

Public Participation in Adaptive Governance to Address the Climate Crisis in Dhaka, Bangladesh

Mahbubur Rahman¹

¹Institute of Governance and Development, BRAC University, Dhaka, Bangladesh

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Corresponding Author:

Mahbubur Rahman

Email:

mbuburrahman@yahoo.co.id

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ABSTRACT

Purpose: This study aims to examine the role of public participation within adaptive governance frameworks in addressing the climate crisis in Dhaka, Bangladesh. Specifically, it investigates how participatory mechanisms contribute to adaptive capacity, institutional learning, and climate-responsive decision-making in a highly vulnerable urban context, while also identifying the structural constraints that limit meaningful citizen influence on climate governance outcomes.

Subjects and Methods: The research employed a qualitative case study design using semi-structured interviews, document analysis, and thematic analysis. Participants included government officials, NGOs, community leaders, and residents from climate-vulnerable areas in Dhaka.

Results: The findings reveal that participatory practices primarily occur through consultations, workshops, and community meetings aimed at increasing climate awareness and preparedness. Participation contributed positively to community learning, collective action, and localized adaptive capacity. However, participatory governance remained largely procedural and consultative, with limited influence on strategic planning and policy decisions. Institutional fragmentation, bureaucratic rigidity, unequal representation, and weak accountability mechanisms significantly constrained the effectiveness of adaptive governance.

Conclusions: The study concludes that public participation enhances localized resilience and procedural legitimacy but remains insufficient for transformative climate adaptation without stronger institutional coordination, inclusive representation, and long-term integration of community participation within formal governance systems.

INTRODUCTION

The climate crisis has emerged as one of the most profound challenges confronting contemporary societies, with its impacts disproportionately affecting rapidly urbanizing cities in the Global South (Das et al., 2024; Anguelovski et al., 2016; Ali et al., 2025; Carvalho & Spataru, 2023). Intensifying floods, heatwaves, water scarcity, and public health risks increasingly threaten urban livelihoods, infrastructure, and governance systems. In this context, urban governance has become a critical arena for climate adaptation, as cities concentrate populations, economic activities, and climate vulnerabilities simultaneously. Recent literature emphasizes that effective climate adaptation requires not only technical and infrastructural solutions but also inclusive governance arrangements that enable learning, flexibility, and responsiveness to uncertainty (Folke et al., 2006; Bulkeley & Tuts, 2013). Adaptive governance has therefore gained prominence as an approach that highlights polycentric institutions, stakeholder participation, and iterative decision-making to manage complex socio-ecological systems under changing climatic conditions.

Public participation is widely recognized as a central component of adaptive governance. It is argued to enhance the legitimacy, effectiveness, and equity of climate responses by incorporating local knowledge, fostering collective ownership, and strengthening accountability (Adade et al., 2020; Chanza & De, 2016). In urban climate governance, participatory processes can improve the design and implementation of adaptation strategies by aligning them more closely with community needs and lived experiences, particularly for vulnerable populations (Chu et al., 2016; Archer et al., 2014; Uittenbroek et al. 2019; Broto et al., 2015). Recent studies underscore that participatory adaptation is especially crucial in cities facing overlapping risks related to poverty, informal settlements, and weak service provision, where top-down interventions often fail to reach those most affected by climate impacts (Anguelovski et al., 2016). As a result, understanding how public participation functions within adaptive governance frameworks has become an important research agenda in climate and urban studies.

Dhaka, the capital of Bangladesh, represents a critical case for examining public participation in adaptive governance under conditions of extreme climate vulnerability. Frequently cited as one of the world's most climate-exposed megacities, Dhaka faces recurrent flooding, waterlogging, heat stress, and climate-induced migration pressures. Its rapid population growth, high density, and prevalence of informal settlements further exacerbate these risks. Bangladesh has been internationally recognized for its proactive engagement with climate adaptation planning, including the development of national strategies and institutional mechanisms (Ayers et al., 2014). However, the translation of these frameworks into effective, inclusive urban adaptation remains uneven, particularly at the city and community levels. Existing studies suggest that governance challenges, such as institutional fragmentation and limited citizen engagement, constrain adaptive capacity in Dhaka's urban context (Swapan & Khan, 2022).

The central research problem identified in the literature concerns the gap between adaptive governance ideals and their practical realization through meaningful public participation. While adaptive governance emphasizes inclusiveness, learning, and collaboration, empirical studies often reveal that participation in climate governance is limited, symbolic, or dominated by elite actors (Sharma-Wallace et al., 2018; Munaretto et al., 2014). In Dhaka, climate-related decision-making is frequently centralized within government agencies and development organizations, with limited opportunities for sustained engagement by local communities, particularly those residing in informal or marginalized areas (Rahman & Islam, 2024). This disconnect raises concerns about the effectiveness and social justice of adaptation initiatives, as policies may fail to reflect local priorities or address differentiated vulnerabilities.

In response to these challenges, the literature proposes several general solutions aimed at strengthening public participation in adaptive governance. One widely discussed approach involves institutionalizing participatory mechanisms within climate planning and implementation processes, such as community consultations, co-production platforms, and participatory risk assessments. Another strand of research highlights the importance of multi-level governance, where coordination between national, municipal, and community actors enables more responsive and context-sensitive adaptation strategies. Capacity building for both public institutions and community actors is also emphasized as a necessary condition for effective participation, ensuring that stakeholders possess the skills, resources, and knowledge required to engage meaningfully in governance processes (Riege & Lindsay, 2006; Robinson & Berkes, 2011).

Beyond these general prescriptions, the literature identifies more specific participatory solutions relevant to climate adaptation in vulnerable urban settings. Community-based adaptation has received significant attention as an approach that foregrounds local knowledge, social networks, and grassroots initiatives in responding to climate risks (Bhanye, 2025; Kettle et al., 2014). In South Asian cities, including Dhaka, studies show that community organizations, non-governmental organizations, and informal networks play a crucial role in managing flood risks, water access, and livelihood diversification. These initiatives are often portrayed as building blocks of adaptive governance by fostering social learning and collective action. However, their scalability and integration into formal governance structures remain contested, with concerns about sustainability and dependence on external support.

Another set of solutions emphasized in the literature relates to collaborative and co-production models of governance. Co-production involves the joint design and delivery of services and policies by public authorities and citizens, and is increasingly promoted as a means of enhancing adaptive capacity in urban climate governance (Mees et al., 2017; Fraser, 2017; Ferrari et al. 2021; Bovaird et al., 2016). Empirical studies suggest that co-produced adaptation initiatives can improve trust between authorities and communities, enhance policy relevance, and generate innovative responses to complex climate challenges. In Dhaka, examples of collaboration between municipal bodies, development agencies, and community groups illustrate the potential of such approaches, while also revealing persistent power imbalances and institutional constraints that limit their transformative potential.

Despite these growing bodies of research, the literature on public participation in adaptive governance remains fragmented, particularly with respect to urban contexts in the Global South. Many studies focus on either adaptive governance as a conceptual framework or participatory practices as isolated interventions, without systematically examining how participation operates within adaptive governance arrangements over time. In the case of Dhaka, existing research often addresses climate vulnerability, informal settlements, or specific adaptation projects, but provides limited integrative analysis of participatory governance across institutional levels and policy domains. This fragmentation points to a research gap concerning how public participation contributes to, or is constrained within, adaptive governance systems in highly vulnerable megacities.

Against this backdrop, this study aims to analyze public participation in adaptive governance to address the climate crisis in Dhaka, Bangladesh. The study seeks to examine how participatory processes are structured, who participates, and how participation influences adaptive decision-making and outcomes. The novelty of this research lies in its integrative focus on public participation as a core mechanism of adaptive governance rather than as a peripheral or instrumental tool. By situating participatory practices within broader governance dynamics, the study contributes to a deeper understanding of the conditions under which adaptive governance can enhance urban climate resilience. The scope of the study is limited to urban climate adaptation in Dhaka, with particular attention to governance processes involving local communities, public institutions, and intermediary actors, offering insights relevant to both theory development and policy practice in climate governance.

METHODOLOGY

Research Design

This study employed a qualitative case study design to examine the role of public participation within adaptive governance frameworks addressing the climate crisis in Dhaka, Bangladesh. A qualitative approach was considered appropriate because the research focuses on governance interactions, institutional dynamics, participatory practices, and social experiences that cannot be adequately captured through quantitative indicators alone. Qualitative inquiry enables a deeper understanding of how actors interpret participation, negotiate power relations, and respond to climate-related challenges within complex urban governance systems. The case study strategy further allowed the research to explore Dhaka as a bounded socio-political and environmental context characterized by high climate vulnerability, rapid urbanization, and fragmented governance structures. The analytical framework of the study was informed by adaptive governance theory, which emphasizes institutional flexibility, social learning, multi-level coordination, and stakeholder participation in managing socio-ecological uncertainty (Folke, 2006; Foxon et al., 2009). Within this framework, public participation was positioned not merely as a procedural mechanism but as a substantive governance process capable of influencing adaptive capacity and resilience outcomes. The study therefore investigated how participatory arrangements functioned in practice, how they shaped decision-making processes, and how institutional structures either enabled or constrained adaptive responses to climate risks in Dhaka. This design aligns with process-oriented climate governance research that emphasizes the importance of contextual and institutional analysis in understanding adaptation practices (Patterson et al., 2019).

Study Area and Research Context

The study was conducted in Dhaka, the capital city of Bangladesh and one of the world's most climate-vulnerable megacities. Dhaka experiences recurrent flooding, waterlogging, extreme heat, drainage congestion, and increasing pressure from climate-induced migration. Rapid population growth, extensive informal settlements, and uneven access to public services intensify urban vulnerability and place substantial pressure on governance institutions. These characteristics make Dhaka an important empirical setting for examining adaptive governance in the Global South. The research focused particularly on climate adaptation governance processes occurring at municipal and community levels. Attention was given to interactions among local government institutions, national agencies, civil society organizations, non-governmental organizations, and residents living in climate-vulnerable neighborhoods. This multi-level governance perspective reflects the adaptive governance literature, which highlights the significance of horizontal and vertical coordination among actors operating across different institutional scales (Robinson & Berkes, 2011). The study also considered how formal adaptation policies intersected with informal community practices, especially in flood-prone and low-income urban areas where local coping mechanisms frequently compensate for institutional limitations.

Data Collection Techniques

Data collection relied primarily on semi-structured interviews and document analysis, supported by relevant secondary literature. The use of multiple qualitative sources enabled methodological triangulation and strengthened the analytical depth of the study. Semi-structured interviews were selected because they provide flexibility for exploring participant experiences while maintaining sufficient consistency across respondents (O'Keeffe et al., 2016). Interviews were conducted with various stakeholders involved in climate adaptation governance in Dhaka. These included municipal officials, representatives of national government agencies, urban planners, non-governmental organizations, community-based organizations, environmental activists, and residents from climate-vulnerable communities. Interview questions explored several themes, including forms of participation, institutional coordination, perceived effectiveness of participatory mechanisms, barriers to engagement, accountability practices, and community experiences with climate adaptation initiatives. The interviews were conducted both face-to-face and through online communication platforms depending on participant availability and accessibility. Each interview lasted approximately 45–90 minutes and was recorded with participant consent.

Interview recordings were subsequently transcribed for analysis. The semi-structured format enabled participants to discuss governance challenges and adaptation experiences in their own terms while allowing the researcher to probe emerging themes related to adaptive governance and participation. Document analysis constituted the second major source of data. The documents reviewed included urban climate adaptation plans, national climate strategies, municipal development policies, donor reports, project implementation documents, and publications from governmental and non-governmental organizations operating in Dhaka. These materials were analyzed to identify formal institutional commitments to participation, policy narratives surrounding climate adaptation, and governance structures associated with urban resilience initiatives. Reviewing policy documents alongside interview data enabled the study to compare official discourses with practical implementation realities. Such comparative analysis is widely recommended in governance and policy research because it helps identify discrepancies between institutional rhetoric and practice (Munaretto et al., 2014). In addition to primary data, the study consulted scholarly literature related to adaptive governance, participatory climate adaptation, urban resilience, and governance in the Global South. Secondary sources were used to contextualize the findings and situate the analysis within broader academic debates concerning climate governance and participation.

Informants and Sampling Strategy

The study employed purposive sampling to identify participants with direct experience or involvement in climate adaptation governance processes. Purposive sampling is appropriate in qualitative research because it enables the selection of information-rich participants capable of

providing detailed insights relevant to the research objectives. Participants were selected based on their institutional roles, community involvement, or professional engagement with climate adaptation initiatives in Dhaka. The informants consisted of government officials from municipal and planning agencies, representatives of environmental and development organizations, leaders of community-based organizations, and residents living in climate-vulnerable neighborhoods. Particular attention was given to including perspectives from marginalized communities affected by recurrent flooding and inadequate infrastructure. The inclusion of diverse stakeholder groups enabled the study to capture variations in perceptions, priorities, and experiences regarding participation and adaptive governance. Snowball sampling was also used during the fieldwork process to identify additional participants recommended by earlier informants. This approach proved useful in accessing community actors and informal networks that may not have been easily identifiable through formal institutional channels. The combination of purposive and snowball sampling contributed to broader representation of governance actors and enhanced the richness of qualitative data.

Data Analysis Procedures

The collected data were analyzed using thematic analysis. This analytical approach was selected because it facilitates the identification, organization, and interpretation of recurring patterns across qualitative data sources. Thematic analysis is particularly appropriate for governance studies that seek to explore institutional interactions, perceptions, and social processes. The analysis proceeded through several stages. First, interview transcripts and policy documents were read repeatedly to achieve familiarity with the data. Initial coding was then conducted to identify references related to participation, institutional coordination, accountability, learning processes, power relations, and adaptive practices. The coding process combined deductive and inductive approaches. Deductive codes were derived from adaptive governance theory and existing literature, while inductive coding allowed new themes to emerge from participant narratives and contextual realities.

Following initial coding, related codes were grouped into broader thematic categories reflecting key dimensions of adaptive governance. These included forms of participation, inclusiveness and exclusion, multi-level governance dynamics, community learning, institutional flexibility, and accountability mechanisms. Analytical memos were used throughout the coding process to record reflections, identify relationships between themes, and support interpretive consistency. The iterative coding process enabled the refinement of themes and facilitated deeper interpretation of the interactions between participation and adaptive governance structures. To support analytical transparency, findings from interviews were continuously compared with documentary evidence and secondary literature. This comparative process strengthened interpretive rigor and allowed the study to identify convergences and contradictions between official policy narratives and community experiences.

Validity, Reliability, and Ethical Considerations

Several strategies were employed to enhance the trustworthiness of the study. First, methodological triangulation was achieved through the use of multiple data sources, including interviews, policy documents, and secondary literature. Comparing information across these sources improved the credibility of findings and reduced dependence on a single perspective. Second, the inclusion of diverse stakeholder groups enabled the study to capture differing viewpoints and minimize interpretive bias. Reflexivity was also maintained throughout the research process. The researcher continuously reflected on personal assumptions, positionality, and potential influence on data interpretation, particularly when analyzing issues related to power relations and governance effectiveness.

Maintaining reflexive awareness is considered essential in qualitative governance research because interpretations are shaped by interactions between researcher and participants (Humphreys et al., 2021). Ethical considerations were carefully integrated into the study design and implementation. Informed consent was obtained from all participants prior to interviews, and participants were informed about the objectives of the study, voluntary participation, and confidentiality procedures. Anonymity was maintained by removing identifying information from

transcripts and research reporting. Given the involvement of vulnerable communities, particular attention was paid to minimizing potential risks, avoiding coercion, and ensuring respectful engagement throughout the research process.

Table 1. Summary of Research Methodology

Methodological Component	Description
Research Design	Qualitative case study
Study Area	Dhaka, Bangladesh
Data Collection	Semi-structured interviews and document analysis
Participants	Government officials, NGOs, community leaders, residents
Sampling Technique	Purposive and snowball sampling
Data Analysis	Thematic analysis
Validation Strategy	Triangulation, reflexivity, and cross-source comparison
Ethical Measures	Informed consent, confidentiality, anonymity

Source: Developed by the author based on the research design

The overall methodological framework employed in this study. The qualitative case study design enabled an in-depth exploration of adaptive governance and public participation within the climate adaptation context of Dhaka, Bangladesh. The combination of semi-structured interviews and document analysis provided comprehensive qualitative evidence regarding governance processes, institutional dynamics, and community experiences. The use of purposive and snowball sampling ensured that participants possessed relevant knowledge and practical involvement in climate adaptation initiatives. Thematic analysis facilitated the identification of recurring patterns and relationships across the collected data, while triangulation and reflexive practices strengthened the credibility and trustworthiness of the findings. Ethical safeguards, including informed consent, confidentiality, and participant anonymity, were consistently maintained throughout the research process to ensure responsible and respectful engagement with all informants, particularly those from climate-vulnerable communities.

RESULTS AND DISCUSSION

This section presents the main findings of the study regarding public participation in adaptive governance to address the climate crisis in Dhaka, Bangladesh. The analysis is organized into several thematic sub-sections derived from the thematic coding process, namely: (1) forms and structures of public participation, (2) power relations and inclusion in participatory governance, (3) institutional coordination and multi-level governance, (4) community learning and adaptive capacity, and (5) accountability and limitations of participatory adaptive governance. The findings are based on semi-structured interviews, document analysis, and triangulation with relevant policy documents and previous studies. The presentation of the results emphasizes how participatory processes operate in practice and how institutional conditions shape adaptive governance outcomes in Dhaka.

Forms and Structures of Public Participation in Adaptive Governance

The findings reveal that public participation in climate adaptation governance in Dhaka primarily occurs through project-based and consultative mechanisms. Participation is generally organized through community meetings, workshops, awareness campaigns, and vulnerability assessments initiated by municipal authorities or development organizations. However, these participatory activities are mostly temporary and linked to externally funded adaptation projects rather than institutionalized governance mechanisms. Several participants emphasized that community involvement usually occurs during the early stages of project planning but becomes limited during implementation and evaluation processes. Government officials explained that participation is mainly intended to gather local information regarding flooding, drainage problems, and neighborhood vulnerabilities.

One municipal planning officer explained:

“Usually, when a climate project starts, we arrange meetings with local people first. We ask them about flooding areas, drainage issues, and what problems they face during heavy

rain. But after the planning stage, most decisions are discussed internally by the agencies because the projects already have fixed targets and timelines. Community people can share opinions, but they do not really decide the final policy direction.”
(Participant 3-Municipal Planning Officer)

Residents from climate-vulnerable settlements stated that participation often feels symbolic because their suggestions are not consistently incorporated into policy implementation. A resident from a flood-prone informal settlement stated:

“People from the project team came here many times and asked us questions about floods and water problems. We explained everything because we thought maybe something would change. But later, we did not really know what happened with those discussions. Some small things improved, but many of our concerns were still the same after the project ended.” (Participant 8-Community Resident)

These findings indicate that participation in Dhaka largely remains procedural rather than collaborative. Although participatory forums exist, they are often limited to consultation and information gathering rather than shared decision-making. This pattern reflects institutional dependence on top-down adaptation planning despite the increasing discourse surrounding inclusive governance.

Table 2. Forms of Public Participation Identified in the Study

Form of Participation	Main Actors Involved	Characteristics
Community consultations	Municipal agencies, residents	Conducted during project initiation
Workshops and training	NGOs, local communities	Focused on awareness and preparedness
Vulnerability assessments	Government agencies, NGOs	Data collection regarding climate risks
Community meetings	Residents, community leaders	Discussion of local environmental issues
Informal collaboration	NGOs and local groups	Small-scale adaptive responses

Source: Interview data and document analysis conducted by the author, 2026

Public participation in adaptive governance in Dhaka was implemented through several forms of interaction involving government institutions, non-governmental organizations, and local communities. The findings indicate that community consultations and vulnerability assessments were primarily initiated by municipal agencies and external organizations during the early stages of climate adaptation projects. Meanwhile, workshops, training activities, and community meetings were mainly directed toward improving public awareness, preparedness, and local coordination in responding to climate-related risks such as flooding and drainage problems. Informal collaboration between NGOs and community groups also emerged as an important mechanism for supporting localized adaptation practices, particularly in vulnerable neighborhoods with limited institutional support. However, the overall pattern suggests that participation remained largely consultative and temporary, with limited opportunities for communities to influence strategic planning or policy decisions. As a result, participatory practices functioned more as mechanisms for information exchange and short-term problem solving rather than as institutionalized forms of shared governance within climate adaptation processes.

Power Relations and Inclusion in Participatory Processes

The study also found that participatory governance in Dhaka is strongly shaped by unequal power relations. Participation opportunities are often mediated through selected community representatives, local elites, or NGO networks, which limits broader representation from vulnerable groups. Government officials acknowledged that involving all residents directly is difficult because of time, budget, and administrative constraints. As a result, institutions often rely on intermediary actors perceived as legitimate representatives of the community.

One government representative explained:

“Honestly, involving every resident is almost impossible because the city is too large and the projects move quickly. Usually, we coordinate with local leaders, NGOs, or community committees because they already know the area and can communicate with residents more easily. It makes the process faster, even though maybe not everyone gets represented equally.” (Participant 2 – Government Official)

Community members argued that this system often excludes marginalized populations, particularly informal settlers, women, and climate migrants. Many residents reported that they rarely participated in strategic planning discussions despite being among the most affected by climate-related risks.

A female resident explained:

“Sometimes meetings are held, but usually the same people attend every time. Women mostly join activities related to cleaning or awareness programs, not discussions about planning or budgets. Many families here also feel hesitant to speak because they think officials will not really listen to them anyway.” (Participant 11 – Female Community Resident)

NGO representatives similarly highlighted that informal settlement residents frequently experience exclusion due to legal and administrative barriers.

One NGO activist stated:

“A lot of people living in vulnerable settlements do not have formal land documents, so their voices are often ignored in city planning. Even though they are the ones facing floods every year, they are treated as temporary communities. Because of that, participation becomes uneven and some groups stay invisible in policy discussions.” (Participant 6 – NGO Representative)

These findings demonstrate that participation alone does not automatically guarantee inclusion. Existing social and institutional hierarchies continue to influence whose voices are prioritized within adaptive governance processes.

Institutional Coordination and Multi-Level Governance

Another important finding concerns the limited coordination between governance levels. Although national climate policies in Bangladesh emphasize participation and decentralization, the practical integration of community input into municipal and national decision-making remains weak. Municipal officials explained that adaptation planning is frequently constrained by bureaucratic procedures, fragmented responsibilities, and rigid administrative structures. Coordination between agencies was often described as inconsistent and project-dependent.

One urban planning official explained:

“There are many institutions working on climate adaptation, but coordination is still difficult. Different agencies have different priorities and budgets. Sometimes local communities provide useful information, but integrating that into formal planning takes a long process. In reality, projects usually follow predetermined guidelines from higher authorities or donors.” (Participant 4 – Urban Planning Official)

Community organizations also perceived a disconnect between local participation and actual policy influence.

A community organizer stated:

“Every year we talk about the same flooding problems, blocked drainage, and waste management issues. We attend meetings and explain what happens during the rainy season, but city planning does not really change much. People feel tired because discussions happen repeatedly without long-term solutions.” (Participant 9 – Community Organizer)

The findings suggest that adaptive governance in Dhaka still faces major institutional fragmentation. Community participation contributes to localized problem identification, but there are limited mechanisms for systematically incorporating local knowledge into broader policy frameworks.

Table 3. Main Institutional Challenges Identified in Adaptive Governance

Institutional Challenge	Description
Fragmented governance	Limited coordination between agencies
Bureaucratic rigidity	Fixed project procedures and timelines
Weak vertical integration	Community input rarely influences higher-level policy
Limited accountability	Lack of monitoring and feedback mechanisms
Unequal representation	Marginalized groups excluded from strategic decisions

Source: Interview data analyzed by the author, 2026

The findings reveal that fragmented governance structures create limited coordination among agencies responsible for climate adaptation, resulting in overlapping responsibilities and inconsistent implementation across sectors. Bureaucratic rigidity further constrains adaptive responses, as projects are often governed by fixed administrative procedures, predetermined timelines, and inflexible budgeting systems that restrict institutional learning and policy adjustment. In addition, weak vertical integration limits the incorporation of community perspectives into higher-level planning and decision-making processes, causing local knowledge and lived experiences to remain insufficiently reflected in formal adaptation policies. The study also identified limited accountability mechanisms, particularly regarding monitoring, evaluation, and public feedback, which reduced transparency and community trust in adaptation initiatives. Furthermore, unequal representation within participatory forums contributed to the exclusion of marginalized groups, including informal settlement residents, women, and climate migrants, despite their high vulnerability to climate risks. Collectively, these institutional constraints demonstrate that while participatory mechanisms are increasingly present in climate governance practices, their transformative potential remains restricted without stronger coordination, inclusiveness, and institutional responsiveness.

Community Learning and Adaptive Capacity

Despite institutional limitations, the findings indicate that participation contributes positively to community learning and localized adaptive capacity. Residents reported increased awareness regarding flood preparedness, waste management, emergency responses, and climate-related risks. Repeated engagement through workshops and community activities enabled residents to develop informal support networks and collective adaptation practices. Community-level learning emerged as one of the strongest outcomes of participatory governance initiatives.

One resident described these experiences as follows:

“Before these programs started, people mostly handled floods individually. Now, neighbors usually share information when heavy rain is coming, and we help each other move important things before water enters the houses. We also learned simple ways to keep drainage clear and organize emergency support for elderly residents during flooding.”
(Participant 10 – Community Resident)

NGO representatives also noted improvements in local preparedness and awareness.

One NGO participant explained:

“Community participation has helped residents understand climate risks more clearly. Even if the infrastructure problems are still there, people are now more organized during emergencies. Local groups have become more active in sharing information and responding quickly when flooding happens.” (Participant 5 – NGO Field Coordinator)

However, institutional learning remained limited. Government officials acknowledged that administrative procedures and short project cycles reduce opportunities for long-term adaptation and iterative policy revision.

A municipal officer explained:

“Most projects already have fixed budgets, schedules, and reporting systems from the beginning. Even if communities provide new information later, it is difficult to revise the project significantly because the administrative process is very rigid.” (Participant 1 – Municipal Officer)

These findings demonstrate that participatory governance strengthens adaptive capacity primarily at the community level, while institutional adaptation remains comparatively inflexible.

Participation, Accountability, and Governance Limitations

The findings further reveal that participation improves procedural legitimacy but has limited impact on accountability mechanisms. Residents generally expressed greater trust toward adaptation initiatives when they were consulted directly and observed visible local improvements.

One participant stated:

“When officials actually come here and talk with residents, people feel more respected. Even small improvements like cleaning drains or fixing pathways make communities feel that someone is paying attention to our problems. That creates more trust compared to projects where nobody explains anything to us.” (Participant 12 – Community Member)

Nevertheless, participants consistently emphasized the absence of formal feedback and complaint mechanisms. Communities often lacked information regarding how decisions were finalized or how adaptation budgets were allocated.

A community leader explained:

“After consultations, we usually do not receive updates about what decisions were taken or why some proposals were rejected. If promises are not completed, there is also no clear process for communities to follow up or ask questions. Because of that, many residents feel participation is only temporary.” (Participant 7 – Community Leader)

These findings indicate that participation in Dhaka remains heavily consultative and lacks strong accountability structures capable of ensuring sustained community influence over adaptation governance. The study demonstrates that public participation contributes positively to localized resilience, awareness, and social legitimacy within adaptive governance processes. However, participation remains constrained by institutional fragmentation, unequal power relations, weak accountability, and limited integration into formal decision-making structures. The findings suggest that adaptive governance in Dhaka requires stronger institutionalization of inclusive participation, greater coordination across governance levels, and more responsive accountability mechanisms to support long-term climate resilience.

Discussion

Public Participation and Power Dynamics in Adaptive Governance

The findings of this study demonstrate that public participation has become an increasingly visible component of climate adaptation governance in Dhaka, yet its implementation remains largely procedural and project-oriented rather than transformative. The interview data indicate that participation is commonly institutionalized through consultations, workshops, and vulnerability assessments conducted during the initial stages of adaptation projects. Although these mechanisms provide opportunities for community engagement, they rarely extend into strategic decision-making or long-term governance processes. This condition reflects a broader pattern identified in adaptive governance literature, where participation is often incorporated symbolically to legitimize policy interventions without substantially redistributing decision-making authority (Cleaver & Whaley, 2018; Pieraccini, 2019).

The predominance of consultative participation suggests that adaptive governance in Dhaka continues to rely heavily on top-down institutional arrangements. Government agencies and development organizations remain the primary actors determining adaptation priorities, project design, and resource allocation. Communities are generally invited to contribute local information regarding environmental risks, but they possess limited influence over final policy outcomes. This finding supports previous arguments that participatory governance in many Global South cities often functions as a mechanism for data extraction rather than collaborative governance. As a result, participation contributes more to administrative efficiency and project legitimacy than to democratic empowerment or institutional transformation.

Another important issue emerging from the findings concerns unequal representation within participatory processes (Christensen et al., 2023; Brown & Kyttä, 2018). The study reveals that participation opportunities are frequently mediated through local elites, community leaders, and NGO representatives who are considered legitimate intermediaries by government institutions. While this approach may simplify coordination and communication, it simultaneously narrows the diversity of perspectives included in adaptation governance. Vulnerable populations, particularly informal settlement residents, women, and climate migrants, often remain underrepresented despite experiencing the highest exposure to climate risks (Hussainzad & Gou, 2024; Tavares et al., 2024; Smith et al., 2026). This demonstrates that participatory governance is shaped not only by institutional design but also by existing social hierarchies and power relations operating within urban communities.

The exclusion of marginalized groups highlights a central contradiction within adaptive governance practices in Dhaka. Adaptive governance theory emphasizes inclusiveness, flexibility, and collaborative learning as foundations for resilience-building. However, the findings suggest that participation remains uneven because institutional recognition is frequently linked to legal status, political connections, or organizational visibility. Informal settlement residents, for example, are often perceived as temporary or unofficial urban populations, limiting their influence within planning processes. Consequently, adaptation governance risks reproducing existing inequalities by privileging actors with stronger institutional access while marginalizing vulnerable communities whose experiences are critical for climate adaptation planning.

The findings also reveal important gender dimensions within participatory governance. Female participants reported that women were generally involved in implementation-related activities such as awareness campaigns, sanitation programs, or emergency preparedness initiatives, but rarely participated in strategic planning discussions or budget allocation processes. This indicates that gender inclusion within adaptive governance remains largely instrumental rather than substantive. Women's participation tends to be framed in terms of community mobilization and social support rather than political influence or governance authority. Such patterns reinforce broader critiques in climate governance literature that participation alone does not automatically produce equitable outcomes unless institutional power structures are explicitly addressed (Sapiains et al., 2021).

Institutional Constraints and Community Adaptive Capacity

The second major finding of this study concerns the tension between community-level adaptive capacity and institutional limitations within climate governance in Dhaka. The results indicate that participatory initiatives have contributed positively to local learning, collective preparedness, and community resilience. Residents reported improved awareness regarding flood risks, emergency responses, waste management, and informal coordination during climate-related disasters. These findings demonstrate that participation can function as an important mechanism for strengthening adaptive capacity at the local level by facilitating knowledge exchange, social learning, and collective action among vulnerable populations (Choudhury et al., 2021; Phuong et al., 2018; Azad et al., 2022).

Community learning emerged as one of the most significant outcomes of participatory governance initiatives. Repeated interaction through workshops, awareness campaigns, and neighborhood meetings enabled residents to develop shared understandings of environmental risks and practical adaptation strategies. Informal networks among residents also became increasingly important during flooding events, particularly in organizing evacuation support, information sharing, and mutual assistance. This finding aligns with adaptive governance perspectives emphasizing that

resilience is not solely dependent on infrastructure or formal policy but also on social capacity and community cooperation.

The findings further indicate that non-governmental organizations play an important intermediary role in strengthening community adaptive capacity. NGOs often act as facilitators connecting vulnerable communities with municipal institutions, technical information, and adaptation resources (Ziervogel, 2019; Cid & Lerner, 2023). Through training activities and localized engagement, NGOs contribute to improving environmental awareness and encouraging community participation in adaptation initiatives. In many cases, NGO involvement compensates for institutional limitations within formal governance structures, particularly in informal settlements where government presence is weak or inconsistent. This highlights the importance of hybrid governance arrangements involving state and non-state actors in urban climate adaptation.

While community adaptive capacity has improved, institutional adaptation remains comparatively rigid and fragmented. Government officials acknowledged that adaptation projects are frequently constrained by predetermined budgets, fixed timelines, and administrative procedures that limit flexibility and iterative policy adjustment. This institutional rigidity contradicts key principles of adaptive governance, which emphasize continuous learning, policy experimentation, and responsiveness to changing environmental conditions. In practice, climate adaptation governance in Dhaka remains strongly influenced by bureaucratic logic rather than adaptive institutional learning.

Fragmented governance structures also emerged as a major institutional challenge. The findings reveal limited coordination among agencies responsible for urban planning, environmental management, disaster response, and climate adaptation. Different institutions often operate independently with overlapping responsibilities and inconsistent priorities. This fragmentation weakens the integration of community-generated knowledge into broader policy frameworks and reduces the effectiveness of participatory governance. Community concerns identified during consultations frequently fail to influence higher-level planning because coordination mechanisms between governance scales remain underdeveloped (Scott & Carter, 2019).

The study also highlights weak vertical integration between local participation and national policy processes. Although Bangladesh has adopted national climate adaptation strategies emphasizing participation and decentralization, local experiences and community knowledge rarely shape formal policy decisions at higher governance levels. Odongo et al. (2024) said that, community actors repeatedly expressed frustration that recurring environmental problems such as flooding, drainage congestion, and waste management continue despite repeated consultations with authorities. This disconnect demonstrates that participation without institutional responsiveness risks generating frustration and reducing public trust in adaptation governance.

Another critical issue identified in the findings concerns accountability limitations within participatory governance. Although participation contributes to procedural legitimacy and improved communication between authorities and communities, residents reported limited access to information regarding decision-making outcomes, project implementation, or budget allocation. Formal feedback and complaint mechanisms were largely absent, reducing transparency and weakening opportunities for communities to monitor adaptation commitments. As a result, participation often becomes episodic and temporary rather than embedded within accountable governance systems.

The findings therefore suggest that adaptive governance in Dhaka currently produces stronger outcomes at the community level than at the institutional level. Localized participation contributes to incremental resilience-building and social preparedness, yet structural governance weaknesses continue to constrain transformative adaptation. Community initiatives alone are insufficient to address broader urban vulnerabilities associated with rapid urbanization, inadequate infrastructure, informal settlements, and environmental inequality (Williams et al., 2019; Zerbo et al., 2020; Sandoval & Sarmiento, 2020). Without stronger institutional coordination, accountability, and policy integration, participatory adaptation risks remaining limited to small-scale and short-term interventions.

This study demonstrates that adaptive governance in Dhaka is characterized by a significant imbalance between active community adaptation and relatively inflexible institutional systems.

Participatory initiatives have strengthened local awareness, social learning, and collective responses to climate risks, indicating the importance of community engagement within urban resilience strategies. Nevertheless, fragmented governance structures, bureaucratic rigidity, weak accountability, and limited policy integration continue to restrict the transformative potential of participation. These findings suggest that strengthening adaptive governance requires not only expanding participation but also reforming institutional structures to support more responsive, inclusive, and integrated climate adaptation governance across multiple scales.

CONCLUSION

Public participation plays an important role in strengthening adaptive governance and community resilience in addressing the climate crisis in Dhaka, Bangladesh, particularly through increased environmental awareness, collective learning, and localized adaptation practices. Participatory mechanisms such as community consultations, workshops, and informal collaborations have contributed positively to preparedness and social coordination at the community level. The findings also reveal that participation remains largely procedural, temporary, and consultative, with limited influence on strategic decision-making and policy transformation. Institutional fragmentation, bureaucratic rigidity, unequal representation, weak accountability mechanisms, and limited integration of community knowledge into higher-level planning continue to constrain the effectiveness of adaptive governance. Marginalized groups, including informal settlement residents, women, and climate migrants, remain insufficiently represented within participatory processes despite their high vulnerability to climate risks. Overall, the study demonstrates that while participatory governance contributes to incremental adaptive capacity and procedural legitimacy, its transformative potential will remain limited without stronger institutional coordination, inclusive representation, policy responsiveness, and long-term integration of community participation within formal climate adaptation governance systems.

REFERENCES

- Adade Williams, P., Sikutshwa, L., & Shackleton, S. (2020). Acknowledging indigenous and local knowledge to facilitate collaboration in landscape approaches—Lessons from a systematic review. *Land*, 9(9), 331. <https://doi.org/10.3390/land9090331>
- Ali, S., Niaz, H., Ahmad, S., & Khan, S. (2025). Investigating how Rapid Urbanization Contributes to Climate Change and the Social Challenges Cities Face in Mitigating its Effects. *Review of Applied Management and Social Sciences*, 8(1), 1-16. <https://doi.org/10.47067/ramss.v8i1.429>
- Anguelovski, I., Shi, L., Chu, E., Gallagher, D., Goh, K., Lamb, Z., ... & Teicher, H. (2016). Equity impacts of urban land use planning for climate adaptation: Critical perspectives from the global north and south. *Journal of Planning Education and Research*, 36(3), 333-348. <https://doi.org/10.1177/0739456X16645166>
- Archer, D., Almansi, F., DiGregorio, M., Roberts, D., Sharma, D., & Syam, D. (2014). Moving towards inclusive urban adaptation: approaches to integrating community-based adaptation to climate change at city and national scale. *Climate and Development*, 6(4), 345-356. <https://doi.org/10.1080/17565529.2014.918868>
- Ayers, J. M., Huq, S., Faisal, A. M., & Hussain, S. T. (2014). Mainstreaming climate change adaptation into development: a case study of Bangladesh. *Wiley Interdisciplinary Reviews: Climate Change*, 5(1), 37-51. <https://doi.org/10.1002/wcc.226>
- Azad, M. A. K., Haque, C. E., & Choudhury, M. U. I. (2022). Social learning-based disaster resilience: collective action in flash flood-prone Sunamganj communities in Bangladesh. *Environmental Hazards*, 21(4), 309-333. <https://doi.org/10.1080/17477891.2021.1976096>
- Bhanye, J. (2025). A review study on community-based flood adaptation in informal settlements in the Global South. *Discover Sustainability*, 6(1), 595. <https://doi.org/10.1007/s43621-025-01449-6>

- Bovaird, T., Stoker, G., Jones, T., Loeffler, E., & Pinilla Roncancio, M. (2016). Activating collective co-production of public services: influencing citizens to participate in complex governance mechanisms in the UK. *International Review of Administrative Sciences*, 82(1), 47-68. <https://doi.org/10.1177/0020852314566009>
- Broto, V. C., Boyd, E., & Ensor, J. (2015). Participatory urban planning for climate change adaptation in coastal cities: lessons from a pilot experience in Maputo, Mozambique. *Current opinion in environmental sustainability*, 13, 11-18. <https://doi.org/10.1016/j.cosust.2014.12.005>
- Brown, G., & Kyttä, M. (2018). Key issues and priorities in participatory mapping: Toward integration or increased specialization?. *Applied geography*, 95, 1-8. <https://doi.org/10.1016/j.apgeog.2018.04.002>
- Bulkeley, H., & Tuts, R. (2013). Understanding urban vulnerability, adaptation and resilience in the context of climate change. *Local Environment*, 18(6), 646-662. <https://doi.org/10.1080/13549839.2013.788482>
- Carvalho, P., & Spataru, C. (2023). Gaps in the governance of floods, droughts, and heatwaves in the United Kingdom. *Frontiers in Earth Science*, 11, 1124166. <https://doi.org/10.3389/feart.2023.1124166>
- Chanza, N., & De Wit, A. (2016). Enhancing climate governance through indigenous knowledge: Case in sustainability science. *South African Journal of Science*, 112(3-4), 1-7. <https://doi.org/10.17159/sajs.2016/20140286>
- Choudhury, M. U. I., Haque, C. E., Nishat, A., & Byrne, S. (2021). Social learning for building community resilience to cyclones: role of indigenous and local knowledge, power, and institutions in coastal Bangladesh. *Ecology & Society*, 26(1). <https://doi.org/10.5751/ES-12107-260105>
- Christensen, H. S., Huttunen, J., Malmberg, F., & Silagadze, N. (2023). Unequal inequalities? How participatory inequalities affect democratic legitimacy. *European Political Science Review*, 15(1), 19-38. <https://doi.org/10.1017/S1755773922000479>
- Chu, E., Anguelovski, I., & Carmin, J. (2016). Inclusive approaches to urban climate adaptation planning and implementation in the Global South. *Climate Policy*, 16(3), 372-392. <https://doi.org/10.1080/14693062.2015.1019822>
- Cid, A., & Lerner, A. M. (2023). Local governments as key agents in climate change adaptation: challenges and opportunities for institutional capacity-building in Mexico. *Climate Policy*, 23(5), 649-661. <https://doi.org/10.1080/14693062.2022.2163972>
- Cleaver, F., & Whaley, L. (2018). Understanding process, power, and meaning in adaptive governance. *Ecology and Society*, 23(2). <https://doi.org/10.5751/ES-10212-230249>
- Das, S., Choudhury, M. R., Chatterjee, B., Das, P., Bagri, S., Paul, D., ... & Dutta, S. (2024). Unraveling the urban climate crisis: Exploring the nexus of urbanization, climate change, and their impacts on the environment and human well-being—A global perspective. *AIMS Public Health*, 11(3), 963. <https://doi.org/10.3934/publichealth.2024050>
- Ferrari, S. G., Kaesehage, K., De Narvaez, S. C., & Bain, A. A. (2021). Adaptation strategies for people: Mitigating climate-change-related risks in low-income and informal urban communities through co-production. *Journal of the British Academy*, 9(s9), 7-37. <https://doi.org/10.5871/jba/009s9.007>
- Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, 16(3), 253-267. <https://doi.org/10.1016/j.gloenvcha.2006.04.002>
- Foxon, T. J., Reed, M. S., & Stringer, L. C. (2009). Governing long-term social-ecological change: what can the adaptive management and transition management approaches learn from

- each other?. *Environmental Policy and Governance*, 19(1), 3-20. <https://doi.org/10.1002/eet.496>
- Fraser, A. (2017). The missing politics of urban vulnerability: The state and the co-production of climate risk. *Environment and Planning A: Economy and Space*, 49(12), 2835-2852. <https://doi.org/10.1177/0308518X17732341>
- Humphreys, L., Lewis Jr, N. A., Sender, K., & Won, A. S. (2021). Integrating qualitative methods and open science: Five principles for more trustworthy research. *Journal of communication*, 71(5), 855-874. <https://doi.org/10.1093/joc/jqabo26>
- Hussainzad, E. A., & Gou, Z. (2024). Climate risk and vulnerability assessment in informal settlements of the global south: a critical review. *Land*, 13(9), 1357. <https://doi.org/10.3390/land13091357>
- Kettle, N. P., Dow, K., Tuler, S., Webler, T., Whitehead, J., & Miller, K. M. (2014). Integrating scientific and local knowledge to inform risk-based management approaches for climate adaptation. *Climate Risk Management*, 4, 17-31. <https://doi.org/10.1016/j.crm.2014.07.001>
- Mees, H., Crabbé, A., & Driessen, P. P. (2017). Conditions for citizen co-production in a resilient, efficient and legitimate flood risk governance arrangement. A tentative framework. *Journal of Environmental Policy & Planning*, 19(6), 827-842. <https://doi.org/10.1080/1523908X.2017.1299623>
- Munaretto, S., Siciliano, G., & Turvani, M. E. (2014). Integrating adaptive governance and participatory multicriteria methods: a framework for climate adaptation governance. *Ecology and Society*, 19(2). <http://dx.doi.org/10.5751/ES-06381-190274>
- Odongo, J. O., Zhang, B., & Ma, D. (2024). Modelling citizen participation in apathetic urban communities: suggestions based on Nairobi's urban solid waste related flood risk management practices. *International Journal of Environment and Pollution*, 74(1-4), 127-153. <https://doi.org/10.1504/IJEP.2024.142560>
- O'Keefe, J., Buytaert, W., Mijic, A., Brozović, N., & Sinha, R. (2016). The use of semi-structured interviews for the characterisation of farmer irrigation practices. *Hydrology and Earth System Sciences*, 20(5), 1911-1924. <https://doi.org/10.5194/hess-20-1911-2016>
- Patterson, J., de Voogt, D. L., & Sapiains, R. (2019). Beyond inputs and outputs: Process-oriented explanation of institutional change in climate adaptation governance. *Environmental Policy and Governance*, 29(5), 360-375. <https://doi.org/10.1002/eet.1865>
- Phuong, L. T. H., Wals, A., Sen, L. T. H., Hoa, N. Q., Van Lu, P., & Biesbroek, R. (2018). Using a social learning configuration to increase Vietnamese smallholder farmers' adaptive capacity to respond to climate change. *Local environment*, 23(8), 879-897. <https://doi.org/10.1080/13549839.2018.1482859>
- Pieraccini, M. (2019). Towards just resilience: representing and including new constituencies in adaptive governance and law. *Journal of Environmental Law*, 31(2), 213-234. <https://doi.org/10.1093/jel/eqz002>
- Rahman, M. M., & Islam, M. S. (2024). Institutional dynamics and climate adaptation: unveiling the challenges and opportunities in coastal Bangladesh. *SN Social Sciences*, 4(8), 150. <https://doi.org/10.1007/s43545-024-00951-4>
- Riege, A., & Lindsay, N. (2006). Knowledge management in the public sector: stakeholder partnerships in the public policy development. *Journal of knowledge management*, 10(3), 24-39. <https://doi.org/10.1108/13673270610670830>
- Robinson, L. W., & Berkes, F. (2011). Multi-level participation for building adaptive capacity: Formal agency-community interactions in northern Kenya. *Global environmental change*, 21(4), 1185-1194. <https://doi.org/10.1016/j.gloenvcha.2011.07.012>

- Sandoval, V., & Sarmiento, J. P. (2020). A neglected issue: informal settlements, urban development, and disaster risk reduction in Latin America and the Caribbean. *Disaster Prevention and Management: An International Journal*, 29(5), 731-745. <https://doi.org/10.1108/DPM-04-2020-0115>
- Sapiains, R., Ibarra, C., Jiménez, G., O'Ryan, R., Blanco, G., Moraga, P., & Rojas, M. (2021). Exploring the contours of climate governance: An interdisciplinary systematic literature review from a southern perspective. *Environmental Policy and Governance*, 31(1), 46-59. <https://doi.org/10.1002/eet.1912>
- Scott, T. A., & Carter, D. P. (2019). Collaborative governance or private policy making? When consultants matter more than participation in collaborative environmental planning. *Journal of Environmental Policy & Planning*, 21(2), 153-173. <https://doi.org/10.1080/1523908X.2019.1566061>
- Sharma-Wallace, L., Velarde, S. J., & Wreford, A. (2018). Adaptive governance good practice: Show me the evidence!. *Journal of Environmental Management*, 222, 174-184. <https://doi.org/10.1016/j.jenvman.2018.05.067>
- Smith, R. D., Nicholls, R. J., Tebboth, M. G., & Kent, A. (2026). Persistent vulnerability and precarious futures: the limits of adaptation in 'climate migrant' informal settlements of coastal Bangladesh. *Climate and Development*, 1-18. <https://doi.org/10.1080/17565529.2026.2619446>
- Swapan, M. S. H., & Khan, S. (2022). Urban informality and parallel governance systems: Shaping citizens' engagements in urban planning processes in Bangladesh. *International Planning Studies*, 27(1), 1-17. <https://doi.org/10.1080/13563475.2021.1899902>
- Tavares, C., Pereira, R. S., Bonnin, C., Duarte, D., Mills, G., Morakinyo, T. E., & Holloway, P. (2024). A global (South) collective burden: A systematic review of the current state of climate-related hazards in informal settlements. *International Journal of Disaster Risk Reduction*, 114, 104940. <https://doi.org/10.1016/j.ijdrr.2024.104940>
- Uittenbroek, C. J., Mees, H. L., Hegger, D. L., & Driessen, P. P. (2019). The design of public participation: who participates, when and how? Insights in climate adaptation planning from the Netherlands. *Journal of Environmental Planning and Management*, 62(14), 2529-2547. <https://doi.org/10.1080/09640568.2019.1569503>
- Williams, D. S., Máñez Costa, M., Sutherland, C., Celliers, L., & Scheffran, J. (2019). Vulnerability of informal settlements in the context of rapid urbanization and climate change. *Environment and urbanization*, 31(1), 157-176. <https://doi.org/10.1177/0956247818819694>
- Zerbo, A., Delgado, R. C., & González, P. A. (2020). Vulnerability and everyday health risks of urban informal settlements in Sub-Saharan Africa. *Global health journal*, 4(2), 46-50. <https://doi.org/10.1016/j.glohj.2020.04.003>
- Ziervogel, G. (2019). Building transformative capacity for adaptation planning and implementation that works for the urban poor: Insights from South Africa. *Ambio*, 48(5), 494-506. <https://doi.org/10.1007/s13280-018-1141-9>