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Advancing Urban Climate Adaptation: Lessons from the Malaysia Adaptation Sharing Hub (MASH)

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Abstract

This paper analyses the first cycle of the Malaysia Adaptation Sharing Hub (MASH), an exploratory national knowledge-transfer and climate-adaptation acceleration network developed under the Penang Nature-Based Climate Adaptation Program (PNBCAP), the country's first urban climate adaptation program. MASH was designed to address the lack of capacity in urban climate adaptation across Malaysian cities, including limited access to localized climate data and challenges in identifying and implementing adaptation measures. Through a structured, three-step framework combining scientific input, community engagement, peer-to-peer exchange, and policy accountability, the network supports local governments in identifying, designing, and committing to concrete adaptation initiatives. As the PNBCAP adopts a nature-based solutions (NbS) approach, these solutions are a particular focus of MASH. Drawing on evidence from the first MASH cycle (2024/2025), including follow-up engagements and online policy-announcement workshops involving ten local councils, this paper documents the types of adaptation initiatives advanced, the conditions enabled by the

framework, the persisting barriers to implementation, and finally, the lessons learned. Findings show that structured, in-person, multi-sectoral engagement is effective in building trust, shared understanding, and stakeholder ownership. Follow-up one-on-one sessions are critical for translating dialogue into concrete adaptation initiatives. Cities respond best to practical, implementable tools rather than purely conceptual frameworks, and capacity needs are strongly oriented toward tailored expert support, access to climate finance, and monitoring indicators. However, the translation of commitments to implementation remains uneven. Persistent constraints, particularly in terms of staff capacity, political will, and budgets, limit progress, while leadership changes and institutional barriers disrupt continuity. Community awareness and engagement remain insufficiently addressed, despite their importance for long-term adaptation success. A total of 14 adaptation initiatives were announced, six of them adopting NbS. In addition, three local governments requested admission to the next MASH cycle (2026/2027) and were accepted, indicating growing institutional interest in and perceived value of the framework.

Keywords
Climate adaptation; urban adaptation; nature-based solutions; mainstreaming adaptation; adaptation governance; city networks; adaptation networks

1. Introduction

Climate adaptation is challenging across all development contexts, due to uncertainties regarding the magnitude, timing, and impacts of climate change. As the future cannot be reliably predicted in complex adaptive systems, efforts are more effective when focused on shaping present conditions rather than forecasting distant outcomes [1]. In the context of the Global South, these challenges are more pronounced due to higher vulnerability and limited institutional capacity. In Malaysia, urban areas are increasingly exposed to climate-related hazards, including flooding, sea-level rise (SLR), and heatwaves, and their associated impacts on public health. While national policies acknowledge climate-related risks, local authorities often lack the capacity to identify these risks, understand and select appropriate adaptation measures, and implement them effectively. The Nature-based Climate Adaptation Program for the Urban Areas of Penang Island (PNBCAP), Malaysia's first urban climate adaptation program, was designed by Think City in partnership with the local government (MBPP) and the Department for Drainage and Irrigation (JPS), to address these challenges [2]. The program was launched in 2023, funded by the Adaptation Fund (AF), with UN-Habitat as the multilateral implementing entity (MIE). An MIE is an accredited multilateral institution that directly receives and manages Adaptation Fund resources to implement adaptation projects in countries from the Global South. The institutional capacity component of the PNBCAP includes a sub-component focused on developing a knowledge transfer platform [3]. In the later stages of the program's AF funding process, it was found that similar online platforms already existed, such as the Asia-Pacific Climate Change Adaptation Information Platform (AP-PLAT: https://ap-plat.nies.go.jp/), which is funded and operated by Japan's National Institute for Environmental Studies. This platform includes multiple support resources, including risk assessment

tools, adaptation planning and capacity-building supporting documents, and financing databases. Despite the platform's usefulness and ease of use, local governments in Malaysia were largely unaware of its existence, as were most climate adaptation researchers. It was therefore reasonable to assume that the mere existence of such a platform was not sufficient to ensure that knowledge reached local governments. This led to an active outreach approach, resulting in the creation of the Malaysia Adaptation Sharing Hub (MASH).

MASH is a collaborative framework that seeks to balance top-down approaches with community involvement and to integrate scientific institutions in support of informed decision-making. Its framework was developed in 2021/2022 [4], and the first cycle was implemented in 2024/2025. MASH was created and is managed by Think City and is partially supported financially by the AF through PNBCAP's outreach and communications activities. It is not fully funded, as it was not included in the original concept note and was only identified as necessary at a later stage. The network seeks to accelerate urban climate adaptation in Malaysia by convening cities, scientific institutions, and civil society representatives to exchange knowledge and promote the adoption of concrete policies, to target two new adaptation initiatives per city annually. The first MASH cycle in 2024/2025 followed a three-step approach that combined knowledge sharing and policy commitments, requiring participating councils to announce and advance concrete adaptation initiatives formally. The outcomes of this first cycle are presented in this study, including the selected adaptation initiatives, key barriers identified, and lessons learned.

2. Materials and Methods

This study adopts a qualitative, exploratory case study approach to analyze the design, implementation, and early outcomes of MASH as a knowledge-transfer and policy-acceleration platform for urban climate adaptation in Malaysia. This approach was chosen because the research focuses on understanding the first MASH cycle within its institutional and social context, where the boundaries between the initiative and context are not clearly defined. A qualitative case study enables in-depth, context-sensitive inquiry into the processes, stakeholder interactions, and emergent outcomes that quantitative or experimental designs cannot adequately capture. The analysis focuses on the first MASH cycle (2024/2025), implemented under the PNBCAP. Primary materials include qualitative document analysis of official project documentation, including technical reports, workshop agendas, presentation materials, and records of policy announcements made by participating city councils during online meetings. These documents were complemented by meeting minutes of MASH activities, including a two-day in-person knowledge exchange workshop held in Penang in October 2024, structured follow-up engagement sessions with the ten local governments participating conducted between April and July 2025, and subsequent online policy announcement sessions held between September and October 2025. The one-on-one sessions were not part of the original three-step framework, having been created to address the city officials' lack of confidence in the suitability of different initiatives. These meetings focused on identifying and discussing city-specific climate risks, institutional constraints, data gaps, and feasible adaptation initiatives and future pathways. Detailed notes from these engagements were used to document local adaptation priorities and the types of policy initiatives considered or announced. The qualitative document analysis was used to examine and interpret the materials generated, including technical reports, workshop records, policy announcements, and follow-up session notes.

This approach provided descriptive and interpretive insights into the design, implementation, and outcomes of the MASH framework, as well as the factors influencing the transition from planning to implementation.

The analytical framework focused on three dimensions: (1) the institutional design of the MASH framework, including stakeholder composition and procedural structure; (2) the nature and scope of adaptation initiatives announced by participating cities, with particular attention to nature-based solutions (NbS); and (3) enabling and constraining factors influencing the transition from adaptation planning to implementation readiness. Data were coded thematically to identify patterns related to governance mechanisms, knowledge transfer processes, accountability structures, and policy outcomes. This process enabled the identification of key enabling factors and implementation barriers. The analysis emphasizes descriptive and interpretive insights rather than causal attribution, reflecting the early-stage and learning-oriented nature of the MASH initiative.

The following methodological boundaries were set for this analysis. First, the analysis is restricted to a single MASH cycle (2024/2025), which limits the findings as specific to the inaugural implementation of the framework; subsequent cycles are not examined. Second, the study primarily relies on meeting minutes, workshop agendas, technical reports, and documented policy announcements. To capture informal dynamics and off-record stakeholder reservations, additional data sources (e.g., semi-structured interviews or anonymous surveys) would be required, a deliberate scoping decision given the early-stage, exploratory nature of the research. Third, self-reported commitments by city councils are treated as announced policy intentions rather than independently verified implementation outcomes, as the study period concluded shortly after the announcement step. Further research will examine the implementation (or not) of the announced policies and their impacts. Fourth, the lead author participated in the design and facilitation of MASH activities, which informs contextual understanding but also introduces potential interpretive bias. The authors address this by grounding the analysis in formal, verifiable project documentation rather than subjective impressions; focusing on descriptive and interpretive analysis instead of judging programme success; involving multiple authors across practitioner and independent academic institutions to ensure external oversight and triangulation; and explicitly adopting a reflexive embedded case-study approach that recognises researcher positionality. Transparency of methods and sources is emphasized so readers can independently assess the interpretations.

The analysis is designed to generate transferable insights for advancing urban climate adaptation in Malaysia, Southeast Asia, and beyond, though it remains tentative given its exploratory scope.

3. The Malaysia Adaptation Sharing Hub Framework

3.1 The Challenge of Accelerating Urban Adaptation in Malaysia

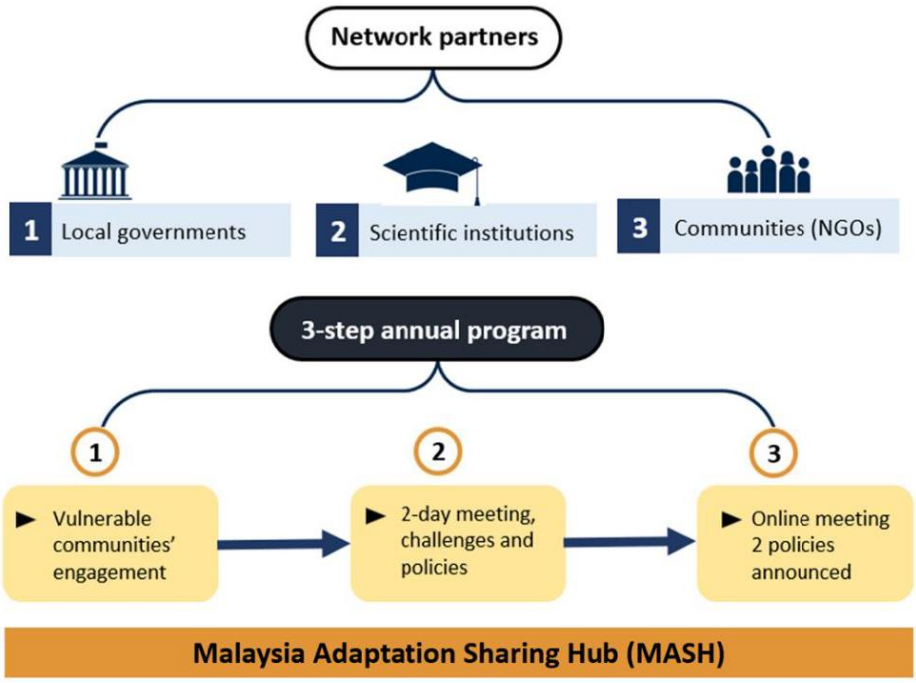
Implementing urban climate adaptation initiatives in Malaysia remains a significant challenge despite the country's growing exposure to climate-related impacts. Key risks include rising temperatures, intensified rainfall, and shifts in rainfall patterns, all of which contribute to recurrent flooding. While climate change is acknowledged in the country as a policy concern, urban adaptation efforts remain fragmented, reactive, and insufficiently embedded within governance and planning systems [5, 6]. The absence of a National Adaptation Plan (NAP), currently under development, has limited the translation of climate objectives into coordinated and actionable local strategies. Urban areas are particularly vulnerable, as Malaysia is among the most urbanized countries in Southeast

Asia; however, national climate frameworks rarely address the challenges of urban heat, the urban heat island (UHI) effect, or related adaptation measures, such as NbS for urban heat adaptation [7]. Instead, urban adaptation initiatives have largely focused on flood management, often relying on conventional grey infrastructure approaches that, despite their merits, fail to address systemic and long-term vulnerabilities. This has resulted in constraints on the adoption of integrated solutions that deliver co-benefits for climate resilience, public health, and social resilience. Institutional capacity gaps further hinder progress. Local authorities often lack the technical expertise, financial resources, and cross-sectoral coordination mechanisms necessary to design and implement adaptation measures such as NbS, and face significant limitations in accessing and producing the data needed to support evidence-based decision-making [8, 9]. Governance structures remain siloed, limiting collaboration between urban planners, environmental agencies, public health institutions, and civil society. For NbS specifically, these challenges are compounded by difficulties in quantifying their benefits, which weakens their perceived legitimacy in decision-making processes [10, 11]—knowledge transfer and scaling also present major challenges. Pilot projects may demonstrate the potential of NbS to address urban climate risks, yet mechanisms to systematically capture, codify, and disseminate insights gained at a national scale are largely absent. Without a more structured knowledge-sharing system, successful local initiatives fail to inform broader urban adaptation efforts or other similarly small initiatives in different cities. Addressing these challenges requires not only access to data and technical solutions but also transformative governance systems that embed learning, collaboration, and flexibility at the core of Malaysia's urban adaptation agenda.

3.2 Framework Proposed

The need for a knowledge-transfer and governance framework designed to accelerate urban climate adaptation emerged from the recognition that while pilot projects such as the PNBCAP generate substantial technical, social, and institutional knowledge, this knowledge often remains localized and is not translated into broader policy and practice across cities. MASH addresses this critical adaptation challenge: the implementation gap between the availability of evidence and the adoption of concrete adaptation policies by local and state governments. Rather than focusing solely on technological innovation, the framework emphasizes procedural, relational, and institutional innovation, drawing on systems of innovation theory, change management theory, and collaborative governance research.

At its core, MASH functions as a coalition-based adaptation accelerator, bringing together three key actor groups, as shown in Scheme 1: local governments, as policy adopters and implementers; scientific and academic institutions, as providers of applied, evidence-based knowledge; and civil society organizations (CSOs), as representatives of community knowledge, social vulnerability, and the lived experience of climate impacts. This structure ensures that adaptation knowledge is not only scientifically robust but also socially grounded and politically actionable. MASH's framework is analytically significant for three reasons. First, its cyclical design reinforces that adaptation is an iterative process. Second, local governments are central to the process, supported by scientific institutions and CSOs, reflecting the fact that effective adaptation requires co-production among evidence, lived experience, and policy authority. Third, it operationalizes the claim that structured, repeatable processes, not just awareness, drive implementation.



Scheme 1 MASH's three-step framework.

3.2.1 Conceptual Foundations

The design of the framework integrates insights from different change and innovation theories [4]. From systems of innovation theory, it adopts the idea that adaptation depends on dense networks of actors, feedback loops, and institutional learning rather than linear policy diffusion. From Kotter's change model, MASH focuses on urgency, coalition-building, shared vision, and action. Rogers' diffusion of innovations theory highlights the roles of communication channels, social systems, and time in the spread of adaptation practices. At the same time, Senge's learning organization model emphasizes shared mental models, team learning, and continuous reflection. Together, these foundations position MASH as a learning-oriented governance network, designed to normalize climate adaptation within municipal decision-making rather than treating it as an exceptional or externally driven agenda.

3.2.2 The Three-Step Annual Approach

MASH operationalizes its framework through a structured 3-step annual cycle, shown in Scheme 1 and repeated annually to build momentum, trust, and cumulative policy change.

- Step 1: Vulnerable Communities Engagement. The cycle is initiated with a community-level engagement, focusing on vulnerable groups such as low-income households, women, elderly populations, migrants, and flood- or heat-exposed neighborhoods. These engagements may be conducted by any of its members and are intended to document experienced climate impacts, coping strategies, and unmet needs. The output is a short report capturing the impacts of climate change on local communities, ensuring that adaptation priorities remain grounded in social vulnerability and local voices.
- Step 2: In-Person Knowledge Exchange and Co-Creation. The second step is a two-day in-person meeting on Penang Island. This is the network's central event, designed to build trust

among partners. During the meeting, PNBCAP stakeholders share progress, evidence, and lessons learned; Scientific institutions present the latest research on climate impacts and NbS effectiveness; CSOs convey community concerns and social dimensions of risk; City governments share successful initiatives and challenges. A key feature of this step is a policy co-creation session in which participants collectively explore a menu of adaptation policy options with varying levels of ambition. This approach encourages ownership and feasibility.

- Step 3: Policy Commitment and Accountability. The third and final step is an online meeting where participating city governments formally announce two new climate adaptation policies to be adopted in the following year. This meeting creates accountability, reinforces peer learning, and demonstrates political commitment.

A post-project review in the following year will evaluate progress, identify barriers, and provide useful learnings for the following cycle.

3.2.3 Intended Outcomes and Transformative Potential

MASH sets an explicit target for each member city to adopt two new adaptation policies per cycle. While incremental, this approach is designed to compound over time, fostering the institutional normalization of climate adaptation. Beyond policy outputs, it aims to reshape governance cultures by building trust, reducing silos, valuing community knowledge, and embedding NbS within mainstream urban planning. In this sense, it is not only a dissemination platform but a framework that seeks to achieve systemic change by translating pilot-project knowledge into consistent city-level adaptation action.

3.3 MASH'S First Cycle 2024/2025

The first cycle comprised ten local governments, all of which attended the first MASH workshop held in October 2024 alongside other organizations.

- Local governments
  - Penang Island City Council (host city)
  - Seberang Perai City Council
  - Sibu City Council
  - Segamat City Council
  - Miri City Council
  - Kota Kinabalu City Hall
  - Petaling Jaya City Council
  - Muar Municipal Council
  - Sandakan City Council
  - Shah Alam City Council
- Key organizations
  - Think City (host organization)
  - Department of Irrigation and Drainage (JPS)
  - Penang State Government
  - UN-Habitat
  - PLANMalaysia
  - Ministry of Natural Resources, Environment, and Climate Change (MNRECC)

  - Penang Green Council
- Academic and Scientific Institutions (universities and research bodies represented in the knowledge-sharing sessions)
  - Tsinghua University Innovation Center in Zhuhai (China)
  - National Water Research Institute of Malaysia (NAHRIM)
  - Center for Environment, Technology and Development (CETDEM)
  - River Engineering and Urban Drainage Research Center (REDAC)
  - Institute for Global Environmental Strategies (IGES, Japan)
  - The Institution of Engineers, Malaysia (Penang Branch)
  - Khazanah Nasional Berhad (listed under research/industry category)
- Civil Society Organizations (CSOs)
  - Klima Action Malaysia (KAMY) (CSO coordinator)
  - Jaringan Ekologi dan Iklim (JEDI)
  - SAVE Rivers
  - Partners of Community Organisations Trust (PACOS Trust)
  - Mercy Malaysia (Malaysian Medical Relief Society)
  - Friends of Bukit Kiara (FoBK)
  - Forever Sabah
  - Zero Waste Malaysia
  - Malaysia Nature Society
  - Southern Volunteer Batu Pahat

3.4 Stakeholder Engagement: The Meeting in Penang (Step 2)

The second and most important of the three steps is the two-day in-person meeting with all stakeholders, held in Penang in October 2024. It was a central component of the framework and served as the core event for multi-sectoral dialogue, knowledge exchange, and collaborative planning. It sought to foster a sense of ownership and collective commitment among stakeholders, while building trust among partners.

The first meeting (Figure 1) focused mainly on knowledge sharing. It brought together a diverse group of 62 participants from local governments, civil society, academia, and scientific and policy-making institutions. It focused on sharing knowledge, best practices, and scientific updates related to urban climate adaptation. Participants included all partners and other guests, such as national agencies like PLAN Malaysia and the Ministry of Natural Resources, Environment, and Climate Change (MNRECC).

Figure 1 Meeting in Penang, October 2024.

The agenda was focused on two main topics: (1) climate impacts in Malaysia, and (2) adaptation strategies and their efficacy. It was structured around three main components: (a) the presentation of the MASH framework and its objectives; (b) thematic group discussions on adaptation priorities; and (c) a collective synthesis session to identify actionable outcomes. The opening remarks by the organizing team emphasized the importance of inclusive stakeholder participation in accelerating urban adaptation in Malaysia. They highlighted the need to transition from isolated pilot projects to scalable strategies aimed at systemic change. KAMY, the CSO coordinator, presented the engagement with vulnerable communities (Step 1), demonstrating climate-related impacts specific to women and girls. The event culminated in a Policy Brainstorming Session to identify potential adaptation initiatives and policies, during which examples of policies were discussed; some are shown in Table 1.

Table 1 Examples of city-level policies to be adopted, organized by challenge and effort level (1-lowest to 4-highest), presented at the Penang meeting.

Examples of policies to be adopted					
Challenge/Effort level	1. Urban Heat	2. Flooding (due to rainfall)	3. Sea Level Rise (SLR)	4. Public Health	5. Disaster Risk Reduction (DRR)
A. Training	1.A. Annual 2-day training landscape department on the strategic impact of greening on temp.	2.A. Annual 2-day training together with JPS on the causes and risks of flooding.	3.A. Annual 2-day training at the urban planning department.	4.A. Annual 2-day training in hospitals on heat.	5.A. Annual 2-day training in DRR.
B. Risk mapping/ prevention	1.B. Adopt ACResT (under the Landscape department).	2.B. Map potential upstream retention areas near rivers in available land.	3.B. Map areas at risk of SLR 2050.	4.B. Identify risk areas for extreme heat; list demographics more impacted.	5.B. Identify main extreme risks, linking with necessary mitigation measures.
C. Develop plan/ pilot project	1.C. Develop an urban heat plan.	2.C. Develop an upstream retention/blue corridors pilot project.	3.C. Develop a mangrove pilot project for an area at high-risk of SLR.	4.C. Develop an annual plan targeting risk areas and vulnerable demographics to raise awareness.	5.C. Develop action plans for heat waves and floods.
D. Comprehensive approach	1.D. Develop an urban greening plan focused on reducing the heat.	2.D. Develop an NbS flood mitigation plan.	3.D. Develop an NbS mitigation plan for SLR.	4.D. Create a CC public health task force.	5.D. Create a DRR unit.

The meeting in Penang successfully demonstrated the effectiveness of NbS and inclusive stakeholder engagement in shaping urban climate adaptation, highlighting that the primary barrier is not a lack of climate finance but rather a shortage of well-prepared, bankable local projects. Key challenges include a funding gap for sustaining the MASH network itself, low awareness among local governments of existing tools and data, and fragmented coordination that leaves rural and Indigenous communities disproportionately vulnerable. The broader implications position PNBCAP and MASH as a replicable model for the region, underscoring the urgent need for integrated knowledge platforms, gender-sensitive policies, and stronger public-private collaboration to systematically build resilience and accelerate the adoption of local adaptation policies across Malaysia.

3.5 Follow-Up Sessions

The meeting in Penang successfully established a foundational knowledge base, covering scientific data on climate impacts (heat, rainfall-induced flooding, and SLR), public health effects, and insights from CSOs. As it became apparent that local government officials required guided interpersonal engagement, individual follow-up sessions were organized between the MASH management team and participating cities, in April-July 2025, to discuss their specific, localized challenges and collaboratively examine tailored, actionable recommendations for overcoming these issues. The one-to-one follow-up sessions were conducted with 9 city councils, all of which are MASH local government partners. The city councils are Sibu Municipal Council, Segamat Municipal Council, Miri City Council, Kota Kinabalu City Hall, Petaling Jaya City Council, Muar Municipal Council, Sandakan City Council, Seberang Perai City Council, and Penang Island City Council. The latter did not announce new policies (as the PNBCAP is currently being implemented), but its participation was valuable for knowledge sharing. During these sessions, participating local governments shared insights on their cities' unique contexts and key climate issues and challenges. Think City worked with each city council to identify and propose several actionable recommendations, outlining key focus areas and next steps for each city. The list of actionable recommendations included adopting the Atlas of Climate-Resilient Street Trees (ACREST) and Coastal Risk Screening Tools for systematic, climate-informed urban planning across all participating councils.

The Step 3 sessions, during which the initiatives were announced, took place in September and October 2025 and marked a crucial transition from theory to practical implementation and accountability. A notable outcome was the sharing of tangible policy progress and on-the-ground initiatives, including MBPP's innovative NbS implementations (such as using soy-based soil), as well as a clearer identification of persistent challenges like severe flooding and SLR in Miri and Sandakan.

Follow-up engagement with Shah Alam City Council did not take place during this period due to leadership changes and the council's extensive schedule related to its 10th anniversary celebrations. In addition, the officer who attended the MASH workshop was unavailable for three months, which further delayed the scheduling of a follow-up session.

4. Results

The initiatives announced are presented in Table 2.

Table 2 Initiatives announced online by local governments to be implemented in 2026.

Initiatives announced by local governments			
No	**Local Government**	**Key Area**	**Initiatives Announced (I1 - Initiative 1; I2 - Initiative 2)**
1	Sibu Municipal Council	Waste management, Vulnerable Communities.	I1: Environmental Sustainability Initiative Climate Action by SMC I2: Community Consultation with Vulnerable Groups.
2	Segamat Municipal Council	Heat	I1: One Air Conditioning, One Tree Initiative. I2: *Shade & Shelter* Program.
3	Miri City Council	-	-
4	Kota Kinabalu City Hall	Flood mitigation, Vulnerable Communities.	I1: NbS & Coastal Infrastructure to be Planned for the Waterfront. I2: Community Consultation with Vulnerable Groups.
5	Petaling Jaya City Council	Flood mitigation, Vulnerable Communities.	I1: Construction of NbS Retention Pond & River Overflow Control System (SKALIS). I2: Community Consultation with Vulnerable Groups.
6	Muar Municipal Council	Waste management, Vulnerable Communities.	I1: Solid Waste Management, MPM Proposal. I2: Community Consultation with Vulnerable Groups.
7	Sandakan Municipal Council	Waste management, Vulnerable Communities.	I1: PLUS Program (Pusat Lestari Upcycle Sandakan). I2: Community Consultation with Vulnerable Groups.
8	Seberang Perai City Council	Energy Efficiency & Flood Mitigation.	I1: Smart Solar Streetlights. I2: NbS Flood Mitigation Project for Jalan Tembikai
9	Penang Island City Council	Heat, Flood Mitigation, Vulnerable Communities, Public Health.	PNBCAP Implementation
10	Shah Alam City Council	-	-

The third step of MASH resulted in the announcement of 14 measurable adaptation initiatives across participating cities, six of them incorporated NbS. Some city councils did not present a second initiative, but agreed to conduct a community consultation with vulnerable groups on climate impacts in their respective places. The initiatives announced address flood mitigation, urban heat

reduction, coastal resilience, waste management, energy efficiency, and public health. Examples include flood-mitigation NbS infrastructure in Seberang Perai and Petaling Jaya, urban greening and heat reduction programs in Segamat, coastal NbS interventions in Kota Kinabalu, circular-economy waste projects in Muar and Sandakan, and integrated environmental and digital engagement strategies in Sibu. Collectively, these initiatives demonstrate a shift from planning to early-stage implementation. Three patterns are identified. First, community consultation with vulnerable groups appeared in five councils, possibly because of its non-binding nature. Second, waste management initiatives announced by smaller municipalities (Sibu, Muar, Sandakan) may imply that these are easier for cities with limited capacity. Third, NbS feature prominently in flood mitigation (Petaling Jaya, Seberang Perai, Kota Kinabalu) and are present for heat response only in Segamat. This suggests that NbS for addressing heat remains less familiar to Malaysian officials. The absence of announcements from Miri and Shah Alam highlights how leadership changes and staff availability can impact participation.

A post-session survey of the 14 participants revealed that the most significant challenges cities anticipate in implementing the policies are staff capacity, political will, and budget constraints (25% each). These were followed by limited technical expertise (16.6%) and low levels of citizen awareness and support (8%). Regarding the types of workshops that would be most valuable, respondents preferred accessing climate finance and preparing grant proposals and developing city-specific monitoring indicators for adaptation policies (each at 28.6%), followed by community engagement and communication masterclasses (21.4%) and hands-on training on Stormwater Management/LID design (14.3%); deep dives on Urban Heat Mitigation strategies were selected by only 7.1%. As for the format of support they considered most useful, one-on-one advisory sessions with experts were rated highest (42.8%), followed by in-person workshops (28.6%) and detailed written guides and toolkits (28.6%). Respondents rated the MASH policy discussions as very useful (71.4%), with 14.3% finding them extremely useful and 14.3% moderately useful.

Three local governments have requested to join the network for its second cycle (2026-2027): Batu Pahat Municipal Council, Yong Peng District Council, and Kuala Lumpur City Hall.

5. Discussion

The main lessons learned from MASH's first cycle and the barriers to implementation identified during the process are presented below.

Key insights gained from MASH's first cycle:

- Structured, in-person, multi-sectoral engagement is effective in building shared understanding, trust, and ownership among diverse urban stakeholders.
- Combining knowledge exchange with follow-up individual sessions helps translate dialogue into concrete, measurable adaptation initiatives.
- Cities respond best to practical, implementable tools (e.g., ACREST, risk screening tools) rather than purely conceptual frameworks.
- Capacity-strengthening needs are strongly oriented toward tailored expert support, access to climate finance, and monitoring indicators.

Barriers to implementation:

- The translation of commitments into implementation remains uneven, with some cities unable to announce initiatives.

- Key constraints (staff capacity, political will, and budget) continue to limit the pace and scale of action.
- Engagement gaps emerged due to leadership changes, which are common in Malaysia, and institutional constraints in certain city councils. This issue should be addressed during the planning of the next cycle.
- Community awareness and support remain comparatively under-addressed despite their relevance for long-term adaptation success.

Additional insights were gained. Local governments demonstrated widely varying capacities to understand the challenges and address them. Access to localized, usable climate data remains a significant challenge. Cities consistently reported difficulties translating national or global datasets into municipal decision-making. It became clear that many local governments lack the capacity to lead urban climate adaptation, requiring sustained facilitation structures. Multi-level governance and peer learning networks can accelerate a shift from pilot projects to systemic adaptation. Embedding NbS and public health considerations within urban planning frameworks shows promise for integrated resilience outcomes. The demand for advisory support and finance-oriented capacity building highlights the importance of linking local adaptation planning to national and international climate finance mechanisms.

As for the theories that supported the development of MASH, the findings confirm some of the framework's underlying theoretical assumptions and challenge others [2]. The findings support both the collaborative governance theory [12] and Rogers' Diffusion of Innovations Theory [13]. In line with collaborative governance, the structured, in-person, multi-sectoral engagement was shown to build trust and shared understanding, leading to 14 concrete policy announcements. Consistent with Rogers' theory, the framework functions as a deliberate communication channel within a social system, enabling cities to progress from knowledge to decision within a structured annual cycle, with peer learning and practical tools driving adoption. The findings, however, challenge Kotter's 8-Step Change Model, particularly its assumption that creating urgency is the primary driver of organizational change [14]. In the context of climate adaptation, raising awareness of climate risks does not appear sufficient, as the main constraints identified were staff capacity, political will, and budget, rather than a lack of urgency. Similarly, Lewin's Change Model [15] is only partially supported by the findings regarding its "refreezing" stage. Implementation remains uneven, and frequent leadership changes disrupt continuity, indicating that adaptation governance is non-linear and reversible rather than stabilizing into a permanent end state. Indeed, in the context of ongoing and unpredictable climate change, adaptation cannot be conceptualized as a stable process of institutional "refreezing", but rather as one of continuous and ongoing adjustment.

This study contributes to the climate adaptation governance literature by providing empirical evidence from the first implementation cycle of a knowledge transfer and policy network in the Global South. It draws on a case where adaptation is shaped less by technical knowledge sharing than by trust-building, peer learning, accountability, and tailored expert support. The MASH case demonstrates that access to information alone is insufficient to drive implementation. Instead, intermediary governance structures are required to translate knowledge into action. Through facilitation, sustained engagement, and context-specific support, such structures help overcome institutional capacity constraints and enable cities to move from planning to implementation. In this process, MASH operates as a collective intermediary, advocating for improved data access and standardized tools, thereby underscoring the importance of data intermediation within adaptation

governance networks. Overall, the findings show how structured knowledge-sharing networks can support the initiation of municipal climate adaptation initiatives. They offer transferable lessons for cities in the Global South seeking to bridge the gap between planning and implementation.

Several limitations should be acknowledged. First, this study analyzes only the first cycle of the network (2024/2025). As such, it captures announcements of initiatives rather than verified implementation outcomes. Second, the exploratory single-cycle design limits the generalization of findings. Extrapolation from this study to other networks, countries, or future MASH cycles should be made cautiously, as contextual factors (institutional settings, political support, funding availability) may differ substantially. Third, the survey data, while informative, are based on a limited sample size (n = 14 respondents among participating city representatives), which restricts the statistical generalizability of the quantitative findings (e.g., perceived barriers and workshop preferences). These results should therefore be interpreted as indicative of emerging patterns rather than representative of all Malaysian local governments. Despite these limitations, the study provides context-specific insights into how a structured knowledge-transfer network can operate in a Global South setting. This study also feeds directly into future research on subsequent MASH cycles, during which the implementation of initiatives and evolving dynamics will be documented. In the second cycle (2026/2027), indicators of success, such as implementation rates and policy uptake, as well as evidence of impact, will be documented and published.

The development of MASH has coincided with the emergence of two other adaptation-focused networks: the *AdaptationHubs* project in Europe [16], launched in late 2025, and the *G7 Adaptation Accelerator Hub* (also known as *The Adaptation Accelerator Hub*) [17], launched in 2024. Both initiatives share a similar focus on advancing climate adaptation through knowledge exchange and collaboration. The *AdaptationHubs* project is the initiative most structurally comparable to MASH. It operates through a network of 27 National Hubs supported by a Central Support Facility, using peer learning and twinning approaches to translate adaptation strategies into action. This model closely mirrors MASH's emphasis on structured, multi-stakeholder processes involving governments, experts, and communities to support implementation. The primary difference lies in scale: while MASH is a national network operating in Malaysia, *AdaptationHubs* spans multiple countries across Europe. The *G7 Adaptation Accelerator Hub* also differs from MASH in scale and scope. Although it similarly seeks to accelerate adaptation action, it functions primarily as a high-level financing mechanism that supports partner countries in transforming National Adaptation Plans into bankable investment portfolios. This contrasts with MASH's grassroots, peer-learning approach focused on strengthening the implementation capacity of local governments. Despite these differences, all three initiatives are founded on a common recognition that a major challenge in climate adaptation is the implementation gap. Consequently, they emphasize structured pathways, peer-to-peer exchange, and formal accountability mechanisms to address institutional capacity constraints and facilitate the transition from planning to action. Given its recent launch, *AdaptationHubs* has not yet reported implementation outcomes. In contrast, the *G7 Adaptation Accelerator Hub* has already announced an investment-focused initiative in Ethiopia targeting critical sectors, including water, agriculture, and infrastructure, as well as technical support activities in several other partner countries.

6. Conclusions

The first cycle of MASH demonstrates that structured, peer-based knowledge-transfer platforms can accelerate urban climate adaptation in contexts of limited capacity. By linking scientific knowledge, community engagement, and policy accountability, the network enabled Malaysian cities to commit to concrete adaptation actions and engage in structured discussions on shared climate-related challenges. Future cycles should place greater emphasis on implementation support and outcome monitoring.

Importantly, accelerating urban adaptation depends less on raising awareness of climate risks and more on creating pathways that translate knowledge into action. Mediation networks, therefore, play a critical role in this process. The combination of facilitated peer learning, policy dialogues, and follow-up commitments proved effective in addressing institutional inertia and planning fatigue, though not without limitations. Access to localized, decision-relevant climate data remains a significant challenge, underscoring the importance of embedding data-intermediation functions within adaptation governance frameworks. Together, these findings suggest that adaptation platforms should prioritize governance design, accountability mechanisms, and institutional embedding alongside technical innovation. As climate impacts intensify, the network offers a scalable approach for strengthening urban adaptation capacity in the country. The recent emergence of initiatives such as *AdaptationHubs* and the *G7 Adaptation Accelerator Hub* provides further evidence that MASH is aligned with a broader international shift towards implementation-oriented adaptation networks, suggesting that its design responds to challenges increasingly recognized across adaptation policy and practice.

Despite limitations, the insights gained from MASH are relevant beyond Malaysia, particularly for other Global South countries seeking to bridge gaps among adaptation knowledge, planning, and implementation. The three-step model demonstrates potential for replication at the regional level and beyond to advance urban adaptation.

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Artificial intelligence (AI) tools were used solely for basic grammar correction and language refinement in the preparation of this manuscript. Specifically, OpenAI's ChatGPT was employed to improve the readability and linguistic clarity of the English text. All scientific content, data interpretation, and conclusions were developed independently by the author. The authors have thoroughly reviewed and edited the AI-assisted text to ensure its accuracy and accept full responsibility for the content of the manuscript.

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