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Comparative Discourse Analysis of Urban Climate Resilience in Iran and Leading Global Cities within the Socio-Ecological Systems Framework

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ABSTRACT

The intersection of rapid urbanization and climate change has positioned cities at the epicenter of environmental crises. Nevertheless, a profound gap persists between the scientific literature produced in Iran and dominant global paradigms in the field of urban climate resilience. The present study was conducted to systematically analyze the structure of climate change knowledge in Iran and to compare it with that of leading global cities, with the aim of identifying prevailing patterns, discursive gaps, and neglected priorities. This research adopted a mixed-methods approach, integrating quantitative and qualitative analyses, and was grounded in the theoretical framework of Socio-Ecological Systems (SES). The study corpus comprised scientific articles and policy documents published between January 2010 and January 2026. The data were examined through directed qualitative content analysis and text-based scientometric analysis, based on the relative frequencies of codes and their comparison across the national and global corpora. The findings indicate that Iran's scientific discourse remains constrained within a reactive and mono-dimensional paradigm, with principal emphasis placed on water management (46%) and hazard management (52.2%). In contrast, the global literature foregrounds compound risks, urban form design (27.2%), and climate justice. The most critical gap in the Iranian context is the near absence of climate finance (0.4%), accompanied by significant weakness in urban governance, whereas leading global cities have activated innovative financial channels through international frameworks and transnational urban networks. A transition toward urban climate resilience in Iran therefore requires a paradigmatic shift from reactive hazard management to preventive, systemic governance. Strategic recommendations include moving from gray/hard engineering approaches toward ecosystem-based Nature-based Solutions (NbS), institutionalizing decentralized climate finance, and integrating the water-energy-food nexus into urban policymaking.

Keywords:
Climate change, Urban resilience, Socio-Ecological Systems (SES), Qualitative content analysis, Climate governance, Iran

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1. Introduction

In the third millennium, the convergence of accelerated urbanization and climate change has transformed human settlements into the principal loci of environmental crises and governance challenges. According to reports by the Intergovernmental Panel on Climate Change (IPCC, 2022), urban areas—home to more than half of the world's population—not only account for a substantial share of greenhouse gas emissions and energy consumption, but also stand on the front line of vulnerability to climatic impacts due to high population density, the concentration of critical infrastructure, and ongoing land-use change (Seto et al., 2013; Grimm et al., 2008). Megacities are confronted with a spectrum of multilayered hazards, ranging from intensified urban heat islands (UHI) and flash floods to chronic droughts and sea-level rise (Yuan et al., 2026). These hazards extend beyond physical threats, jeopardizing public health and social equity through disruptions to water and energy supply networks. In response, the transition toward urban resilience and the adoption of ecosystem-based adaptation strategies have become central policy priorities in leading cities worldwide (Meerow & Newell, 2019; Lin et al., 2021).

However, the nature and severity of these challenges assume distinctive complexities in the Global South, where institutional fragility, structural poverty, and unplanned urban growth intensify climate vulnerability. In such contexts, deficiencies in the provision of basic services, the expansion of informal settlements, and fragmented governance arrangements erode adaptive capacity and heighten the risk of maladaptation (Chung et al., 2026; Abdillah et al., 2025). Iranian cities exemplify this pattern. Their location within the world's arid and semi-arid belt, combined with resource mismanagement and unsustainable physical development, has exposed major metropolitan areas such as Tehran, Isfahan, Ahvaz, and Mashhad to interacting and mutually reinforcing phenomena, including water bankruptcy, land subsidence, intensified urban heat islands, and dust storms (Hesarakizad et al., 2024; Zarghamipour & Malakooti, 2025; Araghizade & Masoodian, 2021). Under these conditions, climate change in Iran can no longer be understood merely as an environmental threat; rather, it has become a determining variable in socio-security dynamics. Climate-induced migration from rural areas and desert margins toward major cities has imposed additional pressure on urban infrastructure and further deepened spatial justice inequalities (Yeghfouri & Rahmani, 2023; Ebrahimipour & Alizadeh, 2026).

Conversely, the experiences of leading global cities demonstrate that successful climate transition depends upon the simultaneous integration of physical, institutional, and financial dimensions. Recent studies underscore the importance of climate justice (Eyni et al., 2025), the role of vegetation cover in mitigating urban heat islands while ensuring the equitable distribution of benefits (McDonald et al., 2026), integrated strategies for addressing urban heat stress and air quality in UK cities (Chauhan et al., 2025), and the necessity of green-blue infrastructure for managing precipitation uncertainty (Hojati Sayah et al., 2026). Economic analyses likewise indicate that measures such as urban greening are cost-effective in the long term and can significantly reduce heat-related mortality (Suomi et al., 2025). Yet transferring these experiences to the Iranian context requires, first and foremost, a careful interrogation of what the domestic scientific literature has "seen" and, equally importantly, what it has "overlooked."

A review of the existing literature suggests that Iranian scholarship has largely concentrated on physical dimensions and climatic modeling—such as urban heat islands and air quality—while lacking a comprehensive perspective on the complex interactions inherent in Socio-Ecological Systems (SES) (Zarghamipour & Malakooti, 2025). Although this body of literature devotes considerable attention to hazard management and the water crisis, it remains substantively underdeveloped in other critical domains, including innovative climate finance mechanisms, energy performance contracting, and large-scale Nature-based Solutions (NbS). Furthermore, the predominance of a reactive-therapeutic approach—such as controlling air pollution after its occurrence—over a preventive design-based approach—such as designing urban form to facilitate natural ventilation—constitutes one of the central critiques of the current knowledge base. As Pazhuhan (2023) demonstrates, the principal barrier to adaptation in Iran is not a shortage of technical knowledge, but rather weak integrated urban governance, discontinuous managerial structures, and the reluctance of local and national institutions to engage in systematic collaboration.

Despite the significance of the issue, no study to date has systematically examined—within the theoretical framework of Socio-Ecological Systems (Ostrom, 2009)—the structure of knowledge produced on urban climate change in Iran through an integrated quantitative and qualitative lens, nor

compared it with global patterns. Most previous studies have been case-specific or one-dimensional and have therefore failed to provide a macro-level picture of research priorities, discursive gaps, and dominant trends within Iran's scientific community. In particular, substantial ambiguity remains regarding the balance between attention to physical hazards versus institutional and financial solutions, and between climate justice and hard engineering approaches.

The present study was designed to address this gap. It should be emphasized that the extraction and analysis of codes do not constitute the ultimate objective of this research; rather, they serve as a methodological instrument for achieving the principal aim: a systematic understanding of climate change challenges in Iranian cities and a comparative assessment of the discursive priorities of domestic scientific literature vis-à-vis the global literature. More specifically, the study seeks to determine which themes are prominent in Iranian research yet marginal in the global literature, and conversely, which issues have received substantial attention among international scholars but remain neglected by Iran's scientific community. To this end, the study employs a combined methodology consisting of directed qualitative content analysis (Hsieh & Shannon, 2005) and thematic analysis (Braun & Clarke, 2019), alongside text-based scientometric analysis of relative code frequencies. The extracted codes are organized into six thematic domains derived from the Socio-Ecological Systems framework: exogenous macro-transformations, ecosystems and hazards, resources, actors, governance, and physical-spatial structure. On this basis, the study addresses three fundamental research questions:

Based on the Socio-Ecological Systems framework, which themes and priorities dominate the scientific literature on urban climate change in Iran?

What are the most significant discursive gaps between the Iranian scientific literature and that of leading global cities, including both themes neglected in Iran and those receiving limited attention at the global level?

What policy and institutional implications do these gaps hold for shifting from a reactive approach toward systemic urban climate resilience in Iranian cities?

2. Data and Methodology

The present study is applied in terms of purpose and descriptive-analytical in terms of design, and was conducted using a Convergent Mixed-Methods Design. In this design, the qualitative component (content analysis) and the quantitative component (textometric bibliometrics) were undertaken in parallel and subsequently integrated at the interpretation stage. The methodological core of the study is Directed Qualitative Content Analysis, which, by drawing on a pre-established theoretical framework, enables a shift from the mere description of data toward the explanation of latent patterns embedded in the scientific literature (Hsieh & Shannon, 2005). The methodological innovation of the study lies in integrating this qualitative approach with quantitative textometric bibliometric techniques, namely the quantification of relative code frequencies and their systematic comparison across the national and global corpora, thereby making it possible to assess both the content and the structure of knowledge simultaneously.

The theoretical framework guiding the analysis is the Social-Ecological Systems (SES) framework, first proposed by Ostrom (2009) for examining sustainability in complex systems. Owing to its capacity to differentiate between endogenous and exogenous layers, this framework provides an appropriate analytical instrument for the dual classification of Iran's climate-related challenges, namely, natural/global drivers versus managerial/domestic factors. On this basis, the study's deductive coding matrix was developed prior to analysis around six overarching themes: (1) exogenous macro-transformations, (2) ecosystems and hazards, (3) resources, (4) actors, (5) governance, and (6) physical-spatial structure. The first two themes were treated as exogenous, denoting forces beyond the direct control of urban management, whereas the remaining four were considered endogenous, referring to domains potentially amenable to intervention by urban management.

Search Strategy, Selection Criteria, and Corpus Description

The study population comprised all peer-reviewed research articles, strategic reports, and policy documents published between January 2010 and January 2026 that directly addressed climate change and urban resilience. The database search was last updated in January 2026, during the revision of the manuscript; no document published after this date was included in the corpus. A systematic search,

adapted from the PRISMA guideline, was conducted across national databases (SID, Magiran, Noormags) and international databases (Scopus, Web of Science) within the title, abstract, and keyword fields. The search string was constructed using Boolean operators as follows:
Policy documents and strategic reports (grey literature) were also collected through targeted searches of the official repositories of relevant institutions, including the Department of Environment, the Ministry of Energy, and the Islamic Consultative Assembly Research Center. The inclusion criteria were as follows: (a) availability of the full text or a structured Persian/English abstract; (b) explicit focus on the urban or regional scale; and © publication within the study period. The exclusion criteria comprised review articles lacking original data, non-peer-reviewed conference papers, and documents without direct thematic relevance.
Following duplicate removal and a two-stage screening of titles/abstracts and full texts by two independent researchers, a total of 490 documents were included in the final analytical corpus. This corpus consisted of two equivalent sub-corpora: first, a national corpus comprising 290 Persian-language documents addressing climate change and urban resilience in Iran; and second, in order to enable comparative analysis, a global reference corpus comprising 200 English-language documents related to cities at the forefront of climate resilience, including documents from the C40 network, the 100 Resilient Cities program, and leading articles indexed in Scopus/Web of Science. This reference corpus was collected using the same search strategy and inclusion criteria—without the Iran-specific geographical restriction—and analyzed using the same coding matrix, thereby ensuring methodological equivalence and comparative validity.

Unit of Analysis and the Coding Process: A Four-Stage Protocol

The unit of analysis was defined as the meaning unit, namely, any sentence or paragraph containing an independent proposition concerning climate change. The coding process was implemented through a systematic four-stage protocol. While its procedural sequencing was inspired by the principles of reflexive thematic analysis developed by Braun and Clarke (2019), its coding logic—given its reliance on a pre-formulated deductive matrix—remains firmly situated within the tradition of directed content analysis (Hsieh & Shannon, 2005).

Stage 1: Descriptive-Inductive Coding.
The full texts were reviewed line by line, and all relevant meaning units were recorded as open codes. A hybrid approach was adopted: in addition to deductive codes derived from the SES framework, emergent codes specific to the Iranian context—such as land subsidence and internal climate migration—were inductively added to the coding tree (Hsieh & Shannon, 2005).

Stage 2: Interpretive and Abstract Coding.
Similar descriptive codes were merged into more abstract categories through constant comparison. For example, the codes declining precipitation, wetland desiccation, and groundwater depletion were aggregated under the interpretive category of chronic water stress.

Stage 3: Quantification of Relative Code Frequencies.
The relative frequency of each interpretive code was calculated as its percentage share of all coded meaning units within the corresponding SES subsystem, separately for the national and global corpora. These relative shares, rather than raw counts, form the basis of the results reported in Section 3, since they allow two corpora of different sizes to be compared on an equal footing.

Stage 4: Comparative Analysis of Thematic Distributions.
For each subsystem, the relative shares of interpretive codes in the national corpus were compared with those in the global corpus, and the differences were expressed in percentage points. Themes markedly more prominent in the Iranian corpus were interpreted as domestic discursive priorities, whereas themes markedly more prominent in the global corpus were interpreted as discursive gaps in the Iranian literature.

Computational Implementation

Text processing, preliminary automated coding, and frequency calculations were conducted using bespoke scripts in Python (version 3.11). The NLTK library was used for natural language processing of English-language texts, and the Hazm library was employed for the normalization, tokenization, and stop-word removal of Persian texts. It should be emphasized that the output of automated coding served

solely as an initial suggestion. All codes were reviewed and validated by the researchers prior to analysis in order to safeguard the semantic validity of the coding process.

Validity and Reliability

To ensure credibility, the study employed both data triangulation—across scientific articles, policy documents, and strategic reports—and methodological triangulation—across qualitative and quantitative techniques. For the assessment of reliability, which is both permissible and well established within the tradition of directed content analysis (Hsieh & Shannon, 2005), 20% of the documents were randomly selected and independently recoded by two coders. Cohen's kappa was calculated at $\kappa > 0.80$, which, according to conventional benchmarks, indicates strong inter-coder agreement. Discrepancies were resolved through joint sessions and by reference to the codebook until full consensus was achieved. Confirmability was further ensured through the maintenance of an audit trail, including successive versions of the coding tree and documentation of analytical decisions. This mixed-methods methodology not only provides a quantitative picture of the volume and distribution of research attention, but also, through the qualitative interrogation of relationships among concepts, reveals the structural gaps in Iran's scientific literature—including the predominance of a reactive over a preventive approach—within a methodologically equivalent and systematic comparison with the global corpus.

3. Results

The frequency distribution of interpretive and descriptive codes within the resource subsystem reveals the clear predominance of urban water management, accounting for 46.0% of interpretive codes (4,812 codes), and water resources management, comprising 44.2% of descriptive codes (4,812 codes). This marked statistical dominance indicates that, within the Iranian scientific literature on climate change, the water crisis is framed as the most critical environmental challenge and the foremost research and policy priority. This concentration is consistent with the country's material realities, including substantial declines in precipitation, severe groundwater depletion, wetland desiccation, and escalating water stress across the central and eastern basins of Iran. Ranked second is land use and forestry, representing 30.3%, which points to sustained attention to land-use change, forest and rangeland degradation, and their implications for natural ecosystems and the hydrological cycle. By contrast, the limited shares of energy resources (5.4%), the urban environment (16.1%), and the circular economy and waste (2.2%) reflect structural discursive gaps in the Iranian scientific literature. This finding suggests that, despite the close interconnections among water crises, energy systems, and the urban environment, prevailing research approaches remain largely sectoral and mono-dimensional, with insufficient attention to the water-energy-food nexus and the systemic interdependencies across these domains. In other words, although the dominance of water discourse reflects an appropriate recognition of the urgency of the crisis, it may also marginalize other dimensions of urban metabolism and impede the emergence of an integrated, systemic approach to resource sustainability in Iran (Figure 1).

The analysis of the actors subsystem indicates a relatively balanced distribution, albeit with the relative predominance of urban food systems, which account for 28.9% of interpretive codes (742 codes). This finding, which differs markedly from the pattern observed in the resource subsystem—where water-related themes were dominant—suggests that, in the Iranian scientific literature, food security, sustainable agriculture, and the resilience of food systems under climate change are framed as major research and policy concerns. This emphasis is strategically significant given the heavy dependence of the agricultural sector on groundwater resources, the decline in cultivated land, rising input costs, and the vulnerability of rural livelihoods and farming communities to recurrent droughts. The second most prominent component is energy transition, comprising 25.4% (652 codes), reflecting attention to decarbonization, energy efficiency, and the development of renewable energy. This is followed by the building sector (22.4%), health and climate adaptation (11.4%), industrial decarbonization (7.7%), and sustainable transport (4.1%). The comparatively limited shares of sustainable transport and industrial decarbonization, relative to urban food systems and energy transition, point to an imbalanced pattern of prioritization in the Iranian scientific literature. It appears that concerns related to rural livelihood vulnerability and food security have outweighed emission-reduction strategies in the industrial and urban transport sectors. This pattern suggests that the Iranian scientific discourse is oriented less toward

systematic decarbonization and technological transition than toward livelihood adaptation and the reduction of vulnerability among marginalized groups (Figure 2).

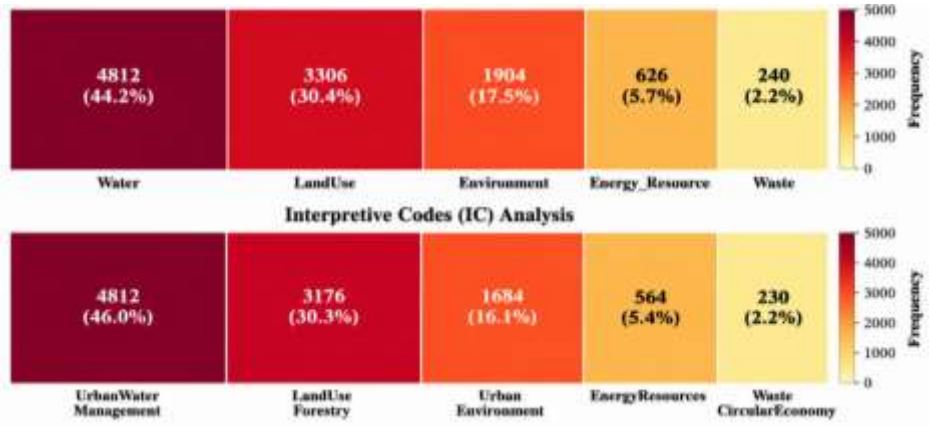


Figure 1. Distribution of interpretive and descriptive codes across the resource subsystem in the Iranian climate change literature.

The analysis of the governance subsystem reveals a profound discursive asymmetry. On the one hand, public sector governance, accounting for 39.6% of interpretive codes (2,208 codes), and social justice and equity, comprising 35.1% (1,958 codes), together occupy more than three-quarters of the coded space within this domain. This dual predominance indicates that the Iranian scientific literature conceptualizes state institutions and administrative-managerial structures as the principal actors of climate governance, while simultaneously emphasizing distributive justice and the protection of vulnerable groups against the impacts of climate change. This pattern is consistent with Iran's socio-economic realities, including widening regional inequalities, climate-induced migration, rural poverty, and urban marginalization. On the other hand, the very limited share of urban climate governance (11.8%) and, in particular, climate finance (0.4%, only 22 interpretive codes), exposes a critical strategic disconnect. This finding suggests that, despite the substantial volume of literature addressing the role of government and social justice, there is virtually no serious body of research in Iran devoted to the financing mechanisms of climate projects, green investment models, energy performance contracts (EPCs), or other innovative financial instruments. Put more plainly, while the Iranian scientific literature has provided considerable clarity regarding the what and the why of climate action, it remains confronted with a major void in relation to the how of financing and operationalizing such measures. This financial–implementation gap constitutes the most important bottleneck to the realization of climate programs in Iran, and future research should engage far more directly with this discursive deficiency (Figure 3).

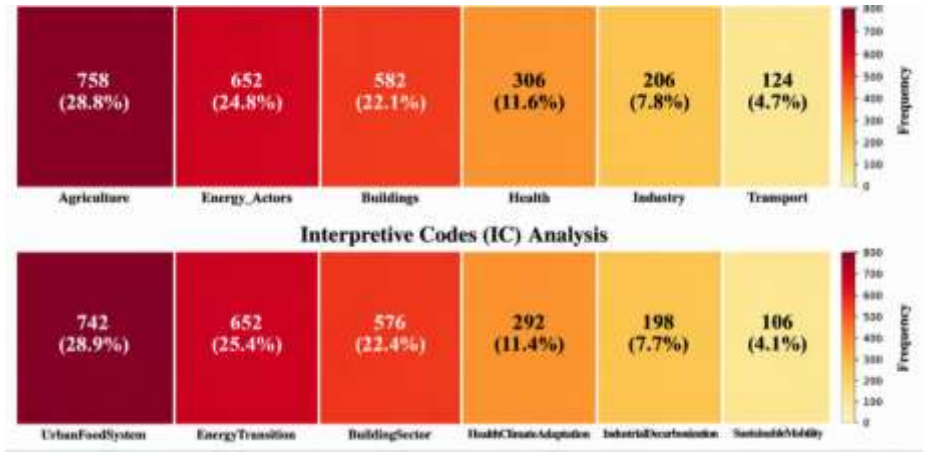


Figure 2. Distribution of interpretive codes across the actors subsystem in the Iranian climate change literature.

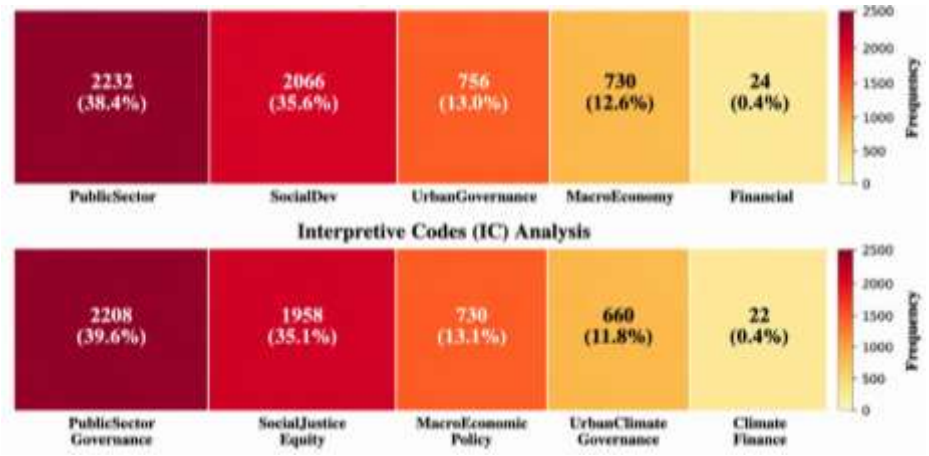


Figure 3. Distribution of interpretive codes across the governance subsystem in the Iranian climate change literature.

The analysis of the spatial–physical subsystem reveals the clear predominance of air quality management, which accounts for 40.4% of interpretive codes (1,584 codes). This finding is fully consistent with the severe air pollution crisis affecting Iran's major metropolitan areas—particularly Tehran, Isfahan, and Mashhad—and its consequences for public health, economic productivity, and quality of life. Ranked second is urban microclimate, comprising 27.6%, which indicates sustained attention to urban heat islands, thermal comfort, and the management of urban temperature regimes. Green–blue infrastructure occupies the third position with 19.2%, while urban form design ranks fourth at 12.9%. This distribution suggests that, within the Iranian scientific literature, corrective process-oriented measures and pollution control strategies are prioritized over more sustainable approaches centered on urban design and spatial regeneration. Put differently, the dominant response to environmental crises remains largely therapeutic and mitigation-oriented, rather than preventive and design-led. The comparatively limited share of urban form design (12.9%, versus 27.2% in the global corpus), relative to air quality and urban microclimate, indicates that the Iranian scientific literature has not yet fully engaged with design-led strategies such as the development of natural ventilation corridors, and instead continues to approach air quality largely through a technocratic and engineering-oriented lens. It should be noted, however, that green–blue infrastructure receives a proportionally larger share in the Iranian corpus (19.2%) than in the global corpus (9.4%); the deficit of Iranian scholarship therefore lies not in green–blue infrastructure as such, but in preventive urban form design and in ecosystem-based measures at the scale of hazard management (see the ecosystems and hazards subsystem below). This gap suggests that Iran's urban planning system requires a transition from single-dimensional pollution-reduction approaches toward integrated, climate-sensitive strategies of spatial regeneration (Figure 4).

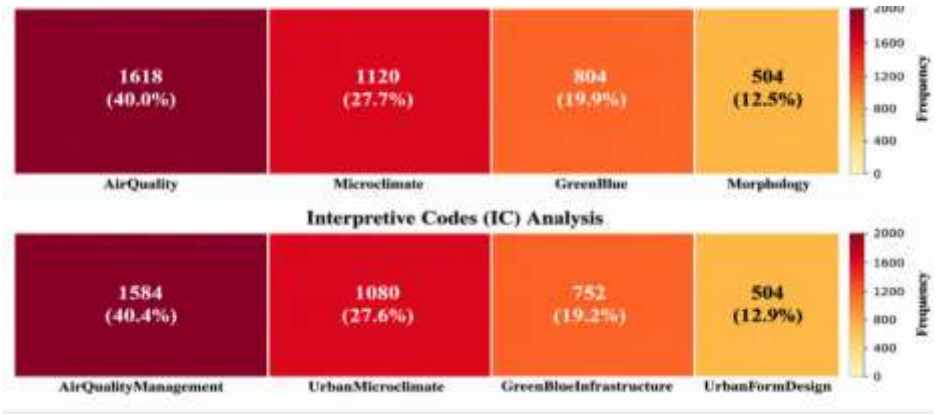


Figure 4. Distribution of interpretive codes across the spatial–physical subsystem in the Iranian climate change literature.

The analysis of the ecosystems and hazards subsystem reveals the decisive predominance of climate hazard management, which accounts for 52.2% of interpretive codes (3,858 codes). This statistical dominance indicates that, within the Iranian scientific literature, the identification, monitoring, and management of climate-related hazards—such as droughts, floods, dust storms, extreme heat, and cold stress—are regarded as the foremost research priority in the field of climate change. Ranked second is compound risk assessment, comprising 25.8% (1,904 codes), which reflects a relatively recent and more systemic approach to the analysis of multiple hazards and their cascading effects across different subsystems, including water, agriculture, health, and the economy. Urban resilience occupies the third position with 16.4% (1,210 codes), while ecosystem-based measures rank fourth at only 5.6% (416 codes). This distribution suggests that, despite the substantial volume of literature devoted to the identification and assessment of hazards, the concept of resilience as a comprehensive and empowering framework has not yet been fully consolidated within the Iranian scientific discourse. In particular, the very limited share of ecosystem-based measures indicates that Nature-based Solutions (NbS)—such as wetland restoration, afforestation, sustainable watershed management, and soil erosion control—remain peripheral to dominant hard-engineering and structural approaches. This finding is consistent with the prevalence of flood-control engineering and emergency-management approaches in Iran, and suggests that the country's hazard management system continues to rely more heavily on physical structures and grey infrastructure than on natural and ecosystem capacities. Such an exclusively structure-oriented approach not only imposes substantial economic costs on the country, but is also likely to prove inefficient and unsustainable in the long term. Future research should therefore engage far more seriously with the promotion and contextual adaptation of Nature-based Solutions in climate hazard management (Figure 5).

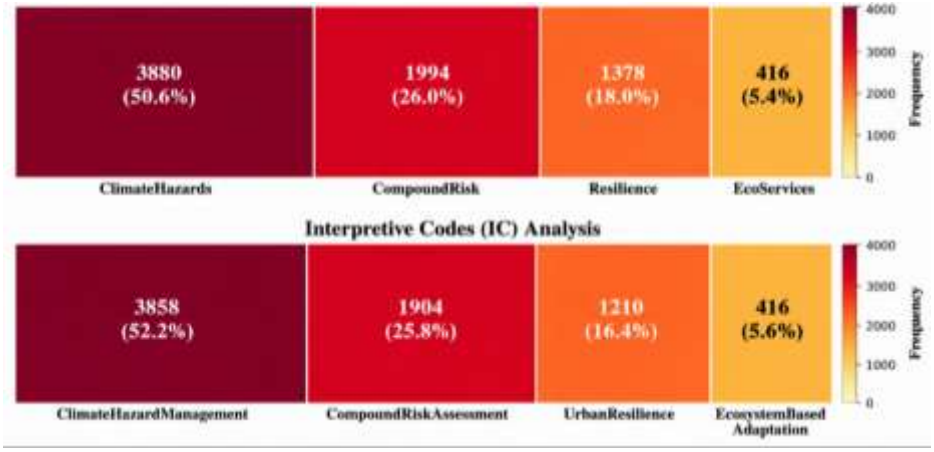


Figure 5. Distribution of interpretive codes across the ecosystems and hazards subsystem in the Iranian climate change literature.

The analysis of the macro-trends subsystem reveals the absolute dominance of macro-trend shocks, which account for 61.9% of interpretive codes (2,580 codes). This highly significant finding indicates that the Iranian scientific literature conceptualizes climate change not as a gradual, plannable phenomenon, but rather as a series of sudden shocks, crises, and extreme events. This shock-oriented framing is fully consistent with Iran's empirical experiences in recent decades, characterized by unprecedented droughts, devastating floods, severe dust storms, sudden declines in precipitation, and unexpected extreme meteorological occurrences. Ranked second is international climate frameworks, comprising 33.0% (1,376 codes), reflecting an awareness of transnational commitments, the Paris Agreement, and global treaties. Conversely, the negligible shares of climate policies (3.9%, 162 codes) and urban network cooperation (1.2%, 50 codes) expose a deep, structural gap in the domestic scientific literature. In other words, despite being highly cognizant of climate shocks and international frameworks, Iranian scholarship has rarely engaged with domestic climate policies, national laws and regulations, institutional action plans, or inter-city and regional collaborations. This strategic oversight indicates that the Iranian scientific discourse remains confined to a passive-reactive phase, failing to transition into an active, policy-formulating phase. Focusing on shocks and crises without providing institutional policy solutions and legislative requirements distances climate research from practical

application and real-world decision-making processes. This finding serves as a serious warning to Iran's scientific community and policymakers alike: as long as climate research fails to address the enhancement of institutional capacities, the drafting of national legislation, and the expansion of cooperative networks, its actual impact on climate crisis management will remain severely constrained (Figure 6).

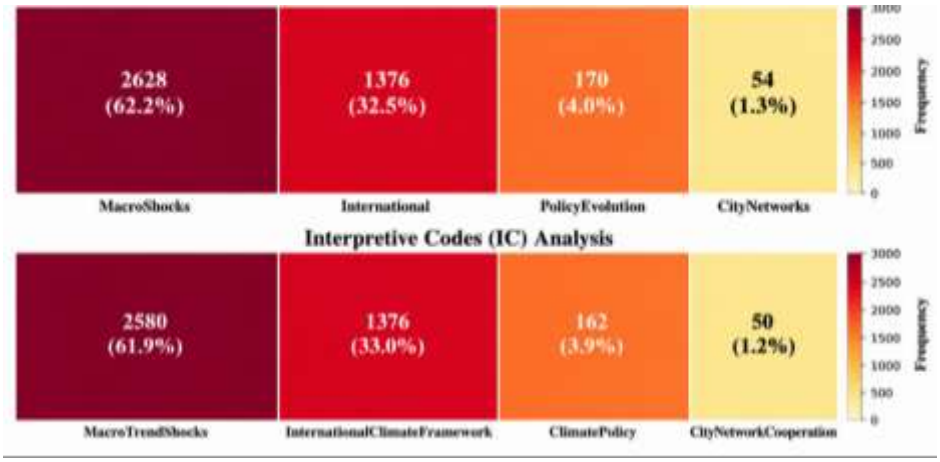


Figure 6. Distribution of interpretive codes across the macro-trends subsystem in the Iranian climate change literature.

The relative distribution of themes across the domestic corpus (n = 290) and the global corpus (n = 200), based on the six subsystems of the Social–Ecological Systems framework (Ostrom, 2009), reveals several critical asymmetries. Water resources management, comprising 46.0% of coded meaning units in the Persian corpus, has become the hegemonic theme of Iranian scholarship, whereas its position in the global corpus is considerably more balanced and situated alongside other resource domains. A similar pattern characterizes urban food systems, which account for 28.9% of Iranian codes versus 10.2% globally—an 18.7-percentage-point divergence favoring the domestic discourse. Within the actors subsystem, social justice likewise exhibits a notable gap, with 35.1% in the Iranian corpus compared to 21.0% globally (a 14.1-percentage-point difference), reflecting the pronounced salience of distributive concerns and the vulnerability of social groups in Iran's framing of climate change. In contrast, three domains reveal inverted structural gaps. Within the governance subsystem, climate finance—at only 0.4% domestically versus 6.0% globally—represents the most underdeveloped theme in the Iranian discourse. Given the centrality of financial mechanisms in global resilience literature, this gap signals not merely a quantitative deficiency but the absence of an institutional agenda. Two further deficits emerge in the ecological and resource domains: ecosystem-based measures (Nature-based Solutions, NbS) within the ecosystems and hazards subsystem appear at 5.6% in Iran versus 16.9% globally (an 11.3-point gap), and waste management and the circular economy within the resource subsystem at 2.2% versus 18.3% (a 16.1-point gap). These gaps indicate that ecosystem-based and circular approaches—now mainstream in global climate discourse—remain marginal within Iranian scholarship. By contrast, green–blue infrastructure within the spatial–physical subsystem is more prominent in the Iranian corpus (19.2%) than in the global corpus (9.4%), indicating that the Iranian deficit concerns ecosystem-based measures rather than green–blue infrastructure per se; within this subsystem, the principal gap lies instead in urban form design (12.9% versus 27.2%). Across the two exogenous subsystems—macro-trend transformations and ecosystems and hazards—both corpora assign relatively high attention to documenting climate trends and hazards, resulting in comparatively limited discursive divergence. This convergence around hazard identification, combined with sharp divergence around response mechanisms, illustrates the broader structural pattern: the Iranian scientific discourse aligns with global scholarship in problem recognition but diverges significantly in institutional, financial, and ecological solution design.

The analysis of macro-level trends demonstrates that urban settlements are increasingly embedded in complex networks of international flows and transboundary shocks. The statistical balance of interpretive codes shows the dominance of international climate frameworks, which account for 62.6% (2,577 codes). This high concentration underscores the continued influence of global agreements and

strategic documents—such as the Paris Agreement and the Sustainable Development Goals—as the primary guiding structures for climate policy in large cities. However, the 22.6% share attributed to macro-trend shocks highlights the pronounced vulnerability of cities to exogenous threats. Phenomena such as large-scale climate migration, forced displacement, and disruptions in supply chains pose substantial risks to the stability of urban social-ecological systems.

Within the ecosystems and hazards domain, climate hazard management accounts for 39.4% of coded units (1,667 codes), indicating that the intensity, frequency, and material impacts of extreme events—urban floods, heatwaves, droughts—have reached levels that compel cities to prioritize physical defenses and early-warning systems. Urban resilience, representing 25.5%, retains its structural weight as the overarching goal of sustainability, while compound risk assessment (18.3%) reflects growing recognition that climate hazards increasingly manifest in cascading and cross-sectoral forms (e.g., concurrent water crises and heatwaves). The relatively modest share of ecosystem-based adaptation (16.9%) indicates that, although NbS and ecosystem services are acknowledged as valuable biophysical buffers, they are still perceived as insufficient on their own for addressing extreme scenarios and must be integrated with physical risk-management strategies.

Within the endogenous resource subsystem, descriptive codes reveal that urban environment (29.7%, 1,392 codes), land use (21.2%, 995), waste and the circular economy (18.2%, 853), water (17.5%, 818), and energy resources (13.4%, 627) constitute the core priority areas. This pattern is mirrored in interpretive coding: urban environmental management (29.0%, 1,307 codes) and land-use and forestry (21.6%, 972) rank highest, followed by waste and circularity (18.3%, 826) and urban water management (18.1%, 818). The distribution suggests that resource sustainability is framed in alignment with closed material flows, groundwater conservation, and biodiversity protection around cities. The 13.0% share of energy resources indicates that physical–ecological dimensions of resources receive greater emphasis relative to industrial energy concerns.

Interpretive codes indicate a shift in thematic focus from food systems toward health and climate adaptation, which accounts for 27.8% (890 codes), and energy transition, with 26.1% (835). This methodological shift reflects a new paradigm in which the urban human—and their physiological well-being under heat stress and climate-related mortality—becomes central. Energy-sector actors engaged in electrification and network optimization are identified as primary drivers of emissions reduction. The building sector (14.8%) and sustainable mobility (11.2%) highlight the growing relevance of construction, energy-efficient design, and clean transport infrastructures. In contrast, urban food systems (10.2%) have become significantly less prominent, aligning closely with industrial decarbonization (10.0%). This suggests that global cities increasingly view intra-urban actors and physical infrastructures—industry, buildings, transport, energy—as the most decisive levers for climate mitigation.

The governance subsystem, with 4,647 interpretive and 4,875 descriptive codes, reveals institutional structures and barriers shaping climate policymaking. Public-sector governance dominates with 44.7% (2,075 codes), supported by urban climate governance (22.7%, 1,053). A substantial 21.0% share (978 codes) dedicated to social justice and equity indicates that achieving sustainable physical adaptation is perceived as contingent upon distributive justice, recognition of local knowledge, and empowerment of low-income groups. However, the extremely low shares of climate finance (6.0%) and macro-economic policy (5.7%) expose a serious financial–institutional gap. Despite strong theoretical discourse, green financing mechanisms remain centralized nationally, and financial channels to municipal governments are insufficiently activated.

Analysis of the spatial–physical layer, comprising 1,752 interpretive and 1,781 descriptive codes, reveals simultaneous attention to atmospheric variables and urban morphology. Air quality management (33.3%, 584 codes) and urban microclimate (30.1%, 528) dominate, focusing on ozone behavior, particulate matter, temperature dynamics, and dust. Meanwhile, the 27.2% share of urban form design (476 codes) underscores the rising importance of morphological criteria in climate-sensitive planning. In this paradigm, controlling urban sprawl is considered essential for reducing surface runoff and safeguarding peri-urban ecological capacities. However, green–blue infrastructure accounts for only 9.4%, indicating its early integration into morphological planning and the need for deeper emphasis in urban policy.

4. Discussion

This study was undertaken to examine the structure of Iran's scientific discourse on climate change and urban resilience, and to compare it with the global corpus within the framework of Social-Ecological Systems (SES) (Ostrom, 2009). The overall findings indicate that Iran's scientific literature has become predominantly focused on a reactive paradigm, in which climate change is conceptualized primarily as an exogenous shock, rather than as an endogenous variable that must be integrated into the design of institutions, financial mechanisms, and urban form. The pronounced emphasis of the Persian corpus on water resources management (46.0%) and hazard documentation, alongside the minimal presence of solution-oriented components, provides quantitative evidence for this claim. In contrast, the global literature—particularly that of leading cities—redefines climate issues within the context of compound risks and climate-sensitive urban form design, and has progressively shifted from the phase of hazard identification toward the phase of mechanism design (Hojati Sayah et al., 2026; Yuan et al., 2026). This foundational divergence, elaborated across the six SES subsystems below, suggests that the distance between Iran's knowledge system and the global research frontier is not merely a matter of production volume but a matter of discursive maturity: the transition from hard engineering and crisis management to ecosystem-based resilience and preventive governance has yet to become a central research priority in Iran.

One of the most critical structural gaps identified in Iran is the governance–finance disconnect. Whereas the global literature places increasing emphasis on climate justice and the equitable distribution of adaptation benefits (Eyni et al., 2025; McDonald et al., 2026), Iranian scholarship—despite a degree of attention to social equity—has almost entirely neglected mechanisms of climate finance (only 0.4 percent) and urban governance. This aligns with the findings of Pazhuhan (2023), which show that the principal obstacle to resilience in Iran is not a shortage of physical knowledge, but the absence of decentralized financial institutions and innovative green investment instruments. By contrast, cities worldwide, despite facing similar financial constraints, have succeeded in mobilizing new funding channels through international frameworks and transnational urban networks. The comparative analysis of the two corpora reveals a dual and asymmetric pattern of discursive gaps that extends beyond a simple research lag. On the one hand, certain themes appear significantly more prominent in the Iranian corpus than in the global literature: food systems (28.9% versus 10.2%) and social equity (35.1% versus 21.0%) illustrate that Iranian scholarship—shaped by lived experiences of water–food insecurity and widening social disparities—has predominantly framed climate issues through the lens of survival and livelihoods. On the other hand, themes constituting the backbone of global resilience discourse are marginalized in Iran: climate finance (0.4% versus 6.0%), ecosystem-based Nature-based Solutions (NbS) (5.6% versus 16.9%), and waste management and the circular economy (2.2% versus 18.3%). This asymmetry indicates that Iran's discourse remains entrenched in problem framing, whereas the global literature has transitioned toward mechanism design. In other words, the principal gap lies not in hazard identification but in the institutional, financial, and ecological instruments for responding to risk. Within the SES framework, this translates into the underdevelopment of the governance subsystem and of the response-oriented components of the ecosystems and hazards and physical–spatial subsystems (ecosystem-based measures and urban form design), contrasted with the relative expansion of the resource and actor subsystems.

Furthermore, the analysis of actors and resources demonstrates that Iranian literature suffers from nexus imbalance. The dominance of water and food security discourse has pushed other dimensions of urban metabolism—such as energy, waste, and sustainable transport—into the background. This mono-dimensionality obstructs the synergies required for energy transition and carbon reduction. Whereas global scholarship identifies actors in the building, transport, and energy transmission sectors as primary drivers of climate mitigation, in Iran these sectors have been overshadowed by the water crisis. The pattern indicates that adaptation strategies in Iran lack a decarbonization agenda and remain centered largely on biological and livelihood survival. The comparative findings yield clear policy implications for institutional actors across all tiers of urban governance in Iran.

First, at the level of climate finance, the 0.4% versus 6.0% gap calls for municipalities—supported by the Ministry of Interior and the Plan and Budget Organization—to establish local climate finance funds and adopt instruments such as municipal green bonds and energy performance contracts (EPCs), reducing exclusive dependence on centralized state budgets.

Second, in the realm of urban physical planning, the marginalization of ecosystem-based NbS and climate-sensitive urban form design necessitates that the Supreme Council of Urban Planning and Architecture institutionalize climate resilience and decarbonization appendices as mandatory components within the approval process of master and detailed plans.
Third, at the level of urban diplomacy, active membership of major Iranian cities in transnational networks such as C40 and ICLEI can facilitate knowledge transfer, access to international funding, and institutional learning from Global South experiences. Collectively, these three interventions chart a pathway for transitioning from the reactive paradigm documented in this study to preventive, multi-level urban climate governance—a transition that will not materialize without the simultaneous redesign of governance and physical–spatial subsystems.

5. Conclusion

This study aimed to systematically examine the structure of climate change knowledge in Iran and compare it with the scientific discourse of leading global cities within the Social-Ecological Systems framework. The findings show that Iran's scientific discourse is entrenched in a predominantly reactive paradigm, characterized by an excessive focus on water resources management (46%) and hazard management, contrasted with the near absence of climate finance (only 0.4% of interpretive codes) and limited attention to urban governance. Meanwhile, the global corpus anchors its discursive emphasis on compound risks, urban form design, and climate justice. These patterns indicate that advancing urban resilience in Iran requires a paradigmatic shift from reactive hazard management toward preventive and systemic governance. As long as endogenous layers—governance, finance, and physical structure—are not dynamically reconfigured alongside exogenous climate shocks, existing strategies will remain vulnerable to inefficiency or maladaptation (Lin et al., 2021; Meerow & Newell, 2019).
From a theoretical perspective, the contribution of the present study lies in applying the SES framework not to a single common-pool resource system but to the anatomy of a national knowledge system, illustrating how discursive gaps themselves may function as endogenous variables that impede resilience. Based on these gaps, a three-pronged operational framework is proposed:

1. Transition from hard engineering to ecosystem-based Nature-based Solutions (NbS), whereby municipalities and national planning councils embed ecosystem-based measures—such as wetland restoration, sustainable watershed management, and urban forestry, which account for only 5.6% of codes in the Iranian corpus versus 16.9% globally—into hazard management, and translate the comparatively strong research base on green–blue infrastructure into practice in stormwater management and heat island mitigation (Hojati Sayah et al., 2026).
2. Institutionalizing decentralized climate finance—the most direct response to the identified 0.4% gap—through the establishment of local climate funds and adoption of instruments such as EPCs to attract private investment and reduce dependence on state budgets.
3. Integrating the water–energy–food nexus into urban policymaking to prevent adaptation actions in one domain from exacerbating crises in another, thereby fostering holistic planning instead of fragmented sectoral approaches.

This study is subject to certain limitations: reliance on written documents (rather than stakeholder perceptions), potential linguistic bias due to the focus on Persian and English sources, and the interpretive nature of coding, which—despite achieving strong reliability ($\kappa > 0.80$)—cannot be entirely dissociated from researcher subjectivity. It is therefore recommended that future research extend this comparative analysis to other Global South regions, particularly the MENA context, and utilize topic modeling with large language models as well as stakeholder interviews for cross-validation of findings. Ultimately, the central message for Iran's scientific community and policymakers is clear: climate resilience is built not through repeated descriptions of shocks, but through the design of proactive institutional and financial mechanisms.

Authors' Contribution
Mohammad Kamangar: Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing—review & editing.

Ali Reza Karbalaee: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing—original draft, Writing—review & editing, Visualization, Project administration.
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Pegah Bahmani: Validation, Formal analysis, Investigation, Data curation, Writing—review & editing.

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Conflict of Interest
The author(s) declares that there is no conflict of interest regarding the publication of the registered research. Furthermore, ethical considerations including plagiarism, informed consent, misconduct, fabrication and/or falsification of data, duplicate publication, and also Journal Policy on Artificial Intelligence Use have been fully observed by the authors.

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