing inclusive climate-resilient Health Care Facilities (HCF) considering the identified high-risk zones as per WHO guidelines (Infection Prevention and Control centres)
44		Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic
45		Developing one-stop solutions for re-emerging diseases (COVID-19, Zika, SARS) and maternity/neonatal services
46		Increasing the number of community clinics and ensuring coordination across all healthcare agencies to improve resilience, especially during disaster events
47		Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services

Appendix 4: Complete List of Prioritization Scores with total 47 Adaptation Options

Rank	Adaptation Options	Importance (34.00)*	Urgency (31.5)*	No-regret (14.5)*	Co-benefits (20)*	Weighted Score**
1	Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks	4.282007	4.547152	4.543611	4.25	**4.405692**
2	Maintaining a 25% green space ratio in cities to reduce the heat-island effect (rooftop gardening, urban landscaping)	4.532872	4.435107	4.239351	4.352941	**4.390068**
3	Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)	4.515571	4.593838	4.097363	4.102941	**4.327428**
4	Strict monitoring and enforcement to reduce encroachment on permeable open lands, khash lands, or green areas	4.377163	4.416433	4.381339	4.014706	**4.29741**
5	Awareness raising to avoid illegal waste dumping into drains or *khals*	4.100346	4.397759	4.097363	4.25	**4.211367**
6	Promoting environmentally friendly vehicles and mass transport	4.342561	4.229692	4.137931	4.102941	**4.203281**
7	Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)	4.290657	4.257703	4.056795	4.161765	**4.19173**
8	Increasing the number of community clinics and ensuring coordination across all healthcare agencies to improve resilience, especially during disaster events	4.256055	3.977591	4.320487	4.132353	**4.171622**
9	Maintaining adequate machineries and infrastructure for garbage cleaning	4.489619	4.42577	3.995943	3.764706	**4.16901**
10	Climate risk assessment and mapping	4.463668	4.341737	3.833671	3.911765	**4.13771**
11	Developing walkways and recreational facilities along the banks of urban waterbodies	4.273356	3.94958	4.097363	4.191176	**4.127869**
12	Decentralisation of development initiatives by LGIs where necessary	4.307958	3.940243	3.914807	4.132353	**4.07384**
13	Maintaining a 10% provision for protected areas	4.230104	4.052288	3.894523	3.985294	**4.040552**

14	Expansion of WASA, piped water supplies, and gender/disability sensitive WASH facilities	4.342561	3.762838	4.137931	3.794118	**4.009362**
15	Addressing the needs of marginal people and slum communities through smart and portable sanitation facilities	4.022491	3.968254	4.137931	3.838235	**3.991728**
16	Implementing the prepared eco-friendly guidelines for construction materials (brick) and the private sector at large	3.979239	4.126984	3.711968	4.102941	**3.980283**
17	Developing city specific and smart climate action plans for the short, medium, and long term	4.32526	4.220355	3.793103	3.529412	**3.967032**
18	Implementing LID measures such as permeable pavement, rainwater harvesting, green parks and rooftops, bioswales, reservoirs, etc.	3.987889	3.781513	4.117647	3.75	**3.909262**
19	Developing one-stop solutions for re-emerging diseases (COVID-19, Zika, SARS) and maternity/neonatal services	4.00519	3.762838	3.935091	3.911765	**3.903721**
20	Preparation of guidelines, feasibility assessments, and ensuring policy support for eco-friendly solutions in the private sector	3.910035	3.986928	3.894523	3.676471	**3.866989**
21	Adopting climate and disaster risk recovery mechanisms for urban slum dwellers, the urban poor, and climate migrants	3.823529	3.874883	3.6714	4.088235	**3.864512**
22	Constructing and rehabilitating artificial drainage networks through water modelling under extreme climate change scenarios	4.282007	4.005602	3.6714	3.485294	**3.861076**
23	Taking stock of baseline information and adaptation needs of communities	3.884083	3.88422	3.853955	3.691176	**3.828359**
24	Mainstreaming Low-Impact Development (LID) principles and 3R principles through policies, feasibility studies, and capacity building	4.195502	3.716153	3.813387	3.441176	**3.791555**
25	Improving and adopting solar energy systems at a higher rate	3.953287	3.902894	3.448276	3.691176	**3.748909**
26	Developing leadership/entrepreneurship programs, innovation labs, and psychosocial telehealth services	3.814879	3.716153	3.691684	3.588235	**3.702738**
27	Establishing inclusive climate-resilient Health Care Facilities (HCF) considering the identified high-risk zones as per WHO guidelines (Infection Prevention and Control centres)	3.83218	3.594771	3.874239	3.455882	**3.689268**

28	Integrating solid waste management with urban drainage management	3.702422	3.417367	4.036511	3.588235	**3.686134**
29	Integrating climate change and adaptation studies in children's education	3.754325	3.977591	3.590264	3.382353	**3.676133**
30	Ensuring proper adherence to policies like the Bangladesh National Building Code and Managed Aquifer Recharge (MAR)	3.892734	3.613445	3.813387	3.367647	**3.671803**
31	Impact assessments of upstream water and hydrological systems to avoid consequences downstream	4.074394	3.510738	3.610548	3.455882	**3.662891**
32	Assessment of climate change impacts on children and youth	3.901384	3.688142	3.529412	3.294118	**3.603264**
33	Introducing tax instruments for green initiatives like rooftop gardening, installation of solar energy, and biodiversity conservation	3.788927	3.492063	3.509128	3.338235	**3.532088**
34	Smart metering systems and assessment to address shadow water prices	3.901384	3.576097	3.56998	3.014706	**3.515542**
35	Advanced water storage and collection through solar-powered water networks, small-scale retention structures, climate-resilient latrines to increase resilience	3.66782	3.314659	3.46856	3.573529	**3.506142**
36	Encouraging private investment in WASH infrastructure and services through Public Private Partnerships (PPP)	3.771626	3.352007	3.346856	3.544118	**3.503652**
37	Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies	3.728374	3.352007	3.56998	3.279412	**3.482443**
38	Expanding urban agriculture through vertical farming	3.66782	3.352007	3.56998	3.191176	**3.445246**
39	Climate-proofing of water management infrastructure	3.66782	3.846872	3.225152	2.970588	**3.427608**
40	Introducing incentives and tax rebates to develop investment ecosystems for the private sector	3.711073	3.473389	3.06288	3.441176	**3.42213**
41	Understanding and assessing the impacts of climate change and extreme climatic events on mental health in varying demographics	3.555363	3.398693	3.448276	3.279412	**3.420436**
42	Awareness raising campaigns for integrated water management	3.685121	3.454715	3.286004	3.102941	**3.382195**
43	Installing lightning arresters in residential and commercial buildings	3.581315	3.436041	3.56998	2.882353	**3.367422**

44	Wide-scale installation of sheds with improved WASH facilities across the city to reduce heat stress and lightning risk	3.434256	2.950514	3.448276	3.25	**3.270761**
45	Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)	3.564014	2.969188	2.819473	3.367647	**3.18008**
46	Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services	3.304498	3.174603	2.920892	3.308824	**3.177204**
47	Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic	3.235294	3.09057	3.103448	2.985294	**3.103652**

*The average weight of each criterion are indicated within parenthesis

**The scores determine the final prioritization rank of the adaptation options

Appendix 5: Complete List of Complexity Scores with total 47 Adaptation Options

Rank	Adaptation options	Technical Complexity (36.39)*	Social Complexity (28.06)*	Institutional Complexity (35.56)*	Weighted Score**
1	Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)	4.07364167	3.564356436	3.871323529	**3.836440545**
2	Decentralisation of development initiatives by LGIs where necessary	3.653345308	2.966802563	4.127757353	**3.582635074**
3	Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies	4.154467894	2.809551543	3.681066176	**3.548361871**
4	Climate-proofing of water management infrastructure	3.960484957	3.312754805	3.366727941	**3.546655901**
5	Maintaining adequate machineries and infrastructure for garbage cleaning	3.556353839	3.197437391	3.714154412	**3.489315214**
6	Developing one-stop solutions for re-emerging diseases (COVID-19, Zika, SARS) and maternity/neonatal services	3.774584643	2.704717531	3.829963235	**3.436421803**
7	Smart metering systems and assessment to address shadow water prices	3.532105972	3.344205009	3.300551471	**3.392287484**
8	Adopting climate and disaster risk recovery mechanisms for urban slum dwellers, the urban poor, and climate migrants	3.726088909	3.050669773	3.391544118	**3.389434266**
9	Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services	3.871576111	2.86196855	3.432904412	**3.388816358**
10	Impact assessments of upstream water and hydrological systems to avoid consequences downstream	3.839245622	2.767617938	3.540441176	**3.382434912**
11	Maintaining a 10% provision for protected areas	3.144140099	3.43855562	3.523897059	**3.368864259**
12	Strict monitoring and enforcement to reduce encroachment on permeable open lands, khash lands, or green areas	3.04714863	3.218404193	3.838235294	**3.367929373**

13	Advanced water storage and collection through solar-powered water networks, small-scale retention structures, climate-resilient latrines to increase resilience	3.443197126	2.830518346	3.829963235	**3.367892902**
14	Promoting environmentally friendly vehicles and mass transport	3.847328244	2.495049505	3.747242647	**3.363206799**
15	Constructing and rehabilitating artificial drainage networks through water modelling under extreme climate change scenarios	3.621014818	2.516016308	3.805147059	**3.314059395**
16	Establishing inclusive climate-resilient Health Care Facilities (HCF) considering the identified high-risk zones as per WHO guidelines (Infection Prevention and Control centres)	3.726088909	2.36924869	3.846507353	**3.313948317**
17	Implementing the prepared eco-friendly guidelines for construction materials (brick) and the private sector at large	3.273462057	2.914385556	3.681066176	**3.28963793**
18	Ensuring proper adherence to policies like the Bangladesh National Building Code and Managed Aquifer Recharge (MAR)	3.04714863	3.124053582	3.65625	**3.275817404**
19	Implementing LID measures such as permeable pavement, rainwater harvesting, green parks and rooftops, bioswales, reservoirs, etc.	3.766502021	2.53698311	3.523897059	**3.275794063**
20	Maintaining a 25% green space ratio in cities to reduce the heat-island effect (rooftop gardening, urban landscaping)	2.998652896	3.050669773	3.714154412	**3.25449236**
21	Mainstreaming Low-Impact Development (LID) principles and 3R principles through policies, feasibility studies, and capacity building	3.435114504	2.966802563	3.358455882	**3.25345765**
22	Expanding urban agriculture through vertical farming	3.418949259	3.008736168	3.193014706	**3.206900044**
23	Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks	3.645262685	2.474082702	3.424632353	**3.181325914**
24	Addressing the needs of marginal people and slum communities through smart and portable sanitation facilities	3.249214189	2.578916715	3.391544118	**3.073225007**

25	Developing city specific and smart climate action plans for the short, medium, and long term	3.580601706	2.159580664	3.416360294	**3.052180888**
26	Integrating solid waste management with urban drainage management	3.443197126	2.222481072	3.449448529	**3.038375576**
27	Improving and adopting solar energy systems at a higher rate	2.990570274	2.86196855	3.242647059	**3.031728628**
28	Preparation of guidelines, feasibility assessments, and ensuring policy support for eco-friendly solutions in the private sector	3.152222721	2.557949913	3.366727941	**3.025633525**
29	Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic	3.224966322	2.683750728	3.159926471	**3.022881174**
30	Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)	3.321957791	1.949912638	3.681066176	**2.984312202**
31	Increasing the number of community clinics and ensuring coordination across all healthcare agencies to improve resilience, especially during disaster events	3.136057476	2.159580664	3.631433824	**2.975690655**
32	Wide-scale installation of sheds with improved WASH facilities across the city to reduce heat stress and lightning risk	3.281544679	2.547466511	3.052389706	**2.960466965**
33	Understanding and assessing the impacts of climate change and extreme climatic events on mental health in varying demographics	2.877413561	2.757134537	3.068933824	**2.90116064**
34	Expansion of WASA, piped water supplies, and gender/disability sensitive WASH facilities	3.38661877	2.21199767	3.102022059	**2.900212833**
35	Encouraging private investment in WASH infrastructure and services through Public Private Partnerships (PPP)	2.780422093	2.704717531	3.052389706	**2.84584311**
36	Climate risk assessment and mapping	3.055231253	2.180547467	3.267463235	**2.834413985**
37	Introducing tax instruments for green initiatives like rooftop gardening, installation of solar energy, and biodiversity conservation	2.513695555	2.830518346	3.143382353	**2.829198751**

38	Taking stock of baseline information and adaptation needs of communities	2.828917827	2.841001747	2.663602941	**2.777840838**
39	Developing leadership/entrepreneurship programs, innovation labs, and psychosocial telehealth services	2.877413561	2.306348282	3.110294118	**2.76468532**
40	Introducing incentives and tax rebates to develop investment ecosystems for the private sector	2.626852268	2.274898078	3.259191176	**2.720313841**
41	Awareness raising to avoid illegal waste dumping into drains or *khals*	2.22272115	2.746651136	3.068933824	**2.67943537**
42	Developing walkways and recreational facilities along the banks of urban waterbodies	2.966322407	1.834595224	3.110294118	**2.637070583**
43	Installing lightning arresters in residential and commercial buildings	2.861248316	2.264414677	2.721507353	**2.615723449**
44	Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)	2.723843736	1.813628422	3.242647059	**2.593373072**
45	Assessment of climate change impacts on children and youth	2.49753031	2.411182295	2.704963235	**2.537891947**
46	Integrating climate change and adaptation studies in children's education	2.117647059	2.21199767	2.969669118	**2.433104616**
47	Awareness raising campaigns for integrated water management	2.02065559	2.641817123	2.630514706	**2.430995806**

*The average weight of each criterion are indicated within parenthesis

**The scores determine the final complexity rank of the adaptation options

Appendix 6: Complete List of Priority/Complexity Ratio Scores with total 47 Adaptation Options

Rank	Adaptation options	Priority	Complexity	Ratio*
1	Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)	4.19173009	2.593373072	**1.616323596**
2	Awareness raising to avoid illegal waste dumping into drains or *khals*	4.211367052	2.67943537	**1.571736755**
3	Developing walkways and recreational facilities along the banks of urban waterbodies	4.127868947	2.637070583	**1.565323649**
4	Integrating climate change and adaptation studies in children's education	3.676133232	2.433104616	**1.510881698**
5	Climate risk assessment and mapping	4.137710155	2.834413985	**1.459811509**
6	Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)	4.327428182	2.984312202	**1.450058804**
7	Assessment of climate change impacts on children and youth	3.603263855	2.537891947	**1.419786157**
8	Increasing the number of community clinics and ensuring coordination across all healthcare agencies to improve resilience, especially during disaster events	4.171621539	2.975690655	**1.401900272**
9	Awareness raising campaigns for integrated water management	3.38219539	2.430995806	**1.391279813**
10	Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks	4.405692416	3.181325914	**1.384860444**
11	Expansion of WASA, piped water supplies, and gender/disability sensitive WASH facilities	4.009361926	2.900212833	**1.382437137**
12	Taking stock of baseline information and adaptation needs of communities	3.828358811	2.777840838	**1.378177885**
13	Maintaining a 25% green space ratio in cities to reduce the heat-island effect (rooftop gardening, urban landscaping)	4.390067859	3.25449236	**1.348925538**
14	Developing leadership/entrepreneurship programs, innovation labs, and psychosocial telehealth services	3.702737721	2.76468532	**1.339298073**
15	Developing city specific and smart climate action plans for the short, medium, and long term	3.967032384	3.052180888	**1.299736985**

16	Addressing the needs of marginal people and slum communities through smart and portable sanitation facilities	3.991727912	3.073225007	**1.298872651**
17	Installing lightning arresters in residential and commercial buildings	3.367422155	2.615723449	**1.28737698**
18	Preparation of guidelines, feasibility assessments, and ensuring policy support for eco-friendly solutions in the private sector	3.866989155	3.025633525	**1.278075855**
19	Strict monitoring and enforcement to reduce encroachment on permeable open lands, khash lands, or green areas	4.297410124	3.367929373	**1.275979882**
20	Introducing incentives and tax rebates to develop investment ecosystems for the private sector	3.422129704	2.720313841	**1.25799077**
21	Promoting environmentally friendly vehicles and mass transport	4.20328116	3.363206799	**1.249783737**
22	Introducing tax instruments for green initiatives like rooftop gardening, installation of solar energy, and biodiversity conservation	3.532088478	2.829198751	**1.248441268**
23	Improving and adopting solar energy systems at a higher rate	3.748908505	3.031728628	**1.236558072**
24	Encouraging private investment in WASH infrastructure and services through Public Private Partnerships (PPP)	3.50365185	2.84584311	**1.231147226**
25	Integrating solid waste management with urban drainage management	3.686133886	3.038375576	**1.213192311**
26	Implementing the prepared eco-friendly guidelines for construction materials (brick) and the private sector at large	3.980282901	3.28963793	**1.209945588**
27	Maintaining a 10% provision for protected areas	4.040552208	3.368864259	**1.199381126**
28	Maintaining adequate machineries and infrastructure for garbage cleaning	4.169009693	3.489315214	**1.194793086**
29	Implementing LID measures such as permeable pavement, rainwater harvesting, green parks and rooftops, bioswales, reservoirs, etc.	3.909262234	3.275794063	**1.193378509**
30	Understanding and assessing the impacts of climate change and extreme climatic events on mental health in varying demographics	3.42043594	2.90116064	**1.178988813**
31	Mainstreaming Low-Impact Development (LID) principles and 3R principles through policies, feasibility studies, and capacity building	3.791554688	3.25345765	**1.16539236**
32	Constructing and rehabilitating artificial drainage networks through water modelling under extreme climate change scenarios	3.861075718	3.314059395	**1.1650593**

33	Adopting climate and disaster risk recovery mechanisms for urban slum dwellers, the urban poor, and climate migrants	3.864511897	3.389434266	**1.140164285**
34	Decentralisation of development initiatives by LGIs where necessary	4.073840371	3.582635074	**1.137107265**
35	Developing one-stop solutions for re-emerging diseases (COVID-19, Zika, SARS) and maternity/neonatal services	3.903721191	3.436421803	**1.135984293**
36	Ensuring proper adherence to policies like the Bangladesh National Building Code and Managed Aquifer Recharge (MAR)	3.671803356	3.275817404	**1.12088157**
37	Establishing inclusive climate-resilient Health Care Facilities (HCF) considering the identified high-risk zones as per WHO guidelines (Infection Prevention and Control centres)	3.689268219	3.313948317	**1.113254603**
38	Wide-scale installation of sheds with improved WASH facilities across the city to reduce heat stress and lightning risk	3.270761364	2.960466965	**1.104812654**
39	Impact assessments of upstream water and hydrological systems to avoid consequences downstream	3.662890528	3.382434912	**1.082915303**
40	Expanding urban agriculture through vertical farming	3.445245931	3.206900044	**1.07432283**
41	Advanced water storage and collection through solar-powered water networks, small-scale retention structures, climate-resilient latrines to increase resilience	3.506142129	3.367892902	**1.041049175**
42	Smart metering systems and assessment to address shadow water prices	3.515541697	3.392287484	**1.036333658**
43	Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic	3.103651518	3.022881174	**1.026719656**
44	Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies	3.482443163	3.548361871	**0.981422777**
45	Climate-proofing of water management infrastructure	3.427608129	3.546655901	**0.966433797**
46	Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services	3.177204367	3.388816358	**0.937555781**
47	Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)	3.180080298	3.836440545	**0.828914266**

*The scores determine the final rank of the adaptation options

Appendix 7: Questionnaire of the Study

Adaptation options for improving Urban Resilience

Survey Questionnaire for Experts/Stakeholders

This form includes statements for various adaptation options related to urban resilience for coping with climate change in the Dhaka Metropolitan area. You, as an expert/important stakeholder, are requested to give your sincere opinion/comment for each of the adaptation options. Your sincere evaluation will be helpful for correct assessment of the adaptation options, and for ensuring urban resilience in the region.

Part 1: Interviewee Identification

Please fill out the following information for identification purposes. Your personal data will not be used outside of the purposes of this study.

Respondent No: _____ (to be filled by author)

Name:
Designation:
Department/Division/Office:
Institute/Organization:
Address:

1

Criteria for *Prioritisation:*

- ***Importance**:* based on the expected benefit(s) of the option
- ***Urgency**:* based on the need to act soon and not later
- ***No-regret** characteristics*: good to implement irrespective of climate change
- ***Co-benefits**:* the option also contributes to other sectors and domains

Criteria for *Complexity/Feasibility:*

- ***Technical feasibility**:* based on technical ease for implementing the option
- ***Social feasibility**:* based on social acceptability for implementing the option
- ***Institutional feasibility**:* based on institutional capability for implementing the option

Part 2: Evaluate the priority and feasibility of adaptation options based on criteria

Please evaluate the adaptation options in terms of the criteria mentioned below by giving a score (1 to 5) in the box of each column according to the following scale:

5–Very High Priority 4–High Priority 3–Moderate Priority 2–Low Priority 1–Very Low Priority

Next, please evaluate the adaptation options in terms of their complexity/feasibility mentioned below by giving a score (1 to 5) in the box of each column according to the following scale:

5–Highly Complex 4–Complex 3–Moderate 2–Feasible 1–Highly Feasible

2

A. Drainage and Waste Management –

(Please avoid generalisation and add appropriate scores according to each criteria; Refer to Page 2 for criteria definitions)

SL No.	Adaptation options	Prioritisation				Complexity		
		Impt.	Urg.	No regret	Co-benefit	Tech.	Soc.	Inst.
1	Constructing and rehabilitating artificial drainage networks through water modelling under extreme climate change scenarios							
2	Maintaining enough room and connectivity for urban water bodies for accommodating excess flood volume (dredging & re-excavation)							
3	Integrating solid waste management with urban drainage management							
4	Awareness raising to avoid illegal waste dumping into drains or khals							
5	Mainstreaming IT-based mechanisms for drainage system management (monitoring, smart warnings, smart pumping stations)							
6	Climate-proofing of water management infrastructure							
7	Maintaining adequate machineries and infrastructure for garbage cleaning							
8	Impact assessments of upstream water and hydrological systems to avoid consequences downstream							

3

B. Green and Blue Infrastructure Development-

(Please avoid generalisation and add appropriate scores according to each criteria; Refer to Page 2 for criteria definitions)

SL No.	Adaptation options	Prioritisation				Complexity		
		Impt.	Urg.	No regret	Co-benefit	Tech.	Soc.	Inst.
1	Developing walkways and recreational facilities along the banks of urban waterbodies							
2	Maintaining a 25% green space ratio in cities to reduce the heat-island effect (rooftop gardening, urban landscaping)							
3	Improving and adopting solar energy systems at a higher rate							
4	Introducing tax instruments for green initiatives like rooftop gardening, installation of solar energy, and biodiversity conservation							
5	Maintaining a 10% provision for protected areas							
6	Promoting environmentally friendly vehicles and mass transport							
7	Expanding urban agriculture through vertical farming							
8	Installing lightning arresters in residential and commercial buildings							
9	Strict monitoring and enforcement to reduce encroachment on permeable open lands, khash lands, or green areas							

4

C. Capacity Building through Planning and Implementation-

(Please avoid generalisation and add appropriate scores according to each criteria; Refer to Page 2 for criteria definitions)

SL No.	Adaptation options	Prioritisation				Complexity		
		Impt.	Urg.	No regret	Co-benefit	Tech.	Social	Inst.
1	Mainstreaming Low-Impact Development (LID) principles and 3R principles through policies, feasibility studies, and capacity building							
2	Implementing LID measures such as permeable pavement, rainwater harvesting, green parks and rooftops, bioswales, reservoirs, etc.							
3	Taking stock of baseline information and adaptation needs of communities							
4	Developing city specific and smart climate action plans for the short, medium, and long term							
5	Climate risk assessment and mapping							
6	Adopting climate and disaster risk recovery mechanisms for urban slum dwellers, the urban poor, and climate migrants							
7	Decentralisation of development initiatives by LGIs where necessary							

D. Inclusive and Advanced WASH technologies -

SL No.	Adaptation options	Prioritisation				Complexity		
		Impt.	Urg.	No regret	Co-benefit	Tech.	Social	Inst.
1	Advanced water storage and collection through solar-powered water networks, small-scale retention structures, climate-resilient latrines to increase resilience							
2	Wide-scale installation of sheds with improved WASH facilities across the city to reduce heat stress and lightning risk							
3	Expansion of WASA, piped water supplies, and gender/disability sensitive WASH facilities							
4	Smart metering systems and assessment to address shadow water prices							
5	Encouraging private investment in WASH infrastructure and services through Public Private Partnerships (PPP)							
6	Addressing the needs of marginal people and slum communities through smart and portable sanitation facilities							
7	Ensuring proper maintenance of WASH systems and avoiding leakages that may lead to waterborne disease outbreaks							
8	Artificial groundwater recharge through Managed Aquifer Recharge (MAR) and rainwater harvesting strategies							
9	Ensuring proper adherence to policies like the Bangladesh National Building Code and Managed Aquifer Recharge (MAR)							
10	Awareness raising campaigns for integrated water management							

E. Youth Development and Well-being –

(Please avoid generalisation and add appropriate scores according to each criteria; Refer to Page 2 for criteria definitions)

SL No.	Adaptation options	Prioritisation				Complexity		
		Impt.	Urg.	No regret	Co-benefit	Tech.	Social	Inst.
1	Assessment of climate change impacts on children and youth							
2	Youth-focused green infrastructure development for improved health and recreation (parks, bicycle lanes, playgrounds)							
3	Integrating climate change and adaptation studies in children's education							
4	Developing leadership/entrepreneurship programs, innovation labs, and psychosocial telehealth services							
5	Understanding and assessing the impacts of climate change and extreme climatic events on mental health in varying demographics							

F. Private Sector Engagement through Eco-friendly Interventions –

(Please avoid generalisation and add appropriate scores according to each criteria; Refer to Page 2 for criteria definitions)

SL No.	Adaptation options	Prioritisation				Complexity		
		Impt.	Urg.	No regret	Co-benefit	Tech.	Social	Inst.
1	Preparation of guidelines, feasibility assessments, and ensuring policy support for eco-friendly solutions in the private sector							
2	Implementing the prepared eco-friendly guidelines for construction materials (brick) and the private sector at large							
3	Introducing incentives and tax rebates to develop investment ecosystems for the private sector							

***G.* Strengthening Healthcare systems –**

(Please avoid generalisation and add appropriate scores according to each criteria; Refer to Page 2 for criteria definitions)

SL No.	Adaptation options	Prioritisation				Complexity		
		Impt.	Urg.	No regret	Co-benefit	Tech.	Social	Inst.
1	Establishing inclusive climate-resilient Health Care Facilities (HCF) considering the identified high-risk zones as per WHO guidelines (Infection Prevention and Control centres)							
2	Scenario-based stress tests for HCFs to ensure accessibility during sudden shocks like the COVID-19 pandemic							
3	Developing one-stop solutions for re-emerging diseases (COVID-19, Zika, SARS) and maternity/neonatal services							
4	Increasing the number of community clinics and ensuring coordination across all healthcare agencies to improve resilience, especially during disaster events							
5	Establishing a correlation between heatwaves and disease outbreaks through extensive research and developing necessary ICT-based advisory services							

Part 3: Weight Distribution

Please indicate the weight of each prioritisation criterion. The sum of the weight should be **100**.

[For example, Importance: 30, Urgency: 30, No-regret: 20, Co-benefits: 20, i.e. 30+30+20+20=100]

Criteria	Weight
Importance	
Urgency	
No-regret	
Co-benefits	

Please indicate the weight of each feasibility/complexity criterion. The sum of weight should be **100**.

[For example, Technical: 40, Social: 30, Institutional: 30, i.e. 40+30+30=100]

Complexity	Weight
Technical complexity	
Social complexity	
Institutional complexity	

###

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