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RESEARCH ARTICLE

The role of visual ethnography in co-producing climate information services in cities

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Diverse approaches to climate information services are emerging as impacts escalate in an urbanising globe. However, the climate information services involving cities are mainly collaborations with actors from science, multilateral, national and municipal authorities. There are limited efforts to build on knowledge from residents in local communities about risk and response options, to steer collaborations on climate information services. This article examines visual ethnography as an enabler of climate information services that connect societal and scientific objectives at local scales in cities. Based on case study findings from Kampala city in Uganda, local-level framings of climate risks and responses were grouped into exploratory and intersectional framings. The exploratory framings are risks and response options directly linked to Sustainable Development Goals (SDGs) 11 and 13 on cities and climate change respectively, while depicting some degree of contradiction. Intersectional framings are risks and response options demonstrating the interrelatedness of climate issues across different SDGs. Local communities do take on scientific information on impacts and adaptation barriers but also connect risks and responses to experiences of tested options, which sometimes only emerge during the process of visual ethnography and are not initially identified. Visual ethnography can be an important source of information not only on stressors experienced and priority actions by local communities, but can also be a climate solutions imagery, that contains positive adaptation stories with opportunities for enriching and complementing scientific inquiry on responses.

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Keywords co-production • local communities • climate action • sustainability • visual ethnography

Key messages

- Visual ethnography empowers local communities to express climate challenges and solutions through imagery.
- Engaging communities through participatory methods fosters collaboration and enhances understanding of climate action.
- Local narratives reveal diverse perspectives on climate adaptation, emphasising context-sensitive SDG indicators.
- There is urgent need for integrating informal practices into urban policies for effective SDG implementation and overall urban development programming.

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Introduction

As cities face escalating impacts of climate change coupled to disruption of path dependencies that hold back sufficient scaling of tested adaptation pathways, a diversity of approaches to information service provision are emerging. Climate information services have been defined by Visbeck (2008: 2) as 'assessment and forecasting capability that gives public and private decision makers worldwide the best possible information on likely climatic developments from months to many decades'. According to the World Meteorological Organization (WMO), climate information services are essential for weather predictions, climate trends, projections, economic analysis and sector-specific services in climate-smart decision making (WMO, 2011). The Global Framework for Climate Services terms refer to the concept as 'needs-based climate services', with climate information services being an effective way to achieve socio-economic benefits that empower communities, businesses, organisations and governments to make informed choices and adapt to changing conditions.

Though probabilistic information on risks, trends and predictions has often offered more precision, it is characterised by more technocracy, which may not necessarily interlink societal and scientific objectives (Palmer, 2012; Menteşe et al, 2023). Enhancing the use of climate information like weather forecasts via user interaction and through a co-production approach may also call for local contexts that enable residents in communities to position themselves as co-providers and not last-mile users of urban climate information services (Vollstedt et al, 2021). This is partly why cities are increasingly adopting a collaborative response to climate change, guided by multiple sources of data and information.

There are several efforts around data generation and exchange on global urban targets, as per the Paris Climate Agreement of 2015 and the Sustainable Development Goals (SDGs). The City Prosperity Initiative's CPI index is one example, which according to UN-Habitat (2017), is a holistic monitoring framework for measuring

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indicators interrelating SDGs 11 and 13, as well as other SDG indicators on city prosperity and sustainability. Cities for Climate Protection has intensified its advocacy to use vehicle-miles-travelled software, in estimating emissions from traffic statistics and costing the benefits of quantifiable reductions in local greenhouse gas emissions (Kousky and Schneider, 2003; Klatko et al, 2017).

Data that interlink climate change with energy, urban health and transport across demographics and urban ecologies are also increasingly being made available, using modelling techniques such as Daily Ambient Apparent Temperature (Tapp) and daily all-cause non-accidental mortality (Wichmann, 2017; Asefi-Najafabady et al, 2018; Scovronick et al, 2018; Katsaros et al, 2024). The Global Protocol for Community-Scale Greenhouse Gas Emissions has been designed and used to account for emissions attributed to city boundaries and city regions (Lwasa, 2017). Artificial intelligence has also demonstrated potential to evaluate SDG indicators, as well as to make future projections and simulations to increase the potential to act in a timely manner. For purposes of this article, the landscape of urban climate information services could entail constant movement of alternative knowledge flows and a compendium of different stakeholder practices, which stem from the heterogeneity of scientific and societal groups. Such alternative knowledge flows could include data portfolios and services on risks and trends, expert knowledge, and crowdsourcing on practices for mitigation or adaptation, localisable policy instruments and strategies at multiple scales, as well as scalable solutions that can leapfrog residents in cities towards resilience, while empowering local actors to assert themselves as knowledge holders, too, in the landscape of actors.

However, there is still limited consideration of climate information services in cities that can integrate and harness the co-benefits of the informal ways in which residents from local communities experience risk and promote home-grown responses. In addition, while the number of collaborations across science, policy and local community practices in cities is increasing steadily, society at large is still viewed as end-users who need to base adaptation measures on the scientific and technical information provided by government authorities in collaboration with climate science institutions (Mabon, 2020). Therefore, there is need to illuminate the alternative roles of urban residents in local communities in defining, negotiating and addressing climate risks and information needs for effective response, through cross-disciplinary partnerships and iterative learning methods.

In order to bring societal stakeholders into the uptake processes of climate science, citizen science approaches have been adopted and adapted to different urban contexts (Simon and Leck, 2015; Land-Zandstra et al, 2021). The aim of citizen science is to engage with and elicit available information from societal stakeholders on climate risks, impacts and response measures as well as data on local conditions that can enable or stand in the way of scientifically proven adaptation measures (Neset et al, 2021). While citizen science has the potential to challenge preconceived notions/ideas about what information is essential for effective responses, the complex interactions with stakeholders who have differing interests can undermine societal credibility and inclusiveness in the process (Buyana et al, 2022). To confront the top-down nature of climate decision-making by governments, Kythreotis et al (2019) propose 'citizen social science' as a novel approach to collaborative climate action. This citizen social science approach is such that citizens could become influential actors in climate change policy processes through platforms where local residents engage

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directly with government officials, to deliberate on strategies and priorities that are embedded in local realities and financial means. However, within citizen social science it could be a challenge for national and municipal policy actors to always assume that democratisation of climate information service provision is always possible within spaces where citizens can contest priorities cast in policies and municipal budgets. Despite the active participation of societal stakeholders that could prevail in citizen social science, the regulations around the structuring of policy-making and budgeting processes ultimately shape the outcomes. This is partly why Manteaw et al (2022) argue that there is still a challenge of foregrounding urban climate information services in citizen-to-government engagements as avenues for breaching siloed actions between science and society.

The role of visual ethnography in co-producing urban climate information services

Visual ethnography refers to a set of methods that creates a context in which researchers can use, for example, contrasts in images, printed or story maps, cameras, tablets, digital technologies, social media and other mechanisms to engage in a reflexive process for producing a nuanced account of a given social phenomenon or come up with strategies to overcome limitations in other research methods (Liebenberg, 2009; Pink, 2021). While visual ethnography has roots in anthropology and sociology, it has evolved into an interdisciplinary methodological approach. This includes various sub-disciplines, such as digital ethnography, which reinterpret traditional concepts in innovative ways.

Given the interrelatedness of climate issues across urban systems and the broad range of challenges in the quest for climate information that is relevant to both science and urban societies, visual ethnography holds promise on several fronts. Co-production of climate information services through visual ethnography transcends visualisation techniques for raising stakeholder consciousness about impacts and eliciting feedback on the local relevance of adaptation measures (Sheppard, 2005; Gallagher et al, 2022). Co-production of climate information services using visual ethnography could, on the one hand, offer opportunities to increase societal usability of climate science, through unearthing what underlies citizen acceptance of, or resistance to, climate policies and programmes, coupled to the nature and source of resources that local residents rely on to get through climate-related hardships. On the other hand, visual ethnography can make societal knowledge on risks and responses accessible and usable across different science disciplines. Visual and digital-enabled tools of ethnography permit co-framing of climate research agendas and can position researchers and the researched as knowledge holders (Joshi et al, 2023).

While visual ethnography can be vital in urban stakeholder interfaces that take on both compatible and incompatible elements between societal and scientific framings of risk and response, it could also ground local-level experiences within the broader sustainable development agenda (Dewulf and Bouwen, 2012; Carneiro et al, 2022). Images and content, generated by residents through, for example, city walks, that combine elicitation of scientific and societal knowledge have communicative qualities to facilitate dialogue on SDGs (Marion Suiseeya and Zanotti, 2019; Stephens and Richards, 2020). Besides, it can also justify inaction on SDGs in local contexts beyond resource constraints, which is often the reason mooted by actors in developing cities

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as the overarching barrier to sustainable climate action. With the advent of different modes of climate finance, the interdependent factors of vulnerability among local communities, technology, knowledge, infrastructure, policy tools, and institutions in developing cities, are centring SDG localisation challenges on including climate change in municipal risk profiles and budgets to attract money from the developed world. Once such context-bound dynamics are pointed out as understood and experienced by urban residents from local communities, the role SDGs play in maintaining or breaking path dependencies could be through visual ethnography that enables surfacing and iteration of conflicting perspectives and ambiguities in framing risks and responses.

The limits for visual ethnography, however, could lie in collective risk and response framing processes capable of improving applicability in different city contexts. This article examines the role of visual ethnography in climate information services that connect societal and scientific objectives at local scales, using the case study of Kampala city in Uganda. Whereas the case study was useful in developing a schematic overview of the visual ethnographic steps embedded in the co-production framework and positioning urban residents from local communities as co-framers beyond users of information on risks and responses, adjusted or alternative application of visual ethnography may be necessary to address any ill-suited elements in other city contexts or local scales.

The case study in Kampala City, Uganda

Approach to the study

We employed visual ethnography as a methodological approach that relies on co-producing photographs with storylines from local community actors, for an engaged, contextually rich and interpretative engagements with SDGs. Visual ethnography emerged from traditional social science research methods including ethnography, systematic observation and interaction with groups in their own environment (Ellen, 1984), an approach that has evolved into multi-sited ethnography, expanding its scope and applications. This entails not only portable video- or camera-based technologies that can be mounted at points for capturing local realities of risks and responses, but also a combination of qualitative data collection techniques including focus group discussions, different modes of interviewing actors at multiple scales, and observation tools, for the purposes of gaining depth of insight and understanding of a particular social phenomenon (O'Reilly, 2012; Falzon, 2016; Peters et al, 2018; Madden, 2022).

Since cities comprise diverse neighbourhood environments that animate social interactions, with concentrated intercultural modes of living (Gidley, 2015; Neal et al, 2015), visual ethnography is a useful mode of inquiry in discerning multiple, commensurate and incommensurate perspectives, and actions on climate change adaptation at local scale in cities. As illustrated in Figure 1, visual ethnography was a process of image elicitation driven by residents from local communities, paired with in-depth interviews and the researchers' own transect walks and fieldwork experiences. Visual ethnography had the advantage of using photos on risks and local responses to climate change, to provide tangible stimuli for tapping into local community knowledge and experiences, regarding barriers and enablers of adaptation, through representations of images and interpretations linked to SDGs.

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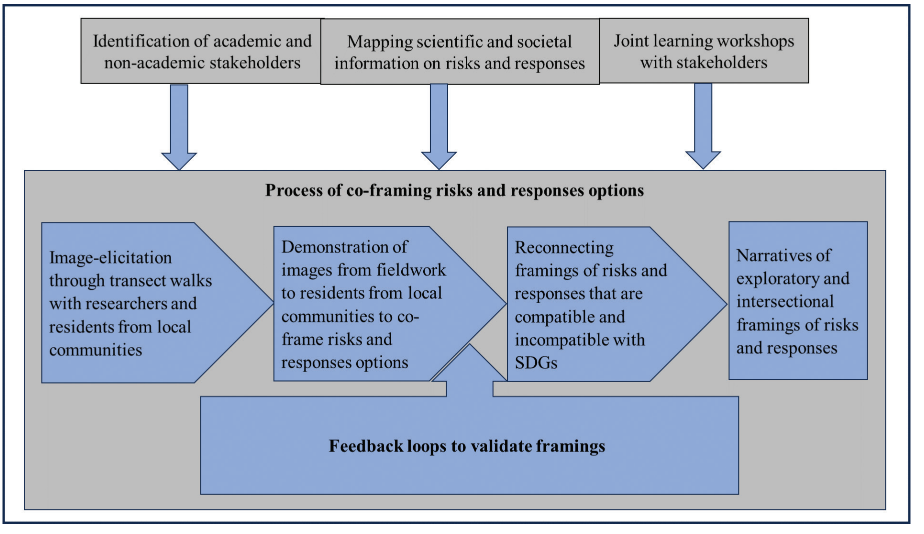
Figure 1: Schema of the visual ethnographic steps in co-framing risks and response options



Study area and population

Neighbourhoods with local climate action groups were purposively selected from Rubaga and Kawempe Divisions of Kampala city, Uganda's largest city and home to 31 per cent of the country's urban population, with 87 per cent living in informal dwellings. Rubaga and Kawempe Divisions border Kampala's central business district in the western and northern parts of the city (Figure 2), with a population of 338,665 and 383,215 respectively (UBOS, 2019). The neighbourhoods selected from the divisions were Lubya and Kasubi-Kawaala in Rubaga, and Bwaise in Kawempe. No administrative boundaries were followed in the selection process, but rather the qualitative criteria were; housing conditions, economic activities, physical environment characteristics and presence of local climate action groups. All the neighbourhoods are low-lying areas under threat from both growth and expansion in settlements, and climate risks, mainly flooding that is associated with inappropriate housing establishments in wetland areas, the after-effects of excavating/opening up hills to erect buildings and an inadequate urban drainage system. The neighbourhoods are officially classified as a slum by Kampala Capital City Authority due to settlement in wetlands and non-compliance to municipal building standards, coupled with a housing mix of semi-permanent and permanent roof, wall and floor materials.

The neighbourhoods have deeply integrated informal economic activities that include food vending, selling of used car parts, operating commercial taxis and dealerships in charcoal, among others. Housing is also looked at as a source of economic livelihood to many through brokerage of rentals, alongside other types of work like carpentry and metalwork, but there are also white-collar jobs such as textile company supervisor, parking space manager, lawyer, bank manager, tobacco company manager, journalist and so on. The allocation of land use, investment in infrastructure, and preservation of open space across the neighbourhoods affects their environment and climate. According to Kwiringira et al (2016), although drainage and road conditions have improved over time, street lighting remains scant, most

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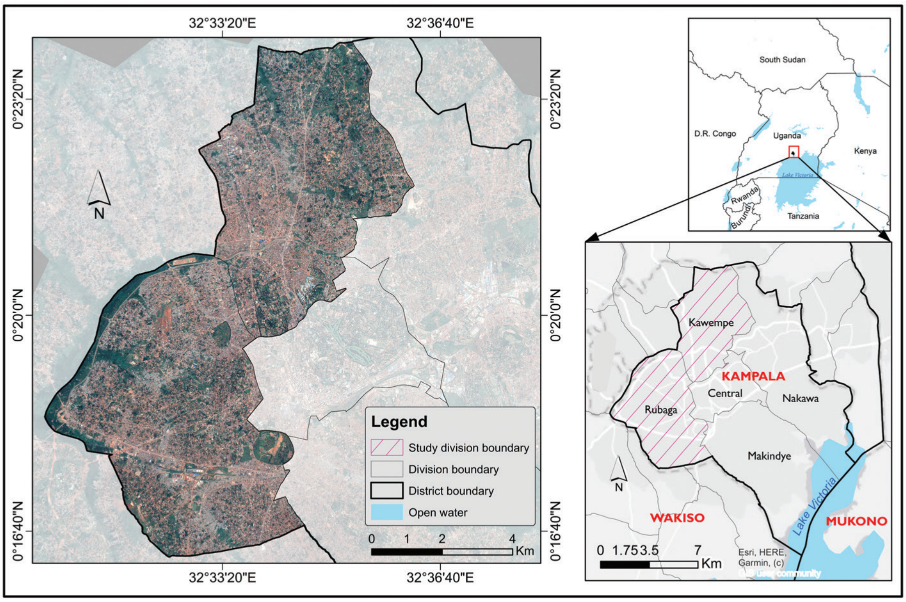
Figure 2: Map of Kampala City showing study area



Source: Urban Action Lab, Makerere University.

households do not have a piped water connection, formal solid waste collection is limited, a situation which worsened after the wasteslide disaster in August 2024 that precipitated the closure of landfill, and pit latrines dominate the sanitation system. A study by Richmond et al (2018) shows that pit latrines are unsafely emptied directly into the environment, discharging untreated sewage into natural waterways thereby polluting the city's main source of clean drinking water. Without affordable on-site sanitation facilities emptying and treatment solutions, households in the neighbourhoods open their latrines during the rainy season to discharge faecal matter. Cholera outbreaks, such as the ones that occurred in 1997, 2007 and 2015, are one direct result of the fact that 48 per cent of Kampala's residents rely on unimproved facilities for their sanitation (Lwasa and Owens, 2018; Twinomuhangi et al, 2021).

Contextual application of visual ethnography

The study employed a mixture of data collection methods that resonate with the broader approach of visual ethnography. Interviews and focus group discussions were held with ten co-researchers selected from local climate action groups. A joint learning workshop was used as an avenue for co-designing research questions and co-defining the roles to be taken on by academic researchers from Makerere University, Uganda and non-academic co-researchers from the groups during fieldwork activities. Further, a total of 23 interviews among purposively selected individuals across neighbourhoods were conducted to deepen engagement and bring to bear local climate narratives and actions within the context of SDGs. This was followed by participatory photomapping in the three neighbourhoods of Lubya, Bwaise and Kasubi-Kawaala. Transect walks by academic and non-academic study partners were undertaken in the neighbourhoods. Handheld cameras were used as the data collection tools for

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creating a visual language that relates to local narratives on vulnerability and pathways to climate change adaptation. The photomapping also took on the identification of objects, signs, technologies and socio-economic activities that speak to local climate actions and challenges. However, in Kasubi Market in Kasubi-Kawaala a trailer for capturing voices of a 13-member focus group was preferred, due to the risk of being suspected as unscrupulous agents of law enforcement. But taking photographs was much more useful in capturing research moments and images that related to the narratives from interviews, and all the data, including the content of the images was co-validated in an after-field workshop.

Generally, photographs aided the documentation of visual representations of neighbourhood actions and build a local narrative of climate change action within the communities. The activities in Table 1 in the next section have demonstrated scalable adaptation and mitigation potential, through reuse of organic waste for cleaner energy briquettes, as opposed to woody biomass that often exerts pressure on the natural resource base in peri-urban and rural areas.

Table 1: Protocol for coding and analysis of image contents

Meta-fields	Image code	Location	Scale of representation	SDG focus	Climate norm	City norm	Validity marker
Sub-fields	Location/ number	Bwaise/ Lubya/ Kasubi-Kawaala	Neighbourhood/ city/city region	Single SDG/ multiple SDGs	Mitigation/ adaptation/ resilience	Inclusive-ness/safety/ resilience	• Scope 1 • Scope 2 • Scope 3
Effect-modifiers	Type of image (trailer, picture, map, symbol, drawing)		Image storyline		Yes/No	Yes/No	

Source: Authors' design of the protocol using an Excel spreadsheet, October 2018.

The iterative measurement of locally applicable Sustainable Development Goals

Thematic content analysis was used to make sense of the data obtained from both focus groups and individual interviews. This allowed the immediate grouping of responses to ultimately triangulate local narratives on climate action with the storylines and visual meanings drawn from the images. A protocol for selecting coding and analysis of the meanings derived from the images was developed. The protocol comprised meta-fields, sub-fields and effect-modifiers. Meta-fields are the overarching descriptive themes, whereas the sub-fields comprise of sub-themes under the meta-fields (Table 1). The effect-modifiers are priori variables set to bring out the differences in relationships between the meta-fields and sub-fields.

The image code comprised two attributes: (1) the location where the image was taken; and (2) the number given to the image at the time of its entry into the protocol. The SDG focus was not restricted to SDGs 11 and 13; rather, the SDGs prioritised during the research co-design process, like SDG 7 on affordable and clean energy, SDG 1 on eliminating poverty, and SDG 3 on access to health and sanitation services for all. The validation marker for the images was based on the image storyline from the local community actors (captured during participatory photomapping) as well as the academic and societal viewpoints gathered during the co-design and after-field workshop. The attributes for the validity marker were mainstream and counter-mainstream images. The mainstream images are those that interlink SDGs 11 and

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13 indicators. Counter-mainstream images contradict the UN (United Nations) indicators for SDGs 11 and 13.

Visual content analysis was used to examine the images for their denotative content. This provided an overview of a domain of visual representation and an understanding of the connotative content of the images (how the objects portrayed relate to SDGs and what intrinsic meanings come to exist), in relation to the storylines from local community actors. Therefore, the selection of images for entry into the protocol was not devoid of the subjective notions constructed in the process, and no thorough attempt was made to systematically reduce biases associated with judging the content in the images. There were images accorded more than one theme or sub-theme, using narratives from interviews.

During entry, however, effort was made to avoid image overlaps, in the sense that images with similar content and storylines were not all included in the protocol, rather one such image was entered. The total number of images taken was 55 before selection and entry into the protocol and all these were pictures, thus excluding maps, symbols, technical drawings and trailers. But after subjecting them to bias control notions, the total number of images entered the protocol is n = 46 (Bwaise n = 14, Kasubi-Kawaala n = 24 and Lubya n = 8). This gave an entry outcome of 83.63 per cent of the images taken during participatory photomapping. The analysis of images provided descriptive statistics such as image location versus storyline, image code versus climate norm versus city norm.

Ultimately results from the protocol were triangulated with interview and focus group discussions that were used in the co-design process, of engaging local climate action groups on the local sensitivity of SDG indicators. This was initiated by establishing partnerships between individual researchers from Makerere University, Uganda, and Kasubi Local Community Development Association (KALOCODE). Through a recursive process of co-defining the roles that would characterise the partnership, both academics and non-academics took on non-traditional research responsibilities that included: coordinators, penholders, intermediaries and photographers. The four academics from Makerere University (a sociologist and three urban geographers) leaned towards being intermediaries and penholders. The intermediary role involved acknowledging each actor's viewpoint through functional participation, continuous promotion of openness and deliberation on SDGs. The role of penholders pertained to documenting the outcomes of co-framing research questions, selection of study sites and the local interpretations of vulnerability and adaptation to climate change. The four representatives from KALOCODE co-ordinated the process of establishing contacts with community groups to elicit the different perceptions of climate change and linking them to the joint learning process on vulnerability and adaptation at local scale. Given the possibility for anyone in the city to take, edit and share photographs, as well as to attract attention, and to stimulate debate among local community groups, it was agreed to share the role of photography among the academic and non-academic researchers.

Urban-leaning indicators for SDGs 11 and 13 were identified based on the UN SDG framework (Table 2). Using the urban-leaning indicator framework for the two SDGs, questions were put to local community groups by the academics. These were: (1) which SDG indicators relate directly to sustainable climate action in cities? (2) what are the linkages between these SDG indicators? and (3) how are these indicators interpreted and connected to initiatives on climate change in your

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Table 2: Key urban-leaning indicators for SDGs 11 and 13

SDG 11: Sustainable Cities and Communities:
Indicator 11.1.1: Proportion of urban population living in slums, informal settlements or inadequate housing
Indicator 11.2.1: Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
Indicator 11.3.1: Ratio of land consumption rate to population growth rate
Indicator 11.3.2: Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
Indicator 11.6.1: Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities
Indicator 11.6.2: Annual mean levels of fine particulate matter (such as PM2.5 and PM10) in cities (population weighted)
Indicator 11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
Indicator 11.a.1: Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city
Indicator 11.c.1: Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource efficient buildings utilising local materials
SDG 13: Climate Action:
Indicator 13.1.1: Number of countries with national and local disaster risk reduction strategies
Indicator 13.3.1: Number of countries that have integrated mitigation, adaptation, impact reduction and early warning into primary, secondary and tertiary curricula
Indicator 13.a.1: Mobilised number of US dollars per year starting in 2020 accountable towards the $100 billion commitment
Indicator 13.b.1: Number of least developed countries and small island developing states that are receiving specialised support, and amount of support, including finance, technology and capacity-building, for mechanisms for raising capacities for effective climate change–related planning and management, including focusing on women, youth and local and marginalised communities

Source: Authors' review of online sources from the Sustainable Development Knowledge Platform, 21 July 2018.

neighbourhood? Feedback from the groups was that the questions could not attract deeper engagement with societal viewpoints but elicit generalist perspectives that are not characteristic of local contextual dynamics. The contestation was that local community actors, even with guidance from the academics, could not easily relate the questions to their general sense of precariousness, regarding work, energy, water, health and housing in the city. Notwithstanding the sentiments that the future might not be any better than the present, research partners with their neon sticky notes and flip charts gave narratives on what it means to live and work sustainably in the city and its connection to climate action.

Results

Exploratory framings of risks and local response options

The exploratory framing of risks with potential alignment to SDGs 11 and 13 indicators, included water and air contamination, flood-prone residential units, and food markets, which topped the local community actors' perspectives on the most adverse climate impacts, and significantly associated with safe and inclusive cities.

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Infrastructure (including roads, markets, electricity poles, schools and health service centres susceptible to the impacts of flooding, due to increased surface run-off worsened by a deficient drainage system, excavation of slopes and destruction of green corridors, to open plots for residential and commercial use), was among the concerns raised by the local community actors in relation to policy and scientific framing of sustainable cities under SDGs 11 and 13.

Though floods do not generally have a very long duration – normally lasting from several hours to at most two days – they do, on one hand, cause major disruptions in transport and can lead to the spread of malaria and cholera while, on the other hand, the urban poor whose choice of where to live is driven by a series of trade-offs between what is affordable, proximity to income-earning opportunities as well as social networks and kinship ties may not move out of hazard-prone areas. The local response options to flooding and the resultant disease outbreaks, like cholera and malaria, were associated with sleeping under mosquito nets, spraying with insecticides, draining stagnant water, cleaning latrines regularly, composting pit latrines using smoked banana leaves and ash during rainy seasons, filling compounds and housing floors with soil to raise ground levels to prevent water from draining inside, placing valuables above the floor, digging trenches around the house, desilting drainage channels, raising embankments along the drainage channels, raising latrine sludge chambers and suspending houses on stilts, among others.

Due to the overlapping nature between challenges and opportunities associated with residency in flood-prone areas, low-income city dwellers can choose two adaptation measures: (1) temporary relocation (this is largely voluntary, within and outside the settlements); and (2) permanent relocation (both voluntary and involuntary, within and outside the settlement). Temporary relocation can be seen as a coping response to the emergency since people often return to their homes immediately after the waters recede. Since floods occur frequently, populations have become used to tackling the consequence by seeking temporary shelter in various places. Residents relocate temporarily during flood events within their settlements, either to a friend or relative whose place is less prone to flooding or where the water does not enter the house, according to a study by Kisembo (2018).

While some narratives from local community actors aligned with UN SDG indicators such as the proportion of the urban population living in slums, informal settlements or inadequate housing, the diverse community perspectives on safety, inclusivity and climate adaptation in the city diverged from the SDG framework. These perspectives were classified as counter-mainstream as illustrated in Table 3. The value of the co-framing approach depicted in Table 3 lies in its context sensitivity and iterative flexibility to articulate between internationally agreed SDG measurements and distinctive local narratives on navigating the combined threats of precarity in the city and climate change. Local community narratives also indicated the intricate nature of interactions between socio-economic and natural urban components, especially regarding the way in which risk is perceived.

The lesson to focus on, however, is that while it is important to understand the local context of each prioritised SDG, the potential for replicating the practice in other contexts should pay attention to certain elements. The research questions continued to change as perceptions emerged from and within the fluid process of consensus-building on what should be taken as framings for incorporating different ideas on risk and response into a single indicator. The outcome was frame accommodation,

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Table 3: Counter-mainstream practices from local climate groups in Kampala

SDG	Key SDG issue/norm	Locally appropriate indicators
SDG 1 (No poverty)***	Safety, access, affordability, switching of fuels, inclusiveness	• Number of water service points in the neighbourhood • Level and source of household income • Available range of alternative house rentals • Tenure status • Nature of employment and income-generating activities
SDG 2 (End hunger, achieve food security)**	Nutrition, hygiene, access, affordability	• Number of meals per day • Type of food most consumed by household • Meal preparation time • Price of energy requirements for meal preparation
SDG 3 (Ensure healthy lives)**	Convenience, availability, safety, access	• Proximity to healthcare by household • Type of diet taken per household • Money spent on medicines per household
SDG 7 (Sustainable Energy)***	Cleanliness, access, affordability, sustainability	• Quantity and type of energy used • Access to alternative cooking energy • Price per type of cooking and lighting energy • Energy mix per household • Adjustment practices used to manage energy shocks • Health effects of a given type of energy
SDG 11 (Sustainable Cities and Communities)***	Safety, hygiene, low emissions, inclusiveness, resilience	• Number of users for each municipal service (water, health, education extra) • Reduction in health risks • Level of greenhouse gas emission • Number iron sheets required for roofing a decent home • Land tenure status • Reduced risk of relocation due to floods • Common property services by neighbourhood (quarries, wells, waste dumpsites)
SDG 12 (Responsible consumption and production)**	Usage of space and natural assets	• Types and number of natural assets in neighbourhood (springs, stone quarries, trees)
SDG 13 (Climate Action)**	Weather conditions (temperature and rainfall), seasonal variations	• Changes in rainfall and temperature • Coldness or hotness of day or month

Note: *** = high priority; ** = medium priority; * = low priority SDG.

Source: Authors' aggregation of feedback from the joint learning workshop, 20 August 2018.

where a single indicator for SDG 11 or 13 accommodated the different elements of perceived or experienced risks with corresponding local response options. This invited different local community actors to the process of interconnecting expert and societal elements within the global indicators for SDGs 11 and 13.

The key contradiction found was that, whereas the SDG 11 measurements look to a reduction in the proportion of urban population living in slums, the images taken

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reflected a mix of semi-permanent and permanent roof, wall and floor materials, with local climate action groups arguing that the measure for decent housing should focus on number of iron sheets needed, affordability of materials required, public service delivery points (water, health and electricity in the neighbourhood) and land tenure status. This implies that SDGs should speak to repurposing or working with informality instead of illegalising it, as a case in many contemporary city planning regimes. Indeed, Arfvidsson et al (2018) stress the critical and yet often overlooked role of informality in urban development, particularly in developing countries, and thus call for clear definitions and robust metrics to assess informal sectors to enable their integration into urban policies. SDGs inadequately address informality, lacking specific targets and excluding informal actors from decision making, which in turn perpetuates marginalisation. The ambition for informal sector integration can be achieved through tracking progress towards public service delivery to urban informal settlements and tapping into the opportunities for cross-scaling nature and technology-based solutions to climate change that stem from local innovations alongside municipal interventions.

Intersectional framings of risks and response options

Beyond the global indicators for SDGs 11 and 13, images and dialogue with the local community representatives revealed interactional framings on poverty (SDG 1), energy price shocks (SDG 7), SDG 3 (ensuring healthy lives), SDG 9 (build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation) and SDG 12 (responsible consumption and production). Energy price shocks associated with reliance on charcoal and hydropower are a risk not directly linked to SDG 13 indicators. Of particular interest was local response options to energy poverty as an intersectional framing of risk. Such response options include self-generation (use of generators, biogas and solar panels), improved energy technologies (energy-saving bulbs and cooking-stoves), adjustments in energy-use practices (abandoning boiling of water and foregoing hot water baths), adjustments in sleeping schedules, abandoning foods that require long hours of preparation alongside illegal connection/theft and tapping of public electricity (Buyana et al, 2019).

The other dominant local response option found to energy poverty was innovative technologies that seek to balance the need for energy with reduced air pollution for better urban health, through organic and inorganic waste reuse and recycling (Figure 3). This involves recovering reusable and recyclable items from the waste stream including: polythene bags for growing mushrooms; banana, cassava and sweet potato peelings and cow dung for compost production and generation of biogas energy; plastic bottles for refilling with juice and drinking water; carbonised char and ash for backyard gardening and urban agriculture; newspapers for making egg trays; tins and mineral water bottles for making shoe soles; bottle straws for knitting baskets; charcoal and sawdust for reducing odour from latrines; oily milk packages used as fuel for cooking; and discarded cardboard serving as walls and roofs of houses for a cool indoor climate in times of excessive heat.

The most common waste innovation marketed by local community groups was garbage briquettes as an alternative cooking fuel to reduce indoor air pollution and respiratory illnesses. The briquettes are created when banana peels and other organic materials are dried and combusted into a large metallic bin (burnt under extremely

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Figure 3: Image of briquette-making machine (left) and solar dryer in proximity of a small banana garden (right)

Source: Image code K2 from the participatory photomapping, October 2018.

high heat, with limited exposure to oxygen) to perhaps create powdered carbonised materials made from garbage instead of trees. The carbonised char is then crushed and mixed with clay and cassava flour (as a binder) and rolled into different shapes (commonly balls and cylinders) to create briquettes that are used as an alternate to charcoal and firewood. One actor from Kasubi Community Development Association (KACODA) reported that 10 kg of sawdust are mixed with four bottles of mushroom seeds together with 20 litres of water and rice husks which are then stirred, cooked and left to decompose for six months, to create fertilisers. The resulting volume of decomposed material can allow the farmer to set up 60 mushroom gardens, each measuring four by four metres. These gardens could generate a daily income of approximately US$15. It was noted that this innovation is a sociotechnological transfer from India, and the yields from this kind of intervention provide curative medicines for heart disease. This provides an insight into how the waste economy can contribute to harnessing the health co-benefits of energy efficiency. Other images depicted inspiring cases on urban agriculture and forestry that transcend local climate change responses to poverty alleviation (SDG 1).

Urban-leaning UN indicators for SDGs 11 and 13 (Table 2) were used as the reference point for co-validating whether the images were exploratory or intersectional framings. Overall, 26 per cent of the images spoke to SDG 11 and 13 indicators with some degree of ambiguity, compared to 46 per cent that were construed as intersectional framings, meaning that their content was reflected in the urban-leading indicators across different SDGs (Table 4).

The intersectional framings were not only mapped using the indicators but also the norms that define the interpretations at local and global scales (Figure 4). Within the SDGs, meanings, representations, overlaps and linkages among the norms were generated. The norms that the study took on were inclusivity, safety and resilience (SDG 11); and mitigation, adaptation and resilience (SDG 13). The challenges and actions visualised from the images were 100 per cent of the total regarding inclusiveness in the city, compared to 41 per cent on safety and 33 per cent on resilience (Figure 4). With respect to SDG 13 norms, 24 per cent spoke to mitigation compared to 43 per cent on adaptation and 30 per cent on resilience, across all the three neighbourhoods (Figure 4).

For what concerns safe cities, the main perspective was energy technologies for averting health-related risks and treatment of waste as resources to reduce danger to

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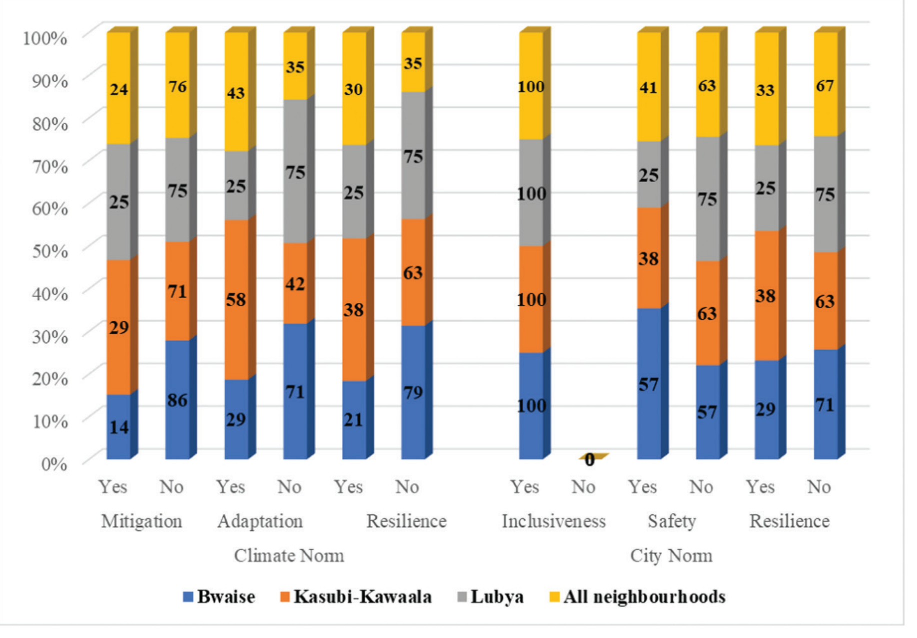
Table 4: Validation of images against UN indicators for SDGs

Image location	Mainstream images (%)	Counter-mainstream images (%)
Bwaise	29	50
Kasubi-Kawaala	25	42
Lubya	25	50
All neighbourhoods	26	46

Figure 4: Image representation of SDG climate and city norms



public health, coupled with municipal interventions for the mitigation of flood risk. The inclusive cities narrative took on urban inequality dimensions, with a view to creating possibilities for equal access to decent housing, secure land tenure and alternative cooking energy either by or beyond the purview of municipal authorities. Resilient cities, the less-understood SDG norm among local community groups, elaborates on how neighbourhood dwellers build back and repair their homes and businesses after flood episodes through social networks and solidarity that institute mechanisms for alternative technologies, such as the Gulper, a pit latrine-emptying service used before and after the rains. The deep and contextual engagement on the local interpretations of SDG norms provided the ground for demonstrating the many interlinkages between urbanisation and climate action, and why SDGs are an 'indivisible whole'.

Discussion

This study reveals that visual ethnography can enhance the ability of actors at local scale to express their climate challenges and scalable solutions in cities. As our findings depict, visual ethnography brought to bear the voices of those directly affected by floods, to validate and align their local experiences to the classification

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and contextualisation of SDG indicators and norms, and the required policy actions at municipal level. The results of this study show that climate extremes can be visualised in ways that are sensitive to local perceptions of risks, but without diluting the discourse on synthesising, downscaling and visualising climate change scenarios using scientific methods (Shaw et al, 2009). The study approach enabled vulnerable communities to get an opportunity to imagine different adaptation futures, building from their own innovations. We therefore argue that the lived experiences of local communities can be an important source of information on not only stressors identified and prioritised by local community residents, but also a climate solutions imagery that contains positive adaptation stories with opportunities for extending scientific inquiry and stakeholder engagement on the needed policy responses.

Although the research was unable to interrogate the subjective notions constructed in the process, community-led provision of relevant climate information, through images and storylines has a valuable part to play in integrating science, policy and societal interpretations of SDGs. However, some scholars, like Creutzig et al (2019), contend that it is prudent and timely to review critically the current landscape of climate information service provision, with the purpose of formulating flexible and meaningful strategies for expanding, integrating and advancing the role of actors outside climate science communities in cities. Potential avenues could imply exploring the potential of visual ethnography in minimising researcher subjectivities in framing of risks and response options. This is because it enables researchers to co-frame priority risks and feasible responses with practitioners across the aisle when coding or classifying their narratives in the process. The transdisciplinary potential of visual ethnography permits interactional framing of converse stakeholder views come through on the discourse about confronting global challenges like climate change and urbanisation.

Conclusion

Overall, visual ethnography can be used to mediate discourse on the integrated nature of SDGs, while discerning the (dis)connections between local and global measurements of sustainable climate action in cities. Different from most existing studies that treat visualisation of climate trends from a quantitative point of view, our article uses visual ethnography to elicit the different local perceptions and actions on climate change, while linking the findings to the joint learning processes of interrogating universality and constellations among SDG 11 and SDG 13 indicators. The locally contextualised nature of climate impacts and urgency for local action require prioritisation of a plethora of non-conventional data-based approaches to document everyday realities, experiences and lessons on local climate adaptation to inform programming, scaling, replicability and comparability of local climate risks and response options for sustainability and transformation endeavours at multiple scales.

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Data availability

The authors take responsibility for the integrity of the data and the accuracy of the analysis. All the data used has been included in the manuscript. Any other details can be obtained through contacting the corresponding author.

Experimentation on humans and animals statement

This research was not carried out humans and/or animal experiments but, rather, involved humans as participants. Human participation in this research adhered to principles of the Declaration of Helsinki coupled with compliance to the ethical safeguards defined by Makerere University including seeking of informed consent from each of the participant.

Conflict of interest

The authors declare that there is no conflict of interest.

References

Arfvidsson, H., Simon, D., Oloko, M. and Moodley, N. (2018) Engaging with and measuring informality in the proposed Urban Sustainable Development Goal, in L.C. Zulu and C. D'Alessandro (eds) *Africa in the Post-2015 Development Agenda: A Geographical Perspective*, Abingdon: Routledge, pp 100–14.

Asefi-Najafabady, S., Vandecar, K.L., Seimon, A., Lawrence, P. and Lawrence, D. (2018) Climate change, population, and poverty: vulnerability and exposure to heat stress in countries bordering the Great Lakes of Africa, *Climatic Change*, 148(4): 561–73, doi: 10.1007/s10584-018-2211-5

Buyana, K., Byarugaba, D., Sseviiri, H., Nsangi, G. and Kasaija, P. (2019) Experimentation in an African neighborhood: reflections for transitions to sustainable energy in cities, *Urban Forum*, 30(2): 191–204, doi: 10.1007/s12132-018-9358-z

Buyana, K., McClure, A., Walubwa, J., Koranteng, K., Mukwaya, P.I. and Taylor, A. (2022) Power dynamics in transdisciplinary research for sustainable urban transitions, *Environmental Science & Policy*, 131: 135–42, doi: 10.1016/j.envsci.2022.02.001

Carneiro, B., Resce, G., Läderach, P., Schapendonk, F. and Pacillo, G. (2022) What is the importance of climate research? An innovative web-based approach to assess the influence and reach of climate research programs, *Environmental Science & Policy*, 133: 115–26, doi: 10.1016/j.envsci.2022.03.018

Creutzig, F., Lohrey, S., Bai, X., Baklanov, A., Dawson, R., Dhakal, S., et al (2019) Upscaling urban data science for global climate solutions, *Global Sustainability*, 2: art e2, doi: 10.1017/sus.2018.16

Unauthenticated | Downloaded 03/19/25 02:31 PM UTC

Dewulf, A. and Bouwen, R. (2012) Issue framing in conversations for change: discursive interaction strategies for 'doing differences', *Journal of Applied Behavioral Science*, 48(2): 168–93, doi: 10.1177/0021886312438858

Ellen, R.F. (ed) (1984) *Ethnographic Research: A Guide to General Conduct*, London: Academic Press.

Falzon, M.A. (2016) Multi-sited ethnography: theory, praxis and locality in contemporary research, in M.A. Falzon (ed) *Multi-sited Ethnography: Theory, Praxis and Locality in Contemporary Research*, Abingdon: Routledge, pp 1–23.

Gallagher, K., Cardwell, N., Denichaud, D. and Valve, L. (2022) The ecology of global, collaborative ethnography: metho-pedagogical moves in research on climate change with youth in pandemic times, *Ethnography and Education*, 17(3): 259–74, doi: 10.1080/17457823.2022.2025879

Gidley, B. (2015) Landscapes of belonging, portraits of life: researching everyday multiculture in an inner city estate, in M.L. Berg, B. Gidley and N. Sigona (eds) *Ethnography, Diversity and Urban Space*, Abingdon: Routledge, pp 14–29.

Joshi, D., Panagiotou, A., Bisht, M., Udalagama, U. and Schindler, A. (2023) Digital ethnography? Our experiences in the use of SenseMaker for understanding gendered climate vulnerabilities amongst marginalized agrarian communities, *Sustainability*, 15(9): art 7196, doi: 10.3390/su15097196

Katsaros, K., Marggraf, C., Ebi, K.L., Buyana, K., Hashizume, M., Lung, S.C.C., et al (2024) Exploring interconnections: a comprehensive multi-country analysis of climate change, energy demand, long-term care, and health of older adults, *Maturitas*, 184: art 107961, doi: 10.1016/j.maturitas.2024.107961

Kisembo, T. (2018) *Flood Risk-Induced Relocation in Urban Areas: Case Studies of Bwaise and Natete, Kampala, MSc dissertation*, Makerere University.

Klatko, T.J., Saeed, T.U., Volovski, M., Labi, S., Fricker, J.D. and Sinha, K.C. (2017) Addressing the local-road VMT estimation problem using spatial interpolation techniques, *Journal of Transportation Engineering, Part A: Systems*, 143(8): art 04017038, doi: 10.1061/JTEPBS.0000064

Kousky, C. and Schneider, S.H. (2003) Global climate policy: will cities lead the way?, *Climate Policy*, 3(4): 359–72, doi: 10.1016/j.clipol.2003.08.002

Kwiringira, J., Atekyereza, P., Niwagaba, C., Kabumbuli, R., Rwabukwali, C., Kulabako, R., et al (2016) Seasonal variations and shared latrine cleaning practices in the slums of Kampala city, Uganda, *BMC Public Health*, 16: art 361, doi: 10.1186/s12889-016-3036-7

Kythreotis, A.P., Mantyka-Pringle, C., Mercer, T.G., Whitmarsh, L.E., Corner, A., Paavola, J., et al (2019) Citizen social science for more integrative and effective climate action: a science-policy perspective, *Frontiers in Environmental Science*, 7: art 10, doi: 10.3389/fenvs.2019.00010

Land-Zandstra, A., Agnello, G., Gültekin, Y.S., Vohland, K., Land-Zandstra, A., Ceccaroni, L., et al (2021) Participants in citizen science, in K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, et al (eds) *The Science of Citizen Science*, Cham: Springer, pp 243–61.

Liebenberg, L. (2009) The visual image as discussion point: increasing validity in boundary crossing research, *Qualitative Research*, 9(4): 441–67, doi: 10.1177/1468794109337877

Lwasa, S. (2017) Options for reduction of greenhouse gas emissions in the low-emitting city and metropolitan region of Kampala, *Carbon Management*, 8(3): 263–76, doi: 10.1080/17583004.2017.1330592

Unauthenticated | Downloaded 03/19/25 02:31 PM UTC

Lwasa, S. and Owens, K. (2018) *Kampala: Rebuilding Public Sector Legitimacy with Sanitation Services*, Washington, DC: World Resources Institute.

Mabon, L. (2020) Making climate information services accessible to communities: what can we learn from environmental risk communication research?, *Urban Climate*, 31: art 100537, doi: 10.1016/j.uclim.2019.100537

Madden, R. (2022) *Being ethnographic: a guide to the theory and practice of ethnography*. 3rd edn, London: Sage.

Manteaw, B.O., Amoah, A.B., Ayittah, B. and Enu, K.B. (2022) Climate-informed decision-making in data-poor environments: managing climate risk through citizen science networks, *Frontiers in Climate*, 4: art 835768, doi: 10.3389/fclim.2022.835768

Marion Suiseeya, K.R. and Zanotti, L. (2019) Making influence visible: innovating ethnography at the Paris Climate Summit, *Global Environmental Politics*, 19(2): 38–60, doi: 10.1162/glep_a_00507

Menteşe, E.Y., Cremen, G., Gentile, R., Galasso, C., Filippi, M.E. and McCloskey, J. (2023) Future exposure modelling for risk-informed decision making in urban planning, *International Journal of Disaster Risk Reduction*, 90: art 103651, doi: 10.1016/j.ijdrr.2023.103651

Neal, S., Bennett, K., Jones, H., Cochrane, A. and Mohan, G. (2015) Multiculture and public parks: researching super-diversity and attachment in public green space, *Population, Space and Place*, 21(5): 463–75, doi: 10.1002/psp.1910

Neset, T.S., Wilk, J., Cruz, S., Graça, M., Rød, J.K., Maarse, M.J., et al (2021) Co-designing a citizen science climate service, *Climate Services*, 24: art 100273, doi: 10.1016/j.cliser.2021.100273

O'Reilly, K. (2012) *Ethnographic Methods*, 2nd edn, Abingdon: Routledge.

Palmer, T.N. (2012) Towards the probabilistic Earth-system simulator: a vision for the future of climate and weather prediction, *Quarterly Journal of the Royal Meteorological Society*, 138(665): 841–61, doi: 10.1002/qj.1923

Peters, P., Carson, D., Porter, R., Vuin, A., Carson, D. and Ensign, P. (2018) My village is dying? Integrating methods from the inside out, *Canadian Review of Sociology*, 55(3): 451–75, doi: 10.1111/cars.12212

Pink, S. (2021) *Doing Visual Ethnography*, 4th edn, London: Sage.

Richmond, A., Myers, I. and Namuli, H. (2018) Urban informality and vulnerability: a case study in Kampala, Uganda, *Urban Science*, 2(1): art 22, doi: 10.3390/urbansci2010022

Scovronick, N., Sera, F., Acquaotta, F., Garzena, D., Fratianni, S., Wright, C.Y., et al (2018) The association between ambient temperature and mortality in South Africa: a time-series analysis, *Environmental Research*, 161: 229–35, doi: 10.1016/j.envres.2017.11.001

Shaw, A., Sheppard, S., Burch, S., Flanders, D., Wiek, A., Carmichael, J., et al (2009) Making local futures tangible: synthesizing, downscaling, and visualizing climate change scenarios for participatory capacity building, *Global Environmental Change*, 19(4): 447–63, doi: 10.1016/j.gloenvcha.2009.04.002

Sheppard, S.R.J. (2005) Landscape visualisation and climate change: the potential for influencing perceptions and behaviour, *Environmental Science & Policy*, 8(6): 637–54, doi: 10.1016/j.envsci.2005.08.002

Simon, D. and Leck, H. (2015) Understanding climate adaptation and transformation challenges in African cities, *Current Opinion in Environmental Sustainability*, 13: 109–16, doi: 10.1016/j.cosust.2015.03.003

Unauthenticated | Downloaded 03/19/25 02:31 PM UTC

Stephens, S.H. and Richards, D.P. (2020) Story mapping and sea level rise: listening to global risks at street level, *Communication Design Quarterly*, 8(1): 5–18, doi: 10.1145/3375134.3375135

Twinomuhangi, R., Sseviiri, H., Mulinde, C., Mukwaya, P.I., Nimusiima, A. and Kato, A.M. (2021) Perceptions and vulnerability to climate change among the urban poor in Kampala City, Uganda, *Regional Environmental Change*, 21: art 39, doi: 10.1007/s10113-021-01771-5

UBOS (Uganda Bureau of Statistics) (2019) *Statistical Abstract for Kampala City*, Kampala: Kampala Capital City Authority and Uganda Bureau of Statistics, https://www.kcca.go.ug/media/docs/Statistical-Abstract-2019.pdf.

UN-Habitat (2017) *City Prosperity Initiative: A Platform to Measure Urban SDGs*, United Nations Human Settlements Programme, https://habnet.unhabitat.org/sites/default/files/documents/CPI_toolkit.pdf.

Visbeck, M. (2008) From climate assessment to climate services, *Nature Geoscience*, 1: 2–3, doi: 10.1038/ngeo.2007.55

Vollstedt, B., Koerth, J., Tsakiris, M., Nieskens, N. and Vafeidis, A.T. (2021) Co-production of climate services: a story map for future coastal flooding for the city of Flensburg, *Climate Services*, 22: art 100225, doi: 10.1016/j.cliser.2021.100225

Wichmann, J. (2017) Heat effects of ambient apparent temperature on all-cause mortality in Cape Town, Durban and Johannesburg, South Africa: 2006–2010, *Science of The Total Environment*, 587–588: 266–72, doi: 10.1016/j.scitotenv.2017.02.135

WMO (World Meteorological Organization) (2011) *Climate Knowledge for Action: A Global Framework for Climate Services – Empowering the Most Vulnerable, Report of the High-Level Taskforce for the Global Framework for Climate Services*, WMO No. 1065, Geneva: WMO.

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