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Perspective

Subaltern forms of knowledge are required to boost local adaptation

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SUMMARY

Evidence shows that current adaptation planning approaches are not always successful in generating actionable knowledge to guide implementation on the ground. There remains a persistent disconnect between the production of (physical) climate science and the implementation of practical, local, and context-specific adaptation actions. We argue for a need to incorporate "subaltern" knowledge (i.e., that which is typically labeled local, traditional, or indigenous knowledge) in climate adaptation science and practice. Building on recent comparative assessment studies, we identify limitations of current local adaptation action in its typical application of scientific knowledge and illustrate key pathways through which the subaltern can be integrated to better inform current approaches. We argue that subaltern knowledge can be a critical source of innovation and can help to broaden the adaptation solution space by enhancing both the effectiveness and the social legitimacy of actions.

INTRODUCTION

Cities and localities are important sites of climate adaptation action. In addition to housing a majority of the world's population, cities are forecasted to continually grow in size over the coming decades.[1] Cities and localities are also facing increasing risks from flooding, heat, drought, sea level rise, loss of biodiversity, and other severe hazard impacts.[2–4] Given the relative concentration of key infrastructure and assets in cities, climate change can lead to high levels of economic loss and loss of human lives. For example, sea level rise and storm surges are projected to cost coastal cities US$50–60 billion per year by 2050 and affect more than 800 million people globally.[5] Approximately 410 million people in urban areas will experience severe drought-induced water scarcity under a 2°C warming scenario.[6] Climate impacts in one locality may also lead to cascading events across regions as cities are linked via myriad transportation, migration, and trade networks.[7,8] Many cities might be highly vulnerable to more than one climate impact.[9] Vulnerable and historically disadvantaged communities—especially those in the Global South or less resourced cities and localities in the Global North—will disproportionately shoulder the costs of climate change as well as its negative implications for health, livelihoods, and economic security.[9–12]

There is thus a need to mobilize efforts to reduce climate impacts and risks to urban communities and infrastructure. A large number of initiatives have emerged over the past decade; hundreds (and possibly thousands) of cities and localities across the world are preparing for climate change through plans, policies, privately supported projects, and community-based actions.[13–23] Many of these efforts focus on assessing local risks and building internal local capacity, leadership, and resources to plan for future risks.[24] Although efforts over the past decade have increased awareness of climate change in cities and localities worldwide, recent scientific assessments of these efforts paint a very mixed picture about the extent to which adaptation outcomes have been broadly effective, equitable (especially across divides in wealth, education, ethnicity, religion, age, gender, abilities, values, or worldviews), and legitimate across different social and geographical contexts.[25–28]

The availability and use of technical scientific knowledge—together with the capacity to generate new knowledge over time and in response to ongoing climate impacts—is one of the main drivers of local climate adaptation planning.[29–32] This includes integrated assessments of future climate scenarios, socioeconomic vulnerabilities, and evaluations of potential adaptation actions in light of political, ecological, economic, and governance constraints. In each step of the decision-making process, technical scientific knowledge helps to justify adaptation decisions among competing demands and limited resources and support effective management and prioritization of adaptation actions. At the same time, local expectations, capacities, and priorities also shape adaptation decision-making,[33–35] suggesting that the scope of knowledge we consider must be wider and also include sources from the bottom up. We call that knowledge, which is typically labeled local, traditional, or indigenous knowledge, "subaltern" knowledge,[36] because it is most often excluded from dominant knowledge-making and expert-led practices. In the varying social landscape of urban (and urbanizing) settings, subaltern knowledge is often linked to experiential knowledge, which may also include experiences that are not directly tied to a given place, such as knowledge of migrants.[37,38] A key challenge for urban adaptation is to find ways to incorporate multiple forms of knowledge[39] (including both technical scientific and subaltern), while also balancing competing imperatives for credibility, salience, and legitimacy,[32] to continuously inform and reflect on adaptation practice.[27]

The need to produce usable knowledge through integrated climate assessments or by including users in the process of knowledge generation across different stages of decision-making is not new.[39,40] While adaptation must occur across different scales from street and city to regional, national, and international levels to avoid transboundary cascading climate direct or indirect impacts[41] (e.g., ground or surface water availability, human migration), it is often assumed that local knowledge is relevant to inform vulnerability only at local levels. On this basis, there continues to be a fundamental, and arguably growing, gap between scientific evaluations of adaptation needs (including potential new sources of vulnerabilities and cascading risks) and the implementation of (micro or macro) adaptation solutions that actually meet such needs within complex local social contexts on the ground. This "urban adaptation action gap" is significant because it is often presumed that local governments can readily bridge between state and community. But emerging evidence suggests that developing robust adaptation action across scales is not at all straightforward, particularly in light of prevailing social inequalities and injustices and vastly different abilities to both participate in and contribute to urban adaptation across diverse social groups.[42–44] For example, technocratic assurances in climate planning (such as when relying on objective prioritization assessments) can inadvertently privilege formal knowledge that is abstract, universal, and rationalistic, while devaluing other forms of local knowledge that can lead to more effective and socially legitimate solutions in specific and highly diverse contexts. Realizing successful adaptation action, therefore, requires a profound engagement with subaltern knowledge in order to draw on a more complete pool of knowledge and thereby design, implement, and evaluate such action in ways that are both globally and locally appropriate.

THE URBAN ADAPTATION ACTION GAP

There is growing worldwide commitment to boost urban adaptation, although cities are reporting highly diverse and uneven approaches to adaptation planning. For example, around 10,300 cities—ranging from small to large—are now signatories to the Global Covenant of Mayors for Climate & Energy. Recent figures, however, show that only 18% of those cities reported having conducted an adaptation assessment or having delivered a formal adaptation plan.[45] For instance, of the more than 700 cities reporting around 2,600 adaptation actions to the Climate Disclosure Project,[46] only 48% reported having used a vulnerability assessment,[47] despite climate impacts being perceived to be serious (56%) or extremely serious (22%).[48] These self-reported data from cities evidence the current fragmentation of local adaptation planning approaches but provide little understanding of the causes and consequences of urban adaptation progress. While it is true that there are increasing efforts to integrate adaptation needs into planning documents or project proposals,[49] comparatively less effort has been invested into evaluating adaptation processes and overall outcomes for a range of reasons, including operational difficulties and definitional ambiguities associated with metrics of what counts, measurement and benchmarking of sufficient progress, and tracking procedures given uneven skills and technological capacities around the world.[50–52]

Most large-scale evaluations of urban adaptation progress to date focus on plans produced by public authorities in large cities (see, e.g., Araos et al., Olazabal et al., and Le[14,16,17]). A recent synthesis[53] found that a majority of these assessments focus on developed regions, particularly North America and Europe,[13,15,18,23,54] although some recent analyses include progress data from the Global South.[14,16,17,19,22] Furthermore, diverse methodological approaches are used to systematize information. Yet, most assessments focus exclusively on stand-alone physical "plans" rather than on other policy outputs. Few studies cover small- and medium-sizes cities that may be more likely to mainstream adaptation into concurrent sustainability, infrastructure, or development strategies rather than advancing high-profile new policy and action agendas. Yet across these studies it is overwhelmingly clear that an urban adaptation action gap exists widely across the globe among cities of all scales and contexts. While more advanced adaptation is sometimes reported in richer, larger, and more developed "global" cities,[13,14,16] the potential of climate adaptation actions to replicate pre-existing social inequalities and patterns of marginalization is increasingly recognized.[51–53] The investment priorities and modes of technocratic knowledge production that are often privileged in adaptation decision-making rarely afford power to diverse local actors. For example, current adaptation policies in cities focus extensively on the public sector and seldom include citizens or the private sector as beneficiaries of adaptation.[20,55]

Even when local governments are well equipped and have access to resources, planning documents tend to be general and vague. Adaptation actions are also often described in abstract terms (e.g., aiming to increase green infrastructure as a normative adaptation goal), tend to only superficially build on scientific data,[16,17,56] lack attention to context-specific risks (including variation across different social groups), and have little systematic consideration of social, cultural, and political factors that shape their successful implementation.[15,16,56] For example, in a recent assessment of adaptation plans globally,[16] the authors found that diagnoses produced during the planning process often overlook potential social and economic changes that may affect the context-specific urbanization dynamics, and thus undercut the long-term effectiveness of adaptation actions on the ground. The well-documented gentrification process as a result of urban greening projects is a particularly stark illustration of the maladaptive consequences of this disconnect in urban settings.[57]

This lack of connection to local needs and implementation guidance is a direct result of a technocratic model too reliant on top-down knowledge generation, which leads to mismatches between science and practical adaptation solutions that consider local institutional conditions, resources, priorities, and experiences. The use of robust and credible scientific information is often invoked as a fundamental principle for "strong climate change planning"[58] that incorporates "empirical data on current conditions (GHG inventory or vulnerability assessment), future projections, and modelled impacts to ensure strategies are well informed"[58] (p. 41). However, the precise role of scientific knowledge—including technical and modeling exercises—in driving targeted local adaptation action is unclear and perhaps weaker than may be expected.

The search for technocratic assurance in climate planning privileges abstract, universal, and rationalistic types of knowledge and knowledge production in ways that crowd out or devalue other forms of local and cultural knowledge. The dominant model of adaptation planning is thus neither responsive to contextual needs nor feasible in a context of climate emergency in which social legitimacy is both essential to long-term sustainable adaptation and more demanding in terms of human investment. To catalyze more effective and equitable local adaptation action, adaptation priorities must be approached within their (socially and spatially variegated) contexts, both within and across cities. This includes taking into consideration local resources, local priorities, and local formal and informal institutions.[59] Doing so is also important for supporting decision-makers who often continue to struggle to integrate climate priorities into their daily routines and longer-term strategic priorities, and require new ways to incorporate relevant knowledge to support adaptation action.[60] For example, a greater recognition for subaltern knowledge might lead to fundamental shifts in social, cultural, and political frames underlying the opportunities for adaptation planning in particular contexts.

As climate change becomes a new force shaping urban action, the impacts of such action are likely to be unevenly distributed and so raise new inequalities in terms of different levels of protection and capacity to respond to climate impacts. Emerging critical scholarship has warned against ignoring the social impacts of climate urbanism.[61] At the same time, such scholarship has turned attention to the diverse alternatives that emerge within specific urban contexts, including what this paper refers to as subaltern knowledge.[62] Subaltern knowledge has the potential to challenge power relations both by turning attention to bottom-up activities and self-identified needs of subjugated actors and groups and by creating alternative sources of resources and finance that contest the imposition of external projects on the grounds of attracting big capital.[63] For example, adaptation initiatives in much of the Global South continue to be heavily influenced by external funders (e.g., donors, international organizations), which can lead to an instrumental focus and overlook complex social contexts and widely varying experiences, needs, and insights of diverse groups.[64]

INCORPORATING SUBALTERN PERSPECTIVES

The role of subaltern knowledge

Subaltern knowledge encompasses knowledge that is inherently local, place-based, and linked to social relations. In the broadest sense, this includes local, traditional, or indigenous knowledge, or combinations thereof, which may be embedded within culture, traditions, worldviews, and practices of different social groups. Such knowledge is often omitted or even marginalized (either through operational oversight or elite-driven forms of sociocultural erasure) in current approaches to adaptation planning. Yet adaptation planning can benefit from such knowledge even when it cannot be easily translated into formal scientific data and models. Subaltern knowledge builds upon a grounded understanding of what is possible and what matters for the lives of diverse communities and citizens residing in urban areas and localities around the world. Thus, it is vital for generating socially rooted, and socially legitimate, adaptation action.

Ideas about subaltern knowledge follow a growing concern about the role of formal knowledge. Sheila Jasanoff, for example, has emphasized the humility of the scientist and expert who should situate the process of knowledge production in specific contexts that are not always accessible through classical methods of scientific knowledge production.[65] This includes attempts to bring a broader range of citizens' perspectives into knowledge production, in line with extensive literature on post-normal science,[66,67] sustainability science,[68–70] or citizen science,[71,72] for example.

An argument for the need to deliver practical solutions despite the existence of multiple, incommensurable perspectives[73,74] also resonates with a parallel debate in the field of development studies, where scholars have long questioned the legitimacy of outsider-driven development interventions.[75] Kothari proposed a focus on subaltern knowledge as an umbrella term for a variety of forms of knowledge that, in the context of science, are variously defined as local knowledge, traditional knowledge, or indigenous knowledge.[36] Subaltern knowledge therefore serves as a means to emphasize the views of those who, because of their social positions, are excluded or marginalized from hegemonic epistemological systems that influence development interventions. This is particularly relevant in the context of urban adaptation planning where development work is globally and generally a top-down activity strongly rooted in technocratic knowledge.

The continued inability of adaptation planning worldwide to include subaltern forms of knowledge is concerning for several reasons. First, there is a long tradition of understanding planning as a collaborative process that bridges multiple perspectives.[76] Second, there have been calls to recognize diverse perspectives to deliver equitable and workable adaptation options.[77] And finally, there is situated evidence demonstrating the importance of subaltern knowledge in guiding adaptation solutions that also respond to the immediate concerns of urban populations.[78–81] However, combining these types of approaches with existing formalized approaches to adaptation policy is not straightforward. Doing so requires an enlarged frame that positions scientific knowledge alongside other forms of knowledge in ways that can lead to mutually productive enrichment.

Emerging efforts

One example of efforts to link technical scientific knowledge and subaltern knowledge is the recent work developed by global scientific bodies such as the Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to incorporate indigenous knowledge into global scientific assessments. It is important not to assume that indigenous and traditional knowledge is solely tied to rural areas, not only because many indigenous people across the world live in urban settings, but also because such knowledge may have great value for understanding resilience and adaptive capacity in urban areas.[82,83] Indigenous peoples hold unique worldviews that link today's generations with generations past and that emerge from indigenous peoples' long inhabitation of a particular place and their interaction with local nature.[84,85] Thus, a consideration of indigenous and local knowledge is particularly salient for understanding relationships between people and nature over long time frames and into the future. Indigenous knowledge systems include both the specific narratives and practices articulated to make sense of the world through multiple forms of empirical evidence and the networks of actors and institutions that organize the production, transfer, and use of knowledge.[86,87] The IPCC and IPBES increasingly seek to recognize a broader range of approaches to the challenges of climate adaptation and society's relationship to the environment.[88–91] While it is still to be seen whether these efforts will succeed, both bodies are developing mechanisms to integrate indigenous and local knowledge into ongoing assessment processes, particularly by recognizing diverse methods to transmit and record scientific knowledge.[92]

However, questions remain about how integration of technical scientific and indigenous knowledge can be genuinely accomplished. For example, there continues to be an assumption that criteria to legitimate scientific knowledge can also be a means to validate other forms of knowledge,[93,94] but a synthesis of knowledge alone should not be the dominant approach to knowledge systems because they are not always mutually understandable and comparable.[92] This echoes our critical reflections on urban adaptation planning worldwide, where the search for "technocratic assurance" is inhibiting wider progress toward social equity and inclusion. Moreover, as Kothari and other post-colonial scholars already point out,[36] there is a need to recognize how structural drivers of oppression and exclusion of people also shape the oppression and exclusion of their knowledge.[89] Subsuming or seeking to validate indigenous knowledge through scientific means[93–96] such as this may disrespect indigenous peoples' very identities and histories, and overlook the fact that for many indigenous peoples the structural drivers of oppression and endangerment are associated with Western civilization itself.[89] Thus, special consideration should be given to less dominant forms of knowledge that should not be put aside on the grounds that they are not comparable to scientific knowledge. Those less-dominant forms shape the ways in which risk is locally understood and experienced and allow for the possibility of developing solutions grounded on place-based experiences and the development of governance systems that match the expectations of different and local knowledge holders.

A second example can be found in recent work on locally led adaptation to incorporate subaltern knowledge into climate adaptation actions by the Global Commission on Adaptation (2018–2021) in partnership with various bi- and multi-lateral donors of climate adaptation funding and nongovernmental organizations such as Shack/Slum Dwellers International. As an alternative to the technocratic assurance approach, here advocates of locally led adaptation have called for fully devolved approaches that involve local actors—including local governments, community-based organizations, and groups representing historically disadvantaged groups such as women, youth, and indigenous communities—to identify, prioritize, implement, and monitor climate adaptation solutions.[97]

Although many locally led adaptation efforts are still in their infancy—and therefore difficult to evaluate as to their effectiveness so far—they do tend to specifically target the historically exclusive ways in which adaptation actions were funded and supported at the local level, thus proposing new objectives and metrics for funding portfolios to facilitate local awareness-building, leadership, and agency over where money is spent (and how).[98,99] The ultimate goal would be to empower local actors—many of whom have so far been excluded from formal adaptation planning processes—to advocate for contextually appropriate actions. Recent experiences include the establishment of decentralized County Climate Change Funds in Kenya, which aim to empower local communities by connecting them to ward-level planning committees charged with identifying local adaptation needs.[100,101] In this case, local knowledge has played a key role in redirecting adaptation financial resources toward local resilience-building actions focused on livestock, water, and natural resources management.[102,103] In Nepal, local communities are supplementing financial expenditure and other adaptation-related budget data to a Citizens Climate Budget with the intention of supporting the national target of 80% of climate finance reaching the local level.[104,105]

These examples highlight emerging ways in which subaltern knowledge is being considered in adaptation action, including by incorporating indigenous knowledge within scientific assessments and by embedding local interests and agencies in technocratic structures of adaptation finance. However, these are only emerging and disparate efforts. Greater attention is needed to connect different knowledge systems and thereby empower subaltern knowledge in shaping adaptation action. At the same time, greater attention is needed to understand how such connection happens in ways that go beyond merely "integrating" subaltern knowledge and facilitate locally led action.[95,106]

Approaches to connect multiple knowledge systems

Within the literature, we can identify four different approaches to facilitate the connection of different knowledge systems: integrative frameworks, worldview intersections, boundary work, and hybrid knowledge systems (see Figure 1). We propose these as a heuristic to understand how multiple knowledge systems could be combined beyond technocratic approaches, although they are not intended to be a perfect reflection of the reality of knowledge co-production in complex environments.

Integrative frameworks

Members of the IPBES have pioneered an approach to knowledge integration that relies on an integrative framework called the "nature's contribution to peoples" framework.[107] The key issue is the mobilization of a shared framework that provides a common conceptual vocabulary and structure of analysis. It thus points toward different areas of analysis where alternative knowledge systems can make a contribution.[90] The framework provides the reference against which multiple evidence sources can be integrated through a strategy of weaving multiple sources of information and collaboration.[88] The nature to people framework, however, has raised criticism among scholars who perceive that the framework is unidirectional and that it does

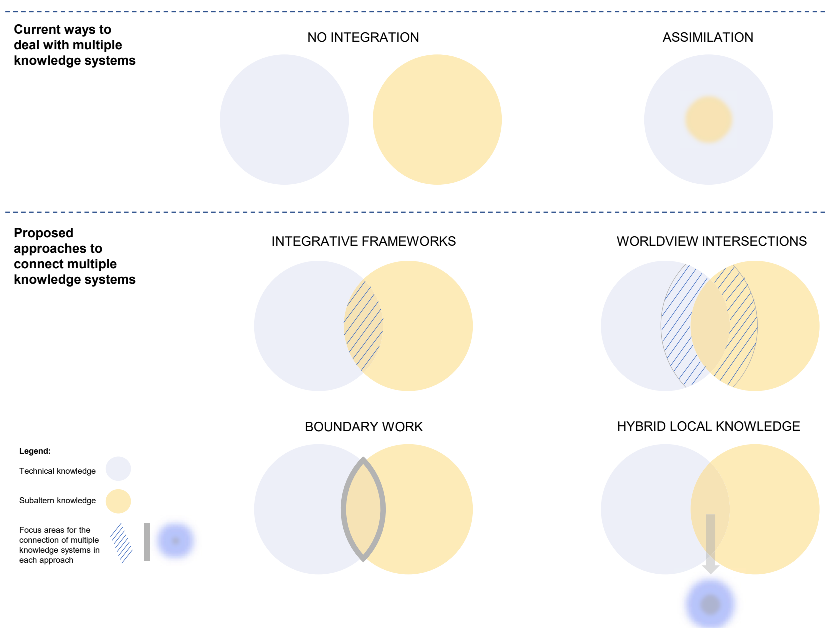

Figure 1. Multiple knowledge systems
Four approaches to bring together scientific/technical knowledge and subaltern knowledge: integrative frameworks, worldview intersections, boundary work, and hybrid local knowledge. The figure illustrates focal areas in connecting multiple knowledge systems under each approach. It also contrasts these approaches with an illustration of current technocratic ways of dealing with multiple knowledge systems that may lead directly to "no integration" or to "assimilation" of local knowledge through technical validation that precludes full understanding of local context (taking only what can be validated) and can even lead to maladaptation.

not recognize the complex feedback loops and planetary environmental changes that could eventually lead to disastrous results.[92]

Worldview intersections

This refers to the possibility of common ground that emerges at the points of connection between two intersecting worldviews. For example, while indigenous knowledge focuses on trusting receiving wisdom and adopting a practice-based holistic perspective, a scientific perspective may be characterized as analytical and informed by skepticism. There can be, however, a recognition that both approaches share some organizing principles about the structure of the world and an inquisitiveness grounded in empirical knowledge that enables the development of a common base of knowledge.[85] Still, intersection works only when there is a clear common ground, for example, the management of heat risks in a particular location, but there may be less ground for intersections when dealing with global environmental change because of the assumed primacy of scientific knowledge and the much larger frame of reference.[108]

Boundary work

Boundaries exist between different forms of understanding the world, for example, between disciplines, between science and policy, and between science and other ways of understanding the world from indigenous peoples and other local groups. Boundary work involves mediating activities that help negotiate what constitutes reliable and useful knowledge at the boundary. An impermeable boundary limits meaningful communication, but a porous boundary may devalue less dominant forms of knowledge.[109] Mediators are needed to facilitate mutual understanding, reach common decisions, or negotiate between conflicting interpretations.[109] This is often evaluated with what is referred to in sustainability science as the SCL criteria to evaluate the effectiveness of boundary work, attending to the *salience* of the knowledge produced (is it relevant for decision-making?), its *credibility* (is it technically adequate?), and its *legitimacy* (is it fair, unbiased, and respectful to stakeholders?).[32,109]

Hybrid local knowledge

Finally, some scholars have advocated for the adoption of long-term processes of collaboration that aim at developing new, problem-oriented forms of hybrid local knowledge, where questions are collectively formulated by all participants through a process of "continual engagement."[110] For example, working with pastoral communities in the Tarangire-Simanjiro-Manyara ecosystem, collaboration between scientists and community members helped to identify price differentials along the livestock marketing chain. This then supported the creation of a marketing cooperative that would help build resilience to fluctuating prices due to changes in the weather ecosystems.[110]

While efforts to date open up new possibilities, there is an enormous challenge in the delivery of models for working with multiple knowledge systems that respect their integrity while addressing the structural drivers of vulnerability and environmental change in specific contexts. Although the concept of knowledge co-creation has been put at the heart of urban climate change adaptation planning research,[31] practical experiences attempting to effectively integrate technical scientific and subaltern knowledge often remain scarce or anecdotal. To boost urban climate change adaptation, we argue that a key priority is to find new ways of working with multiple knowledge systems in urban adaptation planning theory and practice, and that this is key to closing the urban adaptation action gap.

INTEGRATING SUBALTERN KNOWLEDGE TO BROADEN THE URBAN ADAPTATION SOLUTION SPACE

Recently, scholars have defined the adaptation solution space as "the space within which opportunities and constraints determine why, how, when, and who adapts to climate risks"[111] (p. 1). This solution space "is shaped by biophysical, cultural, socioeconomic, and political-institutional dimensions at a given moment in time"[111] (p. 1). As such, processes of how knowledge is perceived, (co-)created, and integrated also shape the adaptation solution space. By finding new approaches for linking technical scientific and subaltern knowledge, and working with multiple knowledge systems more broadly, the urban adaptation solution space stands to be broadened through three key

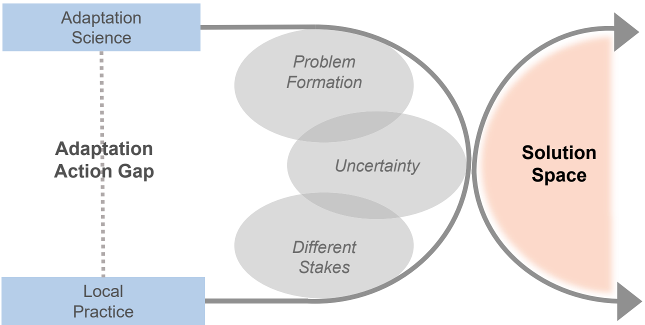

Figure 2. Broadening the adaptation solution space

Filling the gap between adaptation science and practice requires bringing together technical and subaltern knowledge in three key areas: (1) problem formation, (2) connecting different stakes and ways of knowing, and (3) dealing with uncertainty. All too often there is an impasse where adaptation science and local practice are polarized around these three areas, yet the adaptation solution space could be broadened through greater attention to subaltern knowledge.

areas: (1) problem formation, (2) connecting different stakes and ways of knowing, and (3) dealing with uncertainty (see Figure 2). These three areas relate to, first, the construction and understanding of problems including the domains of thinking and practice to bridge (i.e., problem formation); second, finding new ways of *how* to bridge (i.e., dealing with different social positions and stakes); and third, finding ways to deal with inherent uncertainties about the future in terms of both problems at hand and stakes involved for different actors (i.e., uncertainty). These are already major challenges that potentially stand to derail urban adaptation practice. In many cases, yet, they are potential areas for fruitful development through greater attention to subaltern knowledge.

In terms of problem formation, existing theories of change in planning scholarship highlight three distinct stages: issue formation, process design, and institutionalization. Current research on adaptation planning has so far concentrated largely on planning processes and design[25,27,42] rather than on the multi-faceted and socially embedded problems themselves or the formal and informal institutions that are needed to enable action.[112] Problem formation remains understudied. For example, the literature on drivers and incentives of adaptation planning[113]—which include opportunity structures, public awareness, the experience of disaster events, presence of policy champions/entrepreneurs, and external resource drivers—has often referred to scientific knowledge only in an abstract sense, especially in terms of the need for localized, downscaled climate projections. Assuming that the degree of appropriateness and situatedness of climate science in informing how adaptation is recognized, framed, communicated, and understood is critical, particularly in the initial policy formation stage, the current generalization and abstraction of science may actually be inhibiting effective adaptation at the local level. If so, it has profound resonance for whether and how climate knowledge is currently produced and used by local decision-makers. Subaltern voices have the potential to expand the adaptation solution space by making visible and tangible different facets of the problem as well as alternative means for facilitating action.

Connecting different stakes and ways of knowing across science, policy, and practice involves navigating political dynamics—including its contestations, negotiations, and struggles—which come to the fore in local adaptation.[114] In other words, adaptation planning is not a purely technical rational process to translate global climate risk assessments (even if they are downscaled appropriately) into local adaptation action. Many other factors that have to do with social consciousness, epistemology, and values come into play as well. Scholars of postcolonial climate urbanism[62] have noted that although considering and connecting different stakes and ways of knowing are challenging, such an approach can disrupt current power dynamics that capitalize on top-down, technocratic, and market-oriented forms of practice and knowledge. Social actors inhabit different social positions, including those who are marginalized and vulnerable due to a wide range of social, economic, and political reasons, many of which persist notwithstanding climate impacts. Local adaptation practice must therefore not only be highly differentiated—e.g., to different social actors' needs and drawing respectfully on different forms of knowledge—but also be challenged by the need to connect multiple ways of knowing, which inevitably takes time, commitment, and nuance. Transplanting globally driven climate knowledge onto a highly heterogeneous society is not likely to be straightforward. While this raises a major tension between acting rapidly and acting carefully, expanding the knowledge system for local adaptation seems unavoidable, particularly if adaptation is to be socially legitimate, democratic, and equitable.[27]

There is an increasing awareness about the need to integrate top-down and bottom-up climate modeling approaches to deal with uncertainties and fully reflect important context-specific vulnerabilities, especially in climate-sensitive regions.[115] Likewise, local governments are moving toward more flexible and creative ways of adaptation planning, which could overcome some of the constraints related to uncertainty in scientific modeling.[116] While this is true, there are also broader questions of uncertainty and diversity inherent to human experiences, knowledge, and perceptions that might lead to unexpected outcomes.[117–119] Nature-based infrastructure, for example, is often touted as a solution that fits all contexts even when there is ample evidence that these projects may have negative impacts on disadvantaged groups of a population.[57,120] The literature has thus argued in favor of integrating social justice and equity assessment criteria in designing adaptation planning processes.[26,27,57] These criteria may be critical to justifying the sustainability of flexible policies and upscaling of experiments to reduce uncertainties related to adaptation outcomes. Integrating richer and more heterogeneous knowledge into urban decision-making processes could help to recognize the diversity of needs and realities across and within cities, and thus reduce the impacts of uncertainty, especially on those who often have less voice or are omitted and marginalized from decision-making.

Table 1 illustrates the practicalities of the integration of multiple knowledge systems (i.e., technical and subaltern knowledge systems) in the three key areas identified above (see Figure 2). We do this by identifying ways to implement the four approaches proposed to connect multiple knowledge systems (i.e., integrative frameworks, worldview intersections, boundary work, and hybrid local knowledge, see Figure 1) in the key three areas.

Table 1. Illustrative framework for the ways multiple knowledge systems are connected through adaptation priority areas: problem formation, connecting different stakes and ways of knowing, and dealing with uncertainty

	Multi-knowledge approaches			
Adaptation priority area	Integrative frameworks	Worldview intersections	Boundary work	Hybrid local knowledge
Problem formation	mainstreaming	co-production	negotiated	emergent
Connecting different stakes and ways of knowing	structured partnerships and networks	interactive workshops, consultations, broad inclusion, epistemic recognition	collective problem solving, conflict management and resolution	embodiment (ethnographic), deep learning, historic and cultural connections
Dealing with uncertainty	parallel, redundant systems; institutional learning; focus on resilience against shocks	shared and common responsibilities, group capacities to mobilize against risks and losses	systematized monitoring and evaluation tools, tracking and reporting incremental progress	community absorptive capacity and risk tolerance, acceptable levels of risk, holding long-range visions of change

We argue that this would have a particular impact in urban adaptation practice, furthering broad social inclusion and equity in both process and its outcomes.

As discussed below, there are already experiences that show the value of connecting multiple knowledge systems in these key areas. Here we offer an illustrative framework that enables comparison under the four multiple knowledge approaches discussed above and argue that further efforts are required to embed these practices within urban adaptation planning and decision-making. Frameworks that focus on knowledge integration, worldview intersections, boundary work, and hybrid local knowledge systems yield important lessons on how to bridge the urban adaptation action gap. We briefly describe illustrative approaches (as outlined in Table 1) here.

In terms of framing and forming the challenge of local adaptation in the outset, the inclusion of subaltern knowledge can be pursued through mainstreaming—i.e., integrative frameworks—where local interests and values are considered in an accountable and transparent way within ongoing formal planning frameworks (see, e.g., Satorras et al.[121]). Mainstreaming therefore relies on structured partnerships between decision-makers and delegated representative groups, where parallel and redundant systems are put in place to bridge knowledge gaps and learn from one another. As such, they are sometimes seen as cooperative or consultative processes,[95] where outcomes are not necessarily shared or owned. Importantly, structured partnerships and networks can be mobilized to solve shared problems in case of future shocks.

Recognizing worldview intersections across different epistemic communities implies a co-productive approach to problem formation.[122] It strives to collaboratively delineate adaptation challenges and pursue mutual processes and potential shared actions between and across all local actors. Co-productive approaches rely on constant interactions between those participating in the knowledge system—thus sharing and gradually intersecting formerly disparate worldviews—and can yield broadly inclusive outcomes. The need to address future uncertainties is seen as a shared and common responsibility in need of collective mobilization.

In view of local actors' pre-existing interests, boundary work entails investigating and solving potential problems where interests intersect. Common adaptation challenges and potential solutions are thus generated in a "negotiated" fashion, through iterative, problem-solving, and conflict management methods.[114] Dealing with future uncertainties and risks means maintaining constructive and productive boundaries between local actors and agents, such as through tools to systematically track and measure progress as well as to develop shared instruments to resolve conflicts and knowledge inconsistencies (see, e.g., Garmendia et al.[123]).

Finally, climate change can cause varied impacts and risks in local contexts and so new, "emergent" or hybrid local knowledge may emerge. Emergent knowledge is based on community-held cultural frames, values, and practices in situated geographical or temporal contexts. Emergent knowledge is the product of the fusion of different knowledge forms that were never previously embraced by any particular knowledge pool and may not be transferable to other contexts.[31] Long-term visions are critical, as well as the consideration of emergent forms of adaptation based on risk tolerance or the identification of acceptable levels of risk.[124]

CONCLUSION

Addressing the urban adaptation action gap requires finding new ways to overcome the mismatch between adaptation science and local practice. In this paper, we argue that this requires recognizing and incorporating subaltern knowledge by finding ways to productively combine multiple knowledge systems. This will not be a straightforward process for a wide range of instrumental, epistemological, and ethical reasons. Validation and integration of different forms of knowledge can be very complex, particularly when they involve integration into formal procedures of planning and governance in the case of urban adaptation. Experience in the co-creation of knowledge between scientists and indigenous peoples[89,93–96] shows the importance of respecting identities and histories and of generating locally led action. Working with other forms of local and traditional knowledge is also likely to involve similarly complex issues that should not be steamrolled by a conventional technoscientific lens. Thus, to empower subaltern knowledge, there is a need to devote substantial conceptual and practical attention to developing, experimenting with, reflecting on, and sharing approaches that can genuinely bring subaltern knowledge into urban adaptation practice on an equal footing. Some recent efforts that seek to grapple with these challenges can offer a glimpse into new ways of recognizing the importance of multiple forms of knowledge, thereby inspiring new approaches to urban adaptation that are deeply situated in local places and, at the same time, draw on technical scientific insights and imperatives for urgent adaptation. Indeed, such approaches are likely to be essential for effective and ethical adaptation action and can help to overcome some of the criticisms that connect knowledge and justice in the phenomenon of climate urbanism.

Urban adaptation planning navigates through abrupt and challenging times where technocratic efforts have not yielded effective adaptation action, which we have noted as the urban adaptation action gap. We argue that there are three key areas in which subaltern knowledge particularly stands to help advance the adaptation solution space: problem formation, combining multiple stakes, and dealing with uncertainty. We have further identified four different approaches to enable the combination of subaltern knowledge with technical scientific knowledge to inform future local climate adaptation science and practice and illustrated practical ways to make this possible. We also recognize that adaptation knowledge is not dichotomous and that it should be considered as a spectrum where combinations of knowledge systems may vary along the decision-making process and according to other contextual determinants.

Global experiences and emerging efforts show the potential of incorporating subaltern knowledge to improve the effectiveness of adaptation solutions and enhance the social legitimacy and overall effectiveness of urban adaptation. Through this, we therefore find an opportunity to address the urban adaptation action gap while broadening the adaptation solution space. However, changing our conception of knowledge in adaptation is akin to redirecting current adaptation governance toward more just approaches.[27] Moving from technocratic to more plural arrangements that equally incorporate subaltern knowledge involves the active integration of local marginalized populations that hold such knowledge into processes of knowledge production and in making the decisions that affect their lives. This would definitively require setting aside utilitarian conceptions of knowledge, which may result in exploitative practices that sustain power relations and existing vulnerabilities[95] and think instead about pluralizing knowledge as a strategy to democratize urban adaptation planning.

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AUTHOR CONTRIBUTIONS

M.O. led the conception and framing of this work. All authors substantially contributed to its development and critically revised the intellectual content.

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