**Learning about urban mitigation solutions**

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**Climate change assessments by the IPCC and others put increasing emphasis on cities as key actors in mitigation and early policy adoption. While a coherent understanding of barriers and opportunities for climate solutions remains fragmented, there is already a large body of case study literature to learn from and translate into different urban contexts** 1**. But a number of practical and conceptual challenges hinder systematic analysis. First, the literature tends to focus on cases in large, wealthy cities in the global North. Yet, the majority of the global population resides in much smaller agglomerations in the Global South with only partially developed urban infrastructures. Second, a comprehensive overview of which mitigation topics have been researched for what cities is currently missing. Third, comparative analysis and secondary research on the case study literature is sparse and lacks structured methods. Here we perform a systematic review of the literature landscape of case studies on climate mitigation solutions in cities. We find that learning about urban mitigation solutions requires concerted efforts to systematically aggregate the dispersed knowledge on generalizable topics, such as spatial scalability, from individual cities and issues to comparative reviews on large set of cities with multiple entangled climate mitigation strategies.**

Cities experience similar dynamics of agglomeration 2, are faced with structurally comparable decarbonisation challenges 3,4 and are increasingly interconnected through trade, globalisation and coordinated social or political movements 5–8. The opportunities for learning across and between cities are therefore widely discussed 9,10 – and urgently needed in the context of upscaling efforts to keep global warming below 1.5°C or 2°C 11.

The IPCC’s 6th Assessment Cycle will again include dedicated chapters on urban systems, in both Working Groups II and III. Urban assessments and research networks are in their infancy, but gaining momentum, as exemplified by the Urban Climate Change Research Network (UCCRN) and in efforts to foster a global urban science 12–14. Case studies are prominent in these assessments: often they are presented in dedicated boxed sections, are curated in libraries of urban initiatives, or are simply placed in the text as examples of policies and actions. Such cases can have an ambiguous scientific role. Often they tend towards ‘success stories’ rather than failures, favour description over analysis, and lack claims of generalisability. Hence even though there is a proliferation of cases, we have yet to understand how well different climate policies work, for which types of cities, under what circumstances.

Multiple issues in the underlying literature confound learning about urban mitigation solutions. First, cities are known for their conceptual challenges, including how to systematise urban physical boundaries for comparison 13,15, or select topics that are ‘urban’ and not simply general social or global processes 2. Second, there is a supposed bias towards conducting cases in the global North and excluding the urban experiences of the global South 2. Third, the published literature on climate change is following an exponential growth trend 16 and the urban mitigation field is no exception 1. Scientists are no longer capable of tracking developments in their field, raising the risk that attention will only be paid to highly visible, contentious, or successful examples of urban climate change mitigation – overlooking failures and their opportunities for learning, as well as insights from poorly studied locations and contexts. Finally, the case study format itself is open to questions of academic rigour and a perceived lack of generalisability, despite its potential for explanatory power and empirical richness 17.

Here we take stock of the case study research on urban mitigation so far, assessing the extent to which these issues remain unresolved and suggest ways forward. Our analysis focuses on three questions: (1) which types of cities do we know about, in terms of population size and global region? (2) What mitigation topics do we know about, for which cities? And (3), what comparative or secondary analysis is there of the urban case study research? Overall we identify a rich and varied literature of urban case studies, albeit one with regional and topic biases, and a distinct lack of learning on these studies.

To obtain a sample of urban mitigation articles we use a search query that combines synonyms for “urban” and “mitigation” in the Web of Science and Scopus literature databases (see methods). Our interpretation of case study research is straightforward: if an article mentions a city name in the abstract or title, we assume it is a case study located in the city (or cities) mentioned.

**Urban case studies are biased towards large cities and the global North**

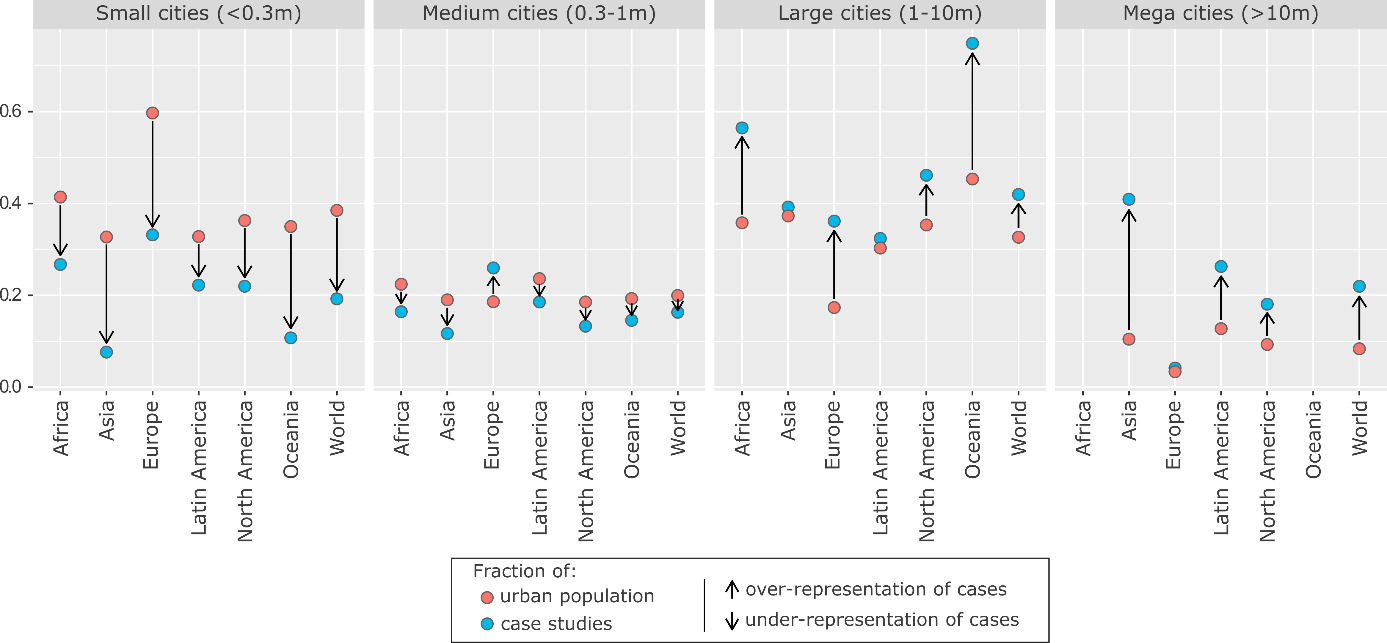
Urban form and infrastructures shape energy use and greenhouse gas emissions on a time-scale of decades to centuries. With the window on 1.5°C rapidly closing it is hence essential to immediately initiate transformations in well-developed cities – and to guide emerging cities towards compact, low-carbon urban forms prepared for deep decarbonisation 18,19. Global urban population data suggests priorities: the largest segment of the world’s urban population currently resides in small Asian cities (SI Text Figure 5); while looking forward to 2030, the fastest urban growth will take place in Africa (SI Text Figure 6) 18,20. These are precisely the cities on which we lack case study research.

Figure 1 shows the spread of case study research across different city sizes, from a small number of familiar ‘mega-cities’ (over 10m inhabitants), to dozens of smaller national and regional capital cities (1-10m), and hundreds of yet smaller regional metropoles. The majority of research so far has focused on larger cities, with a small number of mega-cities receiving particular attention: Beijing (284 articles), New York (146), Shanghai (140) and London (117). Other cities are mentioned in fewer than 100 articles each.



**Figure 1: Summed urban climate mitigation articles, grouped according to city size.** Where available, urban agglomeration data is used. The 15 most frequently studied cities are labelled.

The current focus on larger cities does not seem to be justified in multiple dimensions. Just 10% of the world’s urban population lives in mega-cities, compared to 40% in small cities – yet both groups are treated equally in research, each receiving approximately 20% of the case studies we find (Figure 2). A particularly stark divide can be seen in Asia, where the low proportion of mega-city inhabitants (10%) is served by over 40% of the urban case study literature in this region. Although mega-cities are fast-growing in most regions (SI Text Figure 6), this unbalanced focus leaves smaller urban centres consistently under-represented. This pattern is repeated for literature citations, with progressively larger cities receiving, on average, more citations (SI Text Figure 7).



**Figure 2: Size bias in urban mitigation case study research.** Fractions of population and case studies are relative to regions.

Regionally, we observe a clear bias towards Europe, North America and Oceania, which receive an outsized share of articles relative to their small proportion of the global urban population (SI Text Figure 8). Looking forward to urbanisation trends in 2030, the least well represented region, Africa, has the fastest growing cities. And the least well represented segment, small Asian cities, will have the largest share of the global urban population. A major shift in focus therefore emerges as a clear priority for future research.

**Demand-side topics dominate urban case studies**

Energy demand reduction is increasingly seen as a crucial component of ambitious climate mitigation 21,22. Cities, as the site of everyday behaviours and practices, offer significant scope for shaping energy demand through infrastructures, land-use planning and bottom-up social change 23. We therefore see an important role for urban research in assessing demand-side solutions, not least from the perspective of trade-offs and synergies with broader sustainability issues and human well-being 24,25. Case studies may be well suited for this task, due to their rich contextual analysis and ability to integrate diverse quantitative and qualitative lines of evidence.

As it is increasingly difficult to track the development of rapidly growing scientific fields, we turn to natural language processing methods in order to outline the scope of mitigation research carried out on cities. Using the identified corpus of 3,440 case studies we construct a matrix of documents and the words they contain (abstracts only), factorising to obtain the ‘topics’ that describe commonly co-occurring words across the document set (we subsequently refer to this as “topic modelling”; see methods). In essence, machine reading software discovers the latent topics that permeate the document set and categorises each document accordingly, substituting for the laborious task of reading and tagging each article by hand. The unsupervised ‘learning’ in this method also reduces subjectivity in one’s overall assessment of a body of literature.

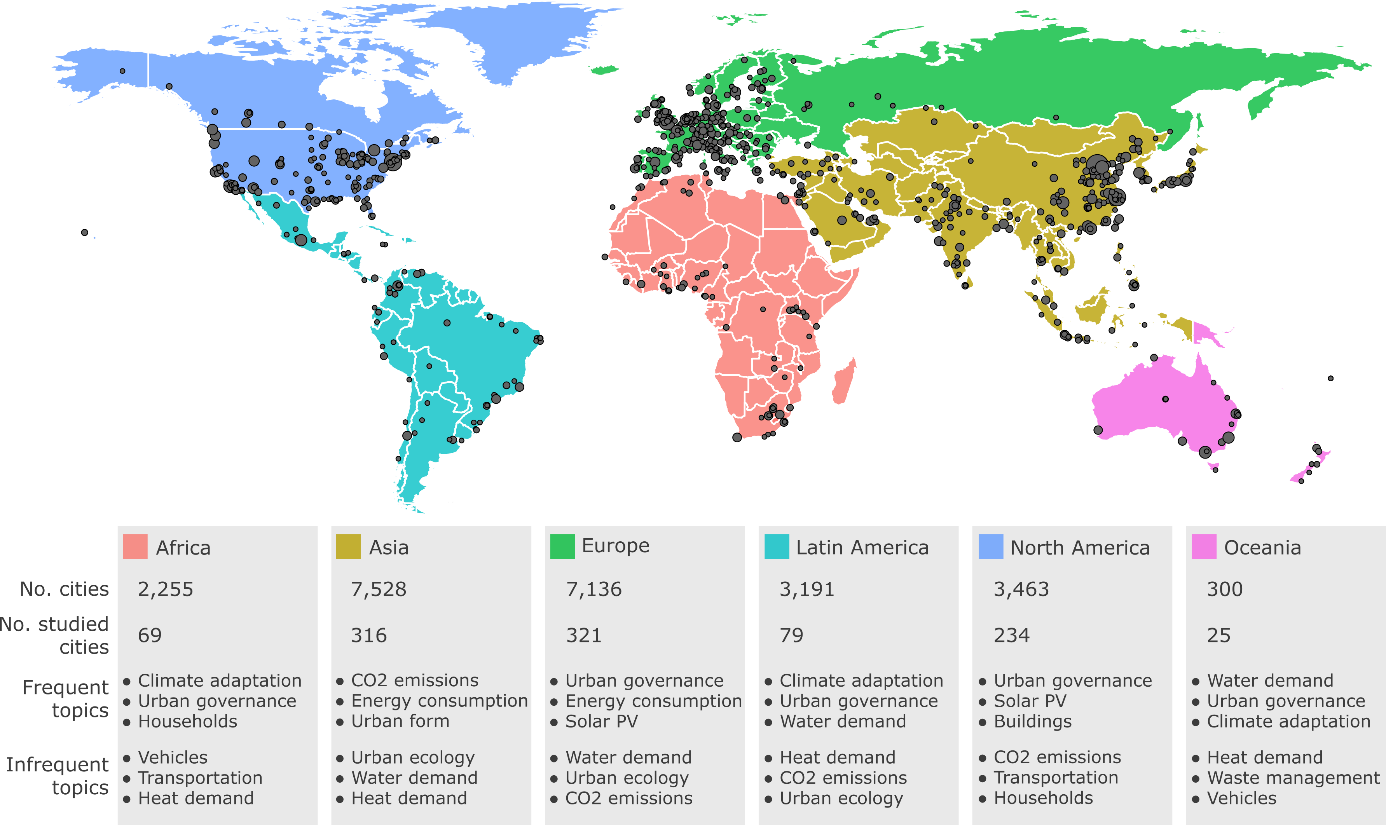


Figure : Urban case study cities and topics by region

We isolate 17 topics areas in the set of case studies (SI Text Table 4). Demand-side topics are indeed prevalent, for instance covering transportation, waste management, and energy and heat demand in buildings – alongside issues of urban governance, urban form and CO2 emissions accounting. A single supply-side topic emerges on solar PV. Wider sustainability issues such as air pollution, water demand, urban ecology and climate adaptation are also integrated in the case studies we identify.

As each case study document is marked up by a combination of these topics, the analysis can be scaled-up to groups of documents, for instance to analyse prevalent (or lacking) topics at a regional level. Here we observe that emissions accounting and urban form are frequent subjects of case study research situated in Asia (Figure 3). This contrasts with the ubiquity of urban governance research, which captures policies and policy-making, in all other regions. Climate adaption also emerges as the most prominent topic in Africa, Latin America and Oceania. As our search query specified no adaptation keywords, this latter result suggests a continued failure to balance urban adaptation research in these regions with a mitigation agenda.

Isolating research topics on individual cities is also possible. For instance we find that low-carbon transportation is scarcely researched for New York City and Chicago, but well developed for London (SI Text Table 5). Again, emissions accounting dominates the research landscape of top-tier cities in China (Beijing, Shanghai and Tianjin), while topics around urban ecology, water demand and waste management are overlooked here – at least in the mitigation focused literature we identify. Table 1 lists the articles we identify for the largest urban centre in Africa, Cairo, showing not just the scarcity of studies on this city, but the potential of topic modelling to rapidly identify the main themes of research to date, in this case a predominant focus on building design and technologies.

|  |  |  |  |
| --- | --- | --- | --- |
| **Title** | **Year** | **Authors** | **Topics** |
| Energy efficiency strategies in urban planning of cites | 2009 | Khalil, H.A.E.E. | Urban governance; Energy consumption; Urban form |
| Active solar retrofit of a residential house, A case study in Egypt | 2010 | Attia, S., De Herde, A. | Buildings; Heat demand; Green roofs; Solar PV |
| Urban form, thermal comfort and building CO2 emissions - a numerical analysis in Cairo | 2011 | Fahmy, M, Sharples, S | Buildings; GHG emissions; Green roofs; Urban form |
| Effect of building form and urban pattern : On energy consumption of residential buildings in different desert climates | 2012 |  | Buildings; Urban form |
| Governing the transition to natural gas in Mediterranean Metropolis: The case of Cairo, Istanbul and Sfax (Tunisia) | 2015 | Verdeil, E, Arik, E, Bolzon, H, Markoum, J | Urban governance; Energy consumption; Heat demand; Urban form |
| Reducing cooling demands in a hot dry climate: A simulation study for non-insulated passive cool roof thermal performance in residential buildings | 2015 | Dabaieh, M, Wanas, O, Hegazy, MA, Johansson, E | Buildings; Green roofs |
| Assessment of building integrated photovoltaics for the residential section in representative Urban areas in Egypt | 2016 |  | Buildings; Energy consumption; Households; Solar PV; Urban form |
| High-rise buildings in context of sustainability; urban metaphors of greater Cairo, Egypt: A case study on sustainability and strategic environmental assessment | 2016 |  | Buildings |

**Table 1: Urban climate mitigation literature on Cairo**

In the context of current research needs, forward looking studies that anticipate lock-in effects and future mitigation bottlenecks are key to enabling urban contributions towards the Paris Agreement goals 19. It is perhaps significant, then, that we find no topic referring to scenarios or forward looking studies. We therefore search abstracts directly for relevant keywords (e.g. “scenario” or “2050”; see methods for more detail). The identified documents (333 in total) mainly emphasise emissions accounting, transportation and air pollution (SI Text Table 6). Urban form is less prominent, despite its centrality to emissions reductions on the decadal timescale. Africa is particularly under-represented, with just 2% of the regional literature taking a forward looking orientation (3 studies, including an assessment of public transportation expansion in Johannesburg). This contrasts with dozens of forward looking studies in other regions, which on average make up 10% of the literature in each (SI Text Table 7).

The topic modelling applied here identifies a strong focus on urban demand-side and sustainability topics, but clear research needs for particular regions and cities going forward. These include diversifying the scope of mitigation topics in large Chinese cities and initiating a mitigation focus in African and Latin American cities, particularly a forward-looking focus. Not least, there may be opportunities for structured learning where well-developed literature streams exist for individual cities.

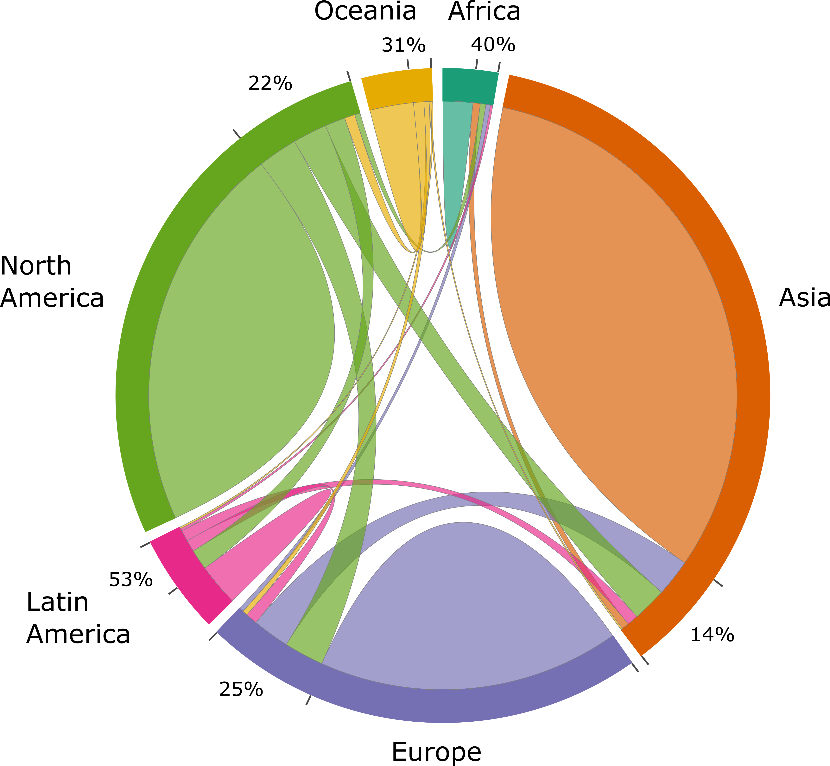
**Limited efforts to learn from case study evidence**

Urban research is inherently diffuse and rooted in specific geographies. Generating broader insight from individual cases is hence central to building a global urban science. Two specific approaches would support an effort to internationalise and consolidate leaning on urban solutions: comparative studies, which contrast two or more cases simultaneously and draw insight from their similarities or differences; and systematic literature reviews, which review or perform secondary analysis on the literature using structured, reproducible methods.

Comparative research is considered a strength of urban studies, albeit a locus of on-going debate. The epistemological value of North-South urban comparisons is widely discussed, for instance, as is the generalisability of highly contextual case studies 26. Our sample of documents suggests the urban mitigation community does not shy away from comparative research, but remains conservative in the number of cases compared. We identify 699 studies that refer to more than one city in the abstract (of 3,440 in the sample – approximately 20%). The majority of these studies (409) mention only two cities, with a steep decline to a few dozen studies on 5 or more cities (SI Text Figure 9).

Inter-regional comparisons are relatively rate. Figure 4 visualises the pairwise correlations of cities within abstracts, aggregating by region. Asian cities tend to be compared to other Asian cities, European cities to European cities, and likewise in North America. Comparative literatures based in Latin America, Africa and Oceania, on the other hand, are far less cautious and have higher fractions of international comparisons, although fewer total studies. Considering the total scope of the urban case study literature (3,440 studies), the subset that is comparative (699), and internationally comparative (202), is vanishingly small.

Based on a random selection and review of documents, we find little justification for why particular cities are bundled together, beyond claims of contextual diversity. Although this decision may often be driven by pragmatic concerns (such as funding and research partners), scientific learning in the field presupposes a transparent discussion of comparative logics 17. For instance, comparisons might proceed from the observation that common structural (political, economic, or geographic) characteristics drive urban phenomena, leading to differing path dependencies in energy consumption, and hence a role for typologies in structuring learning between similar types of cities 3. Alternatively, ubiquitous urban problems have been observed across many types of systems, such as the nexus of health, transportation and pollution externalities arising from agglomeration 27. Where individual cities demonstrate progress on solutions, for example through land-use policies and active travel provisioning, the resulting ‘proof of concept’ can prove highly relevant indeed across the urban landscape 28.



**Figure 4: Inter and intra-regional comparative research on urban climate mitigation.** Each link in the chord diagram is based on the pairwise coupling of two cities within a document. Documents where more than one city is mentioned in the abstract are used, totalling 699 studies. The proportion of regional couplings that pair with other regions (i.e. inter-regional urban comparisons) are indicated as percentages.

Another key route towards learning is through literature reviews and urban assessments. Formal review methods – those that deploy transparent and systematic procedures for literature selection, quality assessment and synthesis – are the gold standard for generating a robust evidence base for policy 29,30. These consist of a wide spread of quantitative, qualitative and mixed formal review approaches that are well-documented in the health sciences literature 31. Again, however, we find limited progress on this front.

We search the original set of documents identified in our urban mitigation query (12,918 articles) for review articles, and identify just 10 studies that apply formal review methods (see methods). The majority of these studies are narrative reviews (Table 2): akin to a normal literature review, but proceeding from a transparent search and selection of literature. Quantitative synthesis methods are sparse, comprising a single meta-analysis of residential demand-response programs (ref) and two studies that extract and analyse quantitative information from literatures on urban ecosystem services (refs). We do not find a single study referring to formal *case study* review methods, such as qualitative comparative analysis, case study meta-analysis, or case surveys 32 – although there are examples of these methods being applied directly to urban data (but not to the existing literature) 33.

|  |  |  |
| --- | --- | --- |
| **Authors & year** | **Title** | **Method** |
| Li & Babcock 2014 | Green roofs against pollution and climate change. A review | Narrative review |
| Lwasa et al. 2014 | Urban and peri-urban agriculture and forestry: Transcending poverty alleviation to climate change mitigation and adaptation | Narrative review |
| Brands 2014 | Prospects and challenges for sustainable sanitation in developed nations: a critical review | Narrative review |
| Lwasa et al. 2015 | A meta-analysis of urban and peri-urban agriculture and forestry in mediating climate change | Narrative review |
| Kwan & Hashim 2016 | A review on co-benefits of mass public transportation in climate change mitigation | Narrative review |
| Garcez 2017 | What do we know about the study of distributed generation policies and regulations in the Americas? A systematic review of literature | Bibliometrics |
| Deng et al. 2017 | Co-benefits of greenhouse gas mitigation: a review and classification by type, mitigation sector, and geography | Bibliometrics and narrative review |
| Francis & Jensen 2017 | Benefits of green roofs: A systematic review of the evidence for three ecosystem services | Quantitative synthesis |
| Srivastava, Passel & Laes 2018 | Assessing the success of electricity demand response programs: A meta-analysis | Meta-analysis |
| Song et al. 2018 | The economic benefits and costs of trees in urban forest stewardship: A systematic review | Bibliometrics, quantitative synthesis, narrative review |

**Table 2: Formal reviews of urban climate change mitigation.** The minimum criteria for a ‘formal review’ is the systematic selection of literature via a database search. See methods for our identification procedure.

The dearth of formal reviews on urban case studies is consistent with the wider field of energy studies and climate change mitigation 16,30 – and unsurprising given the challenge of varied case study methods, locations and scales. Yet, at the very least, a greater focus on transparent literature selection is needed to avoid overlooking research, particularly the minority of studies on smaller cities and less comprehensively covered regions. As with the narrow scope of comparative urban mitigation research, limited progress on this front suggests major innovations are needed to stimulate learning on urban solutions.

**Towards learning about urban mitigation solutions**

In this perspective we survey the landscape of case studies on urban climate mitigation. We focus on the geographic and topic distribution of research to date, and assess progress on comparative studies and systematic reviews. 5 issues appear to stand in the way of learning in this literature domain. (1) A substantial and unwarranted bias exists towards studies on large cities, and studies situated in the global North. (2) Only a handful of studies exist on African cities. These tends to emphasise adaptation over mitigation, and fail to address future urbanisation challenges. (3) The literature on Asian cities is strongly focused on emissions accounting, and is not yet balanced by a focus on policies and sustainability issues. (4) The existing comparative research lacks international scope and tends to be under-justified on conceptual grounds. (5) Only minor attempts have been made at systematically aggregating urban case study research through formal review methods.

Our sample of studies captures some non-English language articles (180 in total), but certainly not all; nor does it capture grey literature such as NGO reports. Nonetheless, these results resonate with calls to develop global urban solutions and ‘leave no city behind’ in scientific assessments 12,34,35. The use of bibliometric techniques and topic modelling show that it is possible to judge progress on these goals with reduced subjectivity, even as the quantity of studies rapidly grows. Scaling the analysis to individual cities, groups of cities, or regions provides a flexible means to track and review literatures in advance of AR6 and future urban assessments. These methods are also applicable to other areas of case study literature, including urban adaptation research 36 and land-use science 37.

Our systematic review and topic modelling reveals that case studies are dominated by demand-side issues, such as demand for heating, transport, and water, but much less on supply-oriented solutions. This contrasts with the majority of climate mitigation scenarios that focus on supply-side technologies in the energy and also transport sector. The higher spatial resolution of city-level analysis appears to coincide with higher resolution on end-users and their concerns, but less investigation of the role of supply-side technologies to realize city-level climate mitigation. This insight has inversely relevant implications for the study of demand-side climate solutions that will have their own chapter in the IPCC’s AR6 report 16. A comprehensive understanding of demand-side solutions will need to build extensively on urban case studies.

Nonetheless, several pre-conditions need to be met to make progress on urban solutions. There are clear research gaps on African cities and smaller cities in Asia. Locating research efforts, as well as stakeholder engagement and policy advocacy in these regions will be instrumental to avoiding lock-in and realising compact, low-carbon urban forms that can tackle the coming mitigation challenge 18,19. Where large bodies of research already exist for other locales, the literature scoping methods shown here could support the consolidation of existing work into systematic reviews, allowing for a shift in focus towards less studied topics and locations.

Above all, a culture of learning is needed in the field. From making individual case studies available for meta-analyses, to increased ambition in comparative research, to large scale reviews of the case study literature that apply formal methods. (…)

**Methods**

*Literature scoping*

We use a search query combining ‘urban’ and ‘mitigation’ synonyms in the Web of Science and Scopus to identify relevant documents (Table 3). As of March 2018 this search returned 12,918 documents (unconstrained by language or document type). To identify urban case studies we search the document set for city names, using the Geonames database of geographic locations. This narrows the document set to 3,440 studies that directly refer to a city in the abstract or title. Double counting where an article mentions multiple cities, we obtain 4,730 case studies.

|  |  |
| --- | --- |
| Urban synonyms | Mitigation synonyms |
| ("urban\*" OR "municipal" OR "city" OR "cities" OR "metropolitan") | (“Paris Agreement” OR “low carbon” OR "decarboni\*ation" OR (“energy” OR “carbon” OR “CO2” OR “GHG” OR “greenhouse gas” OR “climat\*”) NEAR/3 ("mitigation" OR "reduc\*" OR "polic\*" OR "governance")) |

**Table 3: Search query for urban climate mitigation literature.** The two strings are combined with an ‘AND’ operator and entered as a topic search in the Web of Science, and a title-abstract-keyword search in Scopus.

*Topic modelling*

…

*Future-looking case studies*

To identify case studies with a future-looking orientation (including for example, mitigation scenarios, or projections of urbanisation, land-use, or energy demand), we manually search for the following keywords within abstracts: “scenario” OR “2020” OR “2025” OR “2030” OR “2040” OR “2045” OR “2050”. A random selection and screening of these documents showed they were broadly in line with our expectations.

*Systematic reviews*

To identify systematic reviews of the case study literature we return to the original document set (12,918 studies) and manually search for the following keywords: “ meta-“ OR “systematic review” OR “scoping” OR “narrative review” OR “qualitative comparative analysis” OR “QCA” OR “scientometric” OR “synthesis”. The results are hand filtered to exclude non-urban, non-mitigation and non-review articles.

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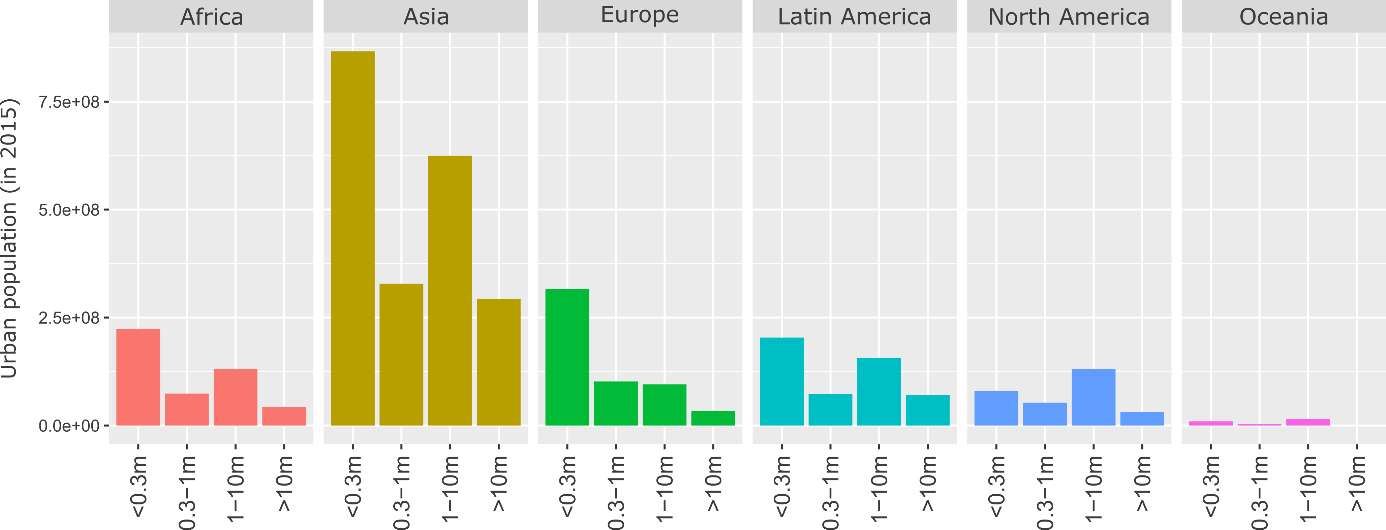
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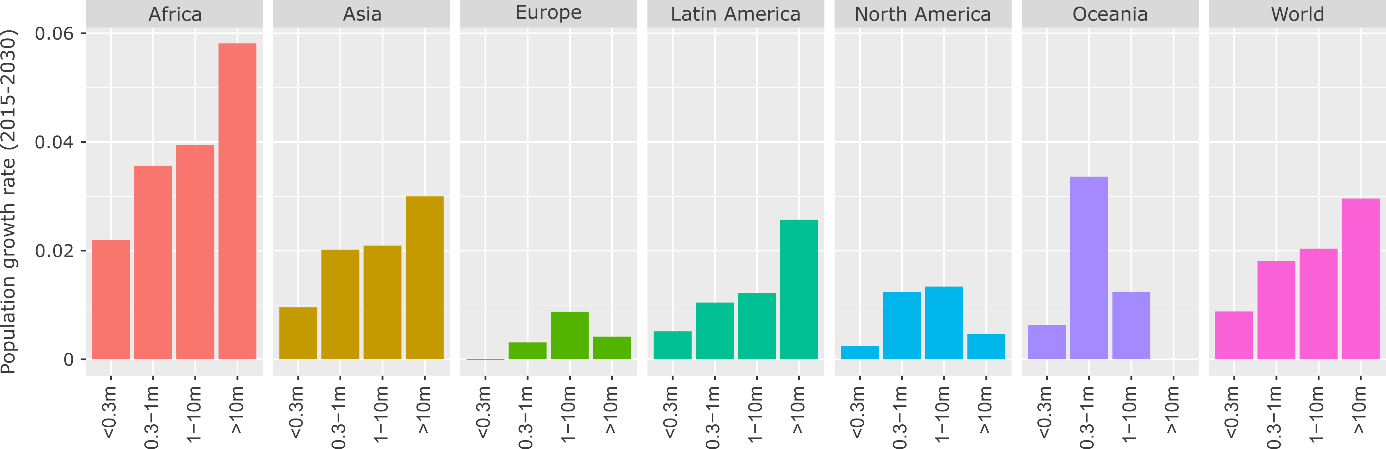
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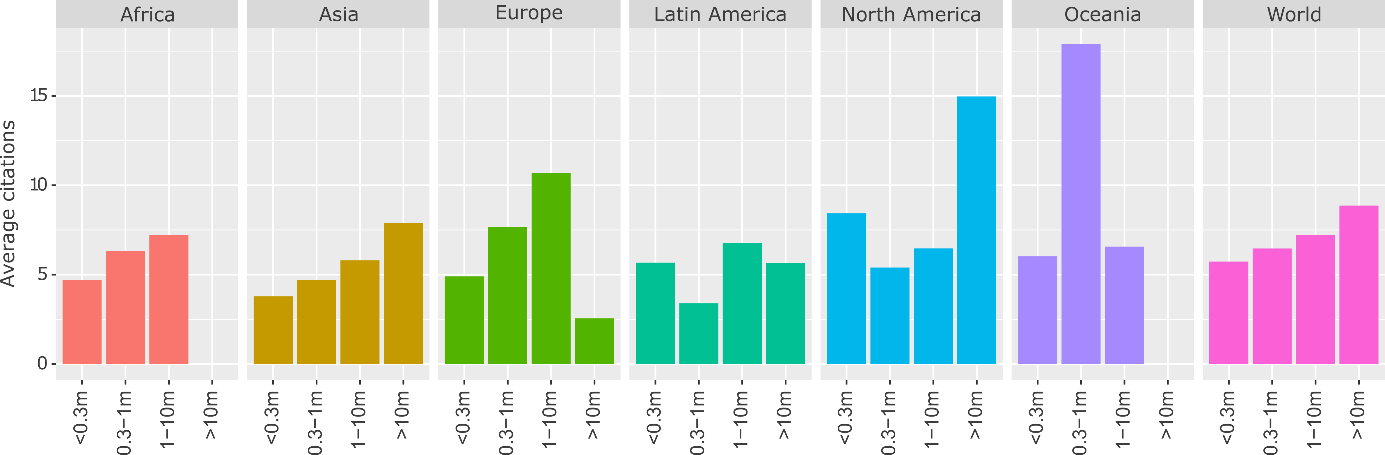
**Supplementary information**

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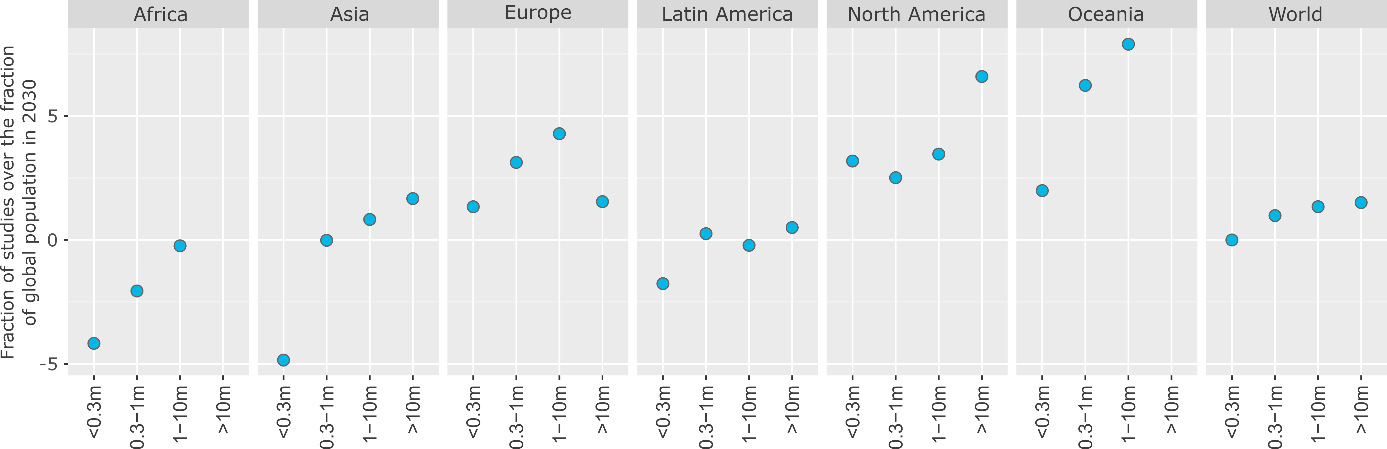
**Figure 5: Total urban population (in 2015) by region and city size**



**Figure 6: Projected population growth rate by region and city size, 2015-2030**



**Figure 7: Average citations of urban case studies by region and city size.** Citations are divided equally among cities in double-counted articles.



**Figure 8: The global distribution of urban case studies versus population**. To normalise, where the numerator (% of global population in a region & city size) exceeds the denominator (% of case studies in a region & city size), we subtract the fraction from 2.

|  |  |  |  |
| --- | --- | --- | --- |
| **ID** | **Topic Name** | **Stemmed Keywords** | **Marginal Topic Distribution** |
| 1 | Urban governance | citi; polici; govern; local; develop | 9.3 |
| 2 | Energy consumption | energi; consumpt; effici; sector; beij | 7.9 |
| 3 | Urban form | urban; area; land; ecolog; model | 7.2 |
| 4 | Solar PV | system; solar; power; electr; energi | 7.0 |
| 5 | CO2 emissions | carbon; emiss; industri; china; lowcarbon | 6.8 |
| 6 | Buildings | build; design; energi; perform; residenti | 6.8 |
| 7 | Climate adaptation | climat; chang; adapt; risk; govern | 6.5 |
| 8 | Air pollution | air; pollut; health; qualiti; concentr | 6.2 |
| 9 | Transportation | transport; travel; traffic; public; car | 5.7 |
| 10 | GHG emissions | ghg; emiss; greenhous; gas; reduct | 5.4 |
| 11 | Vehicles | vehicl; electr; fuel; drive; emiss | 4.8 |
| 12 | Households | household; incom; electr; survey; hous | 4.7 |
| 13 | Waste management | wast; landfil; solid; manag; msw | 4.6 |
| 14 | Water demand | water; suppli; manag; demand; treatment | 4.6 |
| 15 | Heat demand | heat; district; thermal; demand; network | 4.6 |
| 16 | Green roofs | roof; temperatur; cool; green; surfac | 4.5 |
| 17 | Urban ecology | tree; forest; plant; speci; sequestr | 3.4 |

**Table 4: List of topics and their keywords**

|  |  |  |  |
| --- | --- | --- | --- |
| **City** | **N. studies** | **Frequent topics** | **Infrequent topics** |
| Beijing | 284 | CO2 emissions; Energy consumption; Air pollution | Urban ecology; Water demand; Waste management |
| New York City | 146 | Urban governance; Buildings; Climate adaptation | Waste management; Transportation; CO2 emissions |
| Shanghai | 140 | CO2 emissions; Energy consumption; Urban form | Urban ecology; Water demand; Waste management |
| London | 117 | Urban governance; Transportation; Climate adaptation | Water demand; Waste management; Green roofs |
| Tianjin | 66 | CO2 emissions; GHG emissions; Energy consumption | Water demand; Urban ecology; Vehicles |
| Los Angeles | 59 | Green roofs; Water demand; Air pollution | Waste management; Heat demand; CO2 emissions |
| Tokyo | 59 | Solar PV; Urban form; Climate adaptation | Urban ecology; Water demand; Households |
| Chicago | 49 | Urban governance; Urban ecology; Climate adaptation | Waste management; Households; Transportation |
| Melbourne | 49 | Climate adaptation; Water demand; Urban governance | Urban ecology; Vehicles; Heat demand |
| Paris | 47 | Urban governance; Air pollution; Climate adaptation | Water demand; Urban ecology; Green roofs |

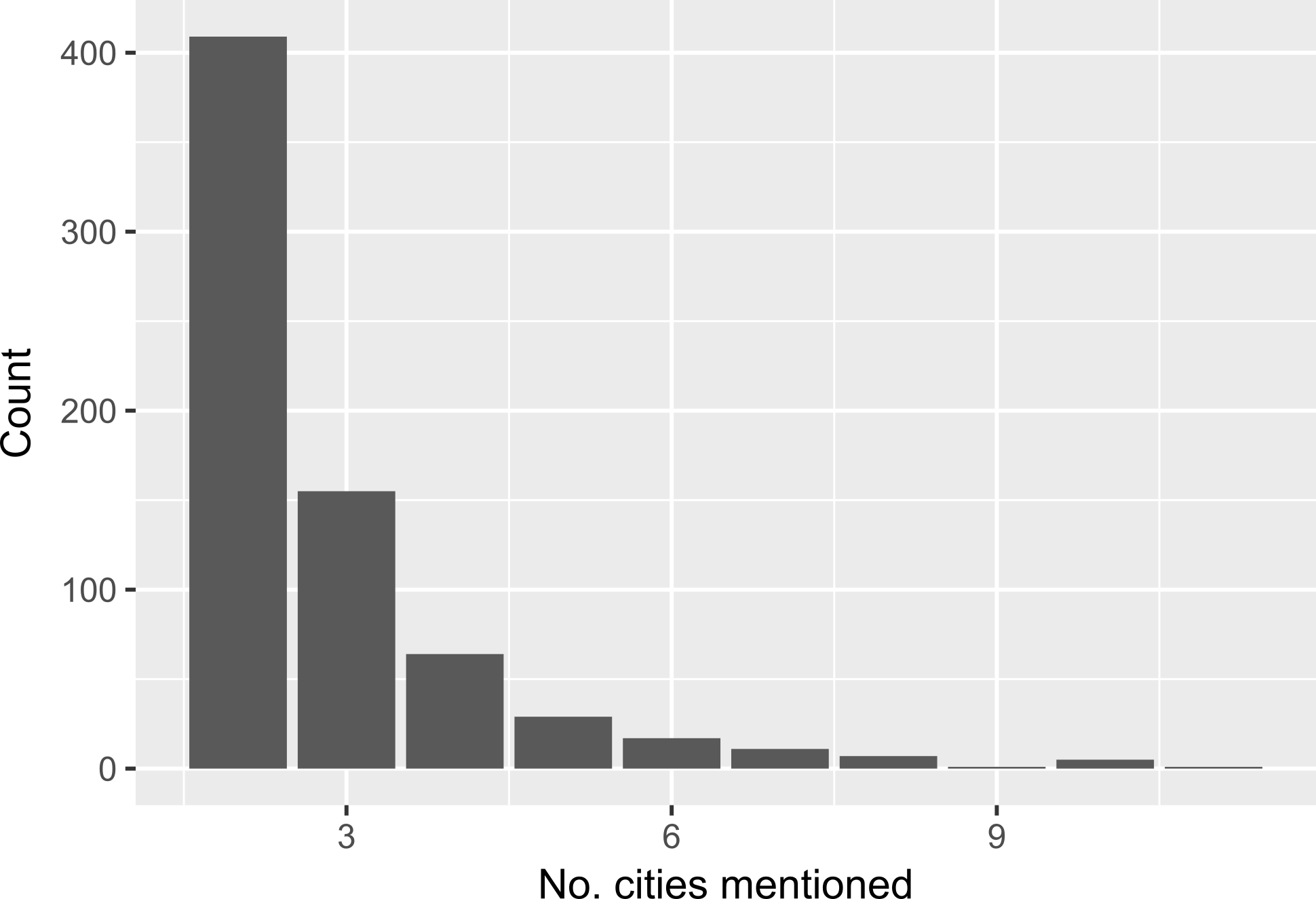
**Table 5: Frequent and infrequent topics in the 10 most studied cities**

|  |  |  |  |
| --- | --- | --- | --- |
| **Topic** | **Proportion** | **Topic** | **Proportion** |
| GHG emissions | 0.19 | Urban form | 0.08 |
| Transportation | 0.16 | Water demand | 0.08 |
| Air pollution | 0.16 | Waste management | 0.07 |
| CO2 emissions | 0.14 | Solar PV | 0.07 |
| Energy consumption | 0.12 | Households | 0.06 |
| Urban governance | 0.11 | Heat demand | 0.06 |
| Vehicles | 0.10 | Urban ecology | 0.05 |
| Climate adaptation | 0.10 | Green roofs | 0.04 |
| Buildings | 0.10 |  |  |

Table : Topic proportions of 'forward-looking' case studies

|  |  |  |  |
| --- | --- | --- | --- |
| **Region** | **No. case studies** | **No. ‘forward-looking’ studies** | **Fraction** |
| Africa | 175 | 4 | 0.02 |
| Asia | 1761 | 190 | 0.10 |
| Europe | 1207 | 129 | 0.11 |
| Latin America | 246 | 26 | 0.11 |
| North America | 1126 | 84 | 0.07 |
| Oceania | 184 | 19 | 0.10 |

Table : Regional coverage of 'forward-looking' case studies



**Figure 9: Number of cities mentioned in comparative studies**