The biodiversity paradox: declining conservation discourse amid ecological crisis in global urban policies

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The biodiversity paradox: declining conservation discourse amid ecological crisis in global urban policies

Ajishnu Roy

Integrative Biology Research Unit (IBRU), Department of Life Sciences, Presidency University, Kolkata, India

Email ID: ajishnuroy1990@gmail.com
ORCID: 0000–0001–9494–3963

Abstract:
Despite escalating biodiversity crises, conservation discourse in urban environmental policies has declined, revealing a governance paradox in which ecological urgency is inversely correlated with policy representation. We analyzed 202 urban environmental policies from 85 countries spanning 1984-2025 using computational text analysis (LDA, NMF, hierarchical clustering). The results reveal an 8.3:1 developmental-to-conservation discourse ratio, with sustainable development, transport, and infrastructure dominating 77.7% of policy content, while explicit conservation themes constitute only 9.4%. Biodiversity topics declined 61.9% from the 2010s peak during the 2020s, coinciding precisely with the Kunming-Montreal Global Biodiversity Framework adoption. Colonial language dominance (66.8% English-Spanish-French) marginalizes Indigenous ecological knowledge, while African policies show zero explicit conservation representation, despite critical biodiversity hotspots. These findings demonstrate that sustainability mainstreaming produces 'discursive dilution', displacing targeted conservation action and demanding mandatory conservation content thresholds, multilingual policy development and scalar governance coordination.

Keywords: urban policy; global governance; text mining; policy discourse; biodiversity conservation;

1. Introduction:

Urban areas house 56% of the global population (4.4 billion people) and are expected to accommodate 68% of the population by 2050 (UN, 2018). Urbanization drives biodiversity loss through habitat conversion, fragmentation, and habitat degradation (Seto et al., 2012; McDonald et al., 2018). Between 2000 and 2030, urban expansion is forecasted to consume 290,000 km² of natural habitat, with concentrated impacts on biodiversity hotspots, where endemic species face extinction risk (McDonald et al., 2018). Recent analyses have revealed that urban land expansion directly threatens 26–39% of assessed species globally, driving habitat loss ≥5% of their ranges, and imperiling 2–3% of species (459–855 species) through habitat loss exceeding 25% (Simkin et al., 2022).

However, cities are not biological deserts. Urban ecosystems support diverse species, provide essential services, including pollination, climate regulation, and water purification, and serve as laboratories for conservation innovation (Nilon et al., 2017; Wang et al., 2024). Recognizing this dual reality, the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) calls for halting biodiversity loss by 2030, including targets to maintain ecosystem integrity, halt human-induced extinctions, and increase native species abundance to resilient levels. Urban areas, where nature and humanity intersect intensively, are critical for achieving these goals.

However, the representation of biodiversity in urban policy remains underexplored. While scientific attention to urban ecology has grown (Haase et al., 2014; Elmqvist et al., 2013), policy documents and texts that guide governance and resource allocation have received limited systematic analysis. Early work by Nilon et al. (2017) examined 135 urban plans from 40 cities and found that 76% included biodiversity goals, but only 24% contained quantitative targets, rendering the plans vague and unactionable. More fundamentally, we lack knowledge about which ecological concepts appear in urban policies, how their prevalence has evolved over time, and whether conservation language keeps pace with the biodiversity crisis.

This gap is significant because language shapes policy by framing issues, defining priorities, and allocating legitimacy (Fish et al., 2024). If biodiversity concepts are absent or declining while climate or infrastructure terms proliferate, this signals a 'representation crisis' in which ecological urgency fails to translate into governance vocabulary. Moreover, policy discourse varies linguistically and geographically, with conservation narratives potentially differing between Global North policies and tropical biodiversity hotspots, where urbanization is accelerating.

Recent advances in computational text analysis have enabled large-scale policy content assessments. Topic modeling methods, particularly Latent Dirichlet Allocation (LDA; Blei et al., 2003) and Non-Negative Matrix Factorization (NMF), identify latent thematic structures in document corpora, revealing what is 'talked about' in policies (Ford et al., 2016). Semantic clustering groups similar documents into 'policy families', exposing typologies and outliers. When applied to climate adaptation plans, these methods reveal temporal framing shifts (Ford et al., 2016), and when applied to urban environmental policies, they can assess ecological representation.

Despite these methodological capabilities, no study has systematically analyzed urban environmental policy discourse on a global scale, over a long time span, or using multiple computational methods to assess biodiversity representation. We posed two primary research questions:

- What thematic landscapes characterize urban environmental policies? Using LDA and NMF topic modeling, we identified latent topic structures and assessed their prevalence.
- How are policies organized semantically? Through clustering analysis, we reveal document families, typologies, and outliers, examining whether policies are grouped by region, topic, or temporal era.

Our central hypothesis is that, despite the acceleration of biodiversity loss, conservation language representation in urban policies has declined over time, displaced by climate change, the circular economy, and infrastructure themes. This is a biodiversity paradox in which ecological urgency is inversely related to the prominence of policy discourse. If confirmed, this finding has implications for urban environmental governance: policies may address symptoms (climate impacts) while neglecting the underlying causes (biodiversity loss), undermining long-term urban sustainability. This study contributes to urban ecology scholarship by:

- Providing the first large-scale computational content analysis of urban environmental policies across 85 countries spanning four decades (1984–2025)
- Quantifying ecological concept representation through multi-method triangulation (LDA, NMF, clustering),
- Revealing temporal trends in conservation discourse that inform whether policy language aligns with biodiversity conservation needs articulated in the Kunming-Montreal Framework.

Our findings offer evidence for policy reform, suggesting how urban environmental governance can better integrate biodiversity with dominant climate and infrastructure agendas.

2. Literature review:

Cities support more than half of the human population and are fundamental to the persistence of biodiversity. Urban ecosystems harbor diverse species and provide essential services, such as pollination and climate regulation, that contribute to human well-being, despite their reputation as ecological deserts. Conversely, urbanization leads to habitat destruction, fragmentation, and species loss.

Recent research has shown gaps between the science of conservation and urban policy. Nilon et al. (2017) reviewed 135 plans from 40 cities and found that while 76% included biodiversity goals, only 24% contained quantitative targets, making plans ‘unsuccessful for actionable conservation’. Pierce et al. (2020) similarly reported that outputs are dominated by governance and management actions, with only sparse coverage of measurable indicators. Kendal and Bush (2025) identified fragmentation across land-use planning, open space management, and conservation systems as limiting coordinated action. These gaps raise questions about how the concepts of biodiversity move in and out of governance texts.

Language shapes environmental policy through issue framing, terminology, and consequent decisions. Fish et al. (2024) contend that language is not only descriptive but also constitutive; it actively constructs what counts as biodiversity and how it should be managed. From a post-colonial perspective, Western frameworks dominate conservation discourse and continue to marginalize Indigenous knowledge systems alongside local languages. This linguistic hegemony has material consequences: imposed conservation narratives may fail to resonate with communities or to address local ecological realities.

Computational text analysis facilitates large-scale policy assessments. Topic modeling, particularly LDA, finds latent thematic structures by assuming that documents are mixtures of topics. Recent applications illustrate the utility of environmental policy analysis. Ford et al. (2016) applied topic modeling to climate adaptation plans. This sheds light on how 'adaptation is talked about' by decision-makers. Takacs and O'Brien (2023) used text mining to analyze 15,310 papers on biodiversity-ecosystem services. They found that topics with human, policy, or economic dimensions performed better than 'pure' biodiversity science. Papaspyropoulos et al. (2023) applied discourse and text mining to Greek biodiversity-forest strategies. This confirmed that text mining enhances the objectivity of discourse analysis. NMF is a deterministic decomposition technique that complements the LDA probabilistic approach. The triangulation of LDA and NMF strengthens topic validity by confirming the robust thematic structures. Recent studies have used AI and text mining to systematically evaluate urban policies. Similarly, environmental policy synergy analyses have tracked temporal evolution. In addition, hierarchical clustering through cosine similarity metrics allows the segmentation of documents through content, hence showing policy 'families' and outliers. Complementing topic modeling, these methods provide document-level structures as opposed to word-level structures. Overall, comparative studies have shown that clustering combined with NLP effectively uncovers structural patterns in policy networks and replication patterns across jurisdictions (Simpson et al. 2023). Subsequently, research on policy typology corroborates that clustering exposes governance innovations, implementation gaps, and knowledge transfer mechanisms across nations (Malandrino, 2024).

Three critical gaps persist despite advances:

Gap 1: Limited large-scale content analyses. Most studies examine small samples ($n<50$ cities) or single-country contexts.

Gap 2: Methodological isolation. Existing studies have employed single methods, limiting triangulation. Integrating multiple text-mining approaches provides convergent evidence of thematic patterns.

Gap 3: Temporal biodiversity tracking. Few studies track conservation discourse evolution across decades to assess whether policy language aligns with ecological urgency.

This study addresses these gaps by asking: How are ecological themes, particularly biodiversity and conservation, represented in global urban policy discourse? How has this representation evolved over time?

3. Methodology:

3.1. Data Source and Policy Selection

We analyzed urban environmental policies from the Food and Agriculture Organization Legal Database (FAOLEX) accessed September 11, 2025. Following the PRISMA 2020 guidelines (Page et al., 2021), we systematically searched the database using ten urban-related terms: urban, city, metropolitan, municipal, town, suburb, settlement, zoning, infrastructure, and built.

The initial database contained 11,337 policy records. After excluding 94 repealed texts, 11,243 active policies remained. Screening for urban relevance, data completeness, and English-language abstracts yielded 202 policies from 85 countries spanning 1984–2025. The final corpus included policy abstracts (mean length: 180 words), titles, FAOLEX-assigned keywords, policy domains (16 categories, including Environment, Water, Biodiversity), geographic metadata (country and administrative level), and enactment dates.

3.2. Analytical Framework

We employed a five-stage framework that integrated linguistic, thematic, and computational text analysis methods.

3.2.1. Language Diversity Analysis

We extracted language metadata from the FAOLEX records to assess linguistic diversity. For each of the 85 countries, we identified the following: (1) number of official languages used in policies, (2) dominant language family (Indo-European, Sino-Tibetan, Austronesian, etc.), and (3) linguistic diversity index (Shannon entropy: $H = -\Sigma(p\_i \times \ln p\_i)$, where p_i is the proportion of policies in language i). Linguistic patterns were mapped to geographic regions (Africa, Americas, Asia, Middle East, Europe, and Oceania) and cross-tabulated with ecological topic prevalence using chi-square tests (α=0.05).

3.2.2. Topic Modeling

We applied unsupervised topic modeling to identify latent thematic structures in policy abstracts. Text preprocessing included: lowercase conversion, stopword removal (NLTK English stoplist plus custom policy terms: ‘act’, ‘law’, ‘policy’), and lemmatization (WordNet lemmatizer). We tested 6–12 topic solutions using coherence metrics (Cv score; Röder et al., 2015), selecting an 8-topic model balancing interpretability and coherence (Cv=0.52). The topics were manually labeled based on the top 15 words per topic and representative documents.

3.2.3. Latent Dirichlet Allocation (LDA)

LDA, a probabilistic generative model (Blei et al., 2003), assumes that documents are mixtures of topics and that topics are distributions over words. We implemented LDA using ‘scikit-learn’ with the following parameters: α=0.1 (document-topic sparsity), β=0.01 (topic-word sparsity), 1000 iterations, random state=42 for reproducibility. Each document received a topic distribution (θ_d), and each topic had a word distribution (φ_k). We extracted the dominant topics

(max θ_d per document) and tracked the topic prevalence across decades. Topic-keyword associations were validated against FAOLEX keyword fields (Jaccard similarity).

3.2.4. Non-Negative Matrix Factorization (NMF)

To triangulate the LDA findings, we applied NMF, which is a deterministic matrix decomposition method. The document-term matrix (TF-IDF weighted) was factorized into document-topic (W) and topic-term (H) matrices with non-negativity constraints. We used eight topics (matching LDA), L2 regularization (α=0.1), and 500 maximum iterations. NMF topics were compared with LDA topics using top-word overlap (top ten words per topic) and document assignment agreement (Cohen's κ). Convergence across methods indicated robust thematic structures.

3.2.5. Semantic Similarity and Clustering

We computed pairwise document similarity using TF-IDF vectors and cosine similarity metrics. Hierarchical agglomerative clustering (Ward linkage) grouped documents based on semantic content. We tested 5–15 cluster solutions using silhouette scores and dendrogram inspection and selected a 10-cluster solution (mean silhouette=0.31). Clusters were profiled by (1) dominant domains, (2) temporal concentration (peak decade), (3) geographic representation, and (4) characteristic keywords (TF-IDF > 0.3). Policy 'families' were identified as groups of ≥3 policies with near-identical content (cosine similarity >0.9), indicating template replication or knowledge transfer across jurisdictions.

Outliers were defined using an isolation score calculated as follows:
$\text{Isolation Score}_i = (1/|C_i|) \times \Sigma\_(j \in C_i) (1 - \text{sim}(d_i, d_j))$

where d_i is document i, C_i is the assigned cluster, and $\text{sim}(d_i, d_j)$ is the cosine similarity between documents i and j. The isolation score ranged from 0 (perfect cluster integration) to 1 (complete isolation). Policies with isolation scores <0.15 were classified as outliers, indicating thematic distinctiveness or hybrid framings that diverged from conventional policy archetypes. These outliers were qualitatively examined to identify innovative governance approaches or unique national contexts.

3.3. Software

All analyses used Python 3.12 with libraries: 'pandas' (data handling), scikit-learn (LDA, NMF, TF-IDF, clustering), 'gensim' (topic coherence), 'nltk' (text preprocessing), 'scipy' (distance metrics, hierarchical clustering), and 'matplotlib'/'seaborn' (visualization). Topic model stability was assessed via 10 fold cross-validation (mean coefficient of variation [CV] coherence variance: 0.04). The inter-method agreement for topic assignments between LDA and NMF achieved a moderate concordance (κ=0.62).

4. Results:

4.1. *Language diversity*:

The policy corpus (**Supplementary File 1**) exhibits limited linguistic diversity despite representing 85 countries, with colonial languages dominating 66.8% of policies. English led at 40.6% (82 policies), followed by Spanish (15.3%, 31 policies) and French (10.9%, 22 policies), while the remaining 23 languages collectively represented only 33.2% (67 policies). Monolingual policies constitute 97% of the corpus, with only six bilingual documents (3%), primarily Arabic-English combinations from the UAE, and one Norwegian-English text (**Fig 1a**). Zero policies incorporated three or more languages, revealing minimal cross-linguistic integration despite global urban biodiversity challenges requiring multilateral cooperation and Indigenous knowledge systems.

Linguistic diversity evolved dramatically but non-linearly, from one language (Spanish) during 1980-1999 to seven languages in 2000-2009, peaking at 20 languages in 2010-2019 before declining to 18 in 2020-2025. This recent contraction coincides with intensifying biodiversity crises, suggesting that as conservation urgency escalates, linguistic representation paradoxically narrows. English maintained dominance at 44.1% (2000s) and 48.6% (2010s) before declining sharply to 36.1% (2020-2025), a 12.5-percentage-point decrease indicating shifting geopolitical influences and potential decolonization of policy discourse.

Regional linguistic patterns reveal an 11 fold disparity in language diversity, reflecting colonial legacies and power asymmetries. Oceania exhibits complete linguistic uniformity (100% English, 100% Anglo-associated), paradoxically in a region harboring significant biodiversity hotspots, whereas Europe demonstrates relative autonomy with 10 languages and only 16.2% Anglo-association. Africa presents a stark binary divide: French (62.5%) versus English (37.5%) with zero representation of indigenous African languages, illustrating how Francophone-Anglophone colonial divisions constrain local linguistic perspectives in urban biodiversity governance. Asia and the Middle East show 58.8% Anglo-association across eight languages, with 14.7% bilingual policies concentrated exclusively in the UAE, suggesting that multilingual integration remains geographically isolated rather than systematically adopted.

Administrative-level analysis reveals that multinational policies demonstrate complete uniformity (100% English, n=5), confirming English as the mandatory lingua franca for transnational coordination and effectively marginalizing non-Anglophone conservation frameworks in international biodiversity governance. National policies exhibit greater linguistic sovereignty (34% English, 20.6% Spanish, 15.6% French), while subnational policies show higher English concentration (51.8%), suggesting that technical policy borrowing and international coordination pressures constrain local linguistic autonomy at the implementation level. This scalar gradient reveals that multilateral cooperation structurally requires linguistic homogenization, potentially excluding Indigenous knowledge systems, local ecological terminology, and non-Western conservation approaches essential for addressing place-based biodiversity challenges (**Fig 1b**).

4.2. ***Topic modeling:***

Policy domain analysis (**Supplementary File 2**) across 16 FAOLEX categories revealed stark prioritization hierarchies that underscore the biodiversity representation crisis. Environment (45.5%, n=92) and Water (43.1%, n=87) dominated, reflecting climate-water-sustainability nexus framing, while biodiversity-specific domains remained marginalized: Wild species and ecosystems ranked 6th (17.3%, n=35), Forestry 7th (14.4%, n=29), and Fisheries and aquaculture 11th (6.4%, n=13). Combined, these explicit biodiversity domains represent only 47% of policies, barely exceeding the single environment domain. An 8.1fold concentration disparity exists between the top five domains (173.3%) and bottom five (21.3%), demonstrating extreme thematic inequality, where broad environmental framing eclipses targeted conservation priorities.

Domain integration complexity and the 2020s collapse: Policies averaged 2.68 domains each, with 70.3% demonstrating multi-domain integration. However, temporal trajectories reveal a critical paradox: integration absent in the 1980s (0%, n=1) rose to 73.5% in the 2000s, peaked at 77.1% in the 2010s (81 of 105 policies), and then collapsed to 57.4% in the 2020s (35 of 61 policies), a 19.8-percentage-point decline. The average number of domains per policy also contracted from 2.87 (2010s) to 2.39 (2020s). This 2020s fragmentation coincides precisely with intensifying ecological crises, paradoxically indicating that as biodiversity threats escalate, governance frameworks retreat from integrated systems-based approaches toward narrow sectoral silos, undermining the holistic responses necessary for conservation (**Fig 1c**).

Wild species and ecosystems require the highest cross-domain integration (4.8 domains per policy on average), yet appear in only 17.3% of the corpus, 2.6 times less frequently than the generic Environment domain. This reveals a structural marginalization: when conservation topics do appear, they demand complex multi-sectoral coordination, but policies systematically avoid this complexity by excluding biodiversity themes entirely rather than engaging with their inherent governance challenges.

Geographic inequalities in policy integration: Regional integration disparities are extreme; Oceania leads with 88% multi-domain integration with four domains per policy, whereas Africa trails at 50% with only 1.96 domains per policy, a 38-percentage-point gap, and a 2.04fold domain intensity difference. The Americas (77.3%, 2.73 domains/policy), other regions (76.3%, 2.71), Asia and the Middle East (67.6%, 2.53), and Europe (59.5%, 2.3) occupied intermediate positions. This geographic gradient reflects divergent capacities: high-income Anglophone nations in Oceania pursue comprehensive systems-based frameworks, while biodiversity-rich African nations adopt narrower sectoral approaches driven by immediate development imperatives, poverty alleviation, infrastructure deficits, and economic growth that supersede conservation integration. Policy integration capacity correlates with economic development rather than ecological urgency, exacerbating global inequities in conservation effectiveness as the regions facing the greatest biodiversity loss possess the least integrated governance frameworks.

Australia dominated as the most common country across seven of the 15 domains (46.7%), including Environment, Wild species and ecosystems, land and soil, agricultural and rural development, General, Forestry, and Cultivated plants. This concentration reveals that a single developed Anglophone nation disproportionately shapes global urban biodiversity policy discourse, potentially marginalizing diverse conservation approaches from biodiversity-rich developing regions and reinforcing the linguistic and conceptual hegemony documented in Section 4.1.

Cross-domain co-occurrence patterns: Environment-Water emerges as the dominant integration pair (22.8%, n=46), followed by Agriculture-Environment (18.3%, n=37), Environment-Land (17.3%, n=35), Agriculture-Water (15.3%, n=31), and Land-Water (14.9%, n=3). The top six co-occurrence pairs all involve either the Environment or Water domains, demonstrating that environmental framing now structures water, land, and agricultural policy rather than existing as a standalone conservation sector. While this mainstreaming superficially suggests environmental prioritization, it paradoxically dilutes targeted biodiversity action as conservation imperatives are diffused across multiple domains without a dedicated institutional focus. Multi-domain combinations most frequently included Environment-Water (n=9), Land-Water-Waste urban infrastructure triad (n=7), and Environment-Land (n=5), revealing that integration prioritizes infrastructure-service delivery nexuses over ecological protection (**Fig 1d**).

Thematic homogenization across domains: Domain-specific thematic analyses reveal disconcerting keyword convergence. Environment policies emphasize ‘climate change, sustainable development, policy/planning’ as the top three keywords; water policies prioritize ‘climate change, policy/planning, pollution control’; land and soil policies focus on ‘sustainable development’, ‘policy/planning’, ‘protection of environment’; and agricultural and rural development highlights ‘sustainable development, climate change, policy/planning’. This homogenized language, with ‘sustainable development’, ‘policy/planning’, ‘climate change’, and ‘protection of environment’ appearing across all major domains, suggests rhetorical standardization that obscures substantive implementation differences and potentially dilutes targeted conservation action through generic sustainability framing. ‘biodiversity’ appears as a subordinate keyword within the general Environment domain but lacks standalone domain priority commensurate with the Kunming-Montreal Global Biodiversity Framework urgency.

Administrative scale paradox: Sub-national policies demonstrated the highest integration complexity (3.04 domains/policy), exceeding multinational (2.8) and national frameworks (2.53). This inverse scalar relationship indicates that local governments managing tangible urban challenges, infrastructure provision, land-use conflicts, and service delivery require comprehensive cross-sectoral approaches, while national policies maintain strategic sectoral orientations. However, this pattern reveals a critical disconnect: national frameworks articulate broad sustainability visions without operational specificity, while implementation responsibility devolves to sub-national authorities with fragmented sectoral mandates and limited capacity. This governance gap explains why rhetorical environmental commitments at higher scales fail to translate into effective ground-level biodiversity conservation, widening

the chasm between strategic ambitions and operational realities that characterizes the biodiversity paradox.

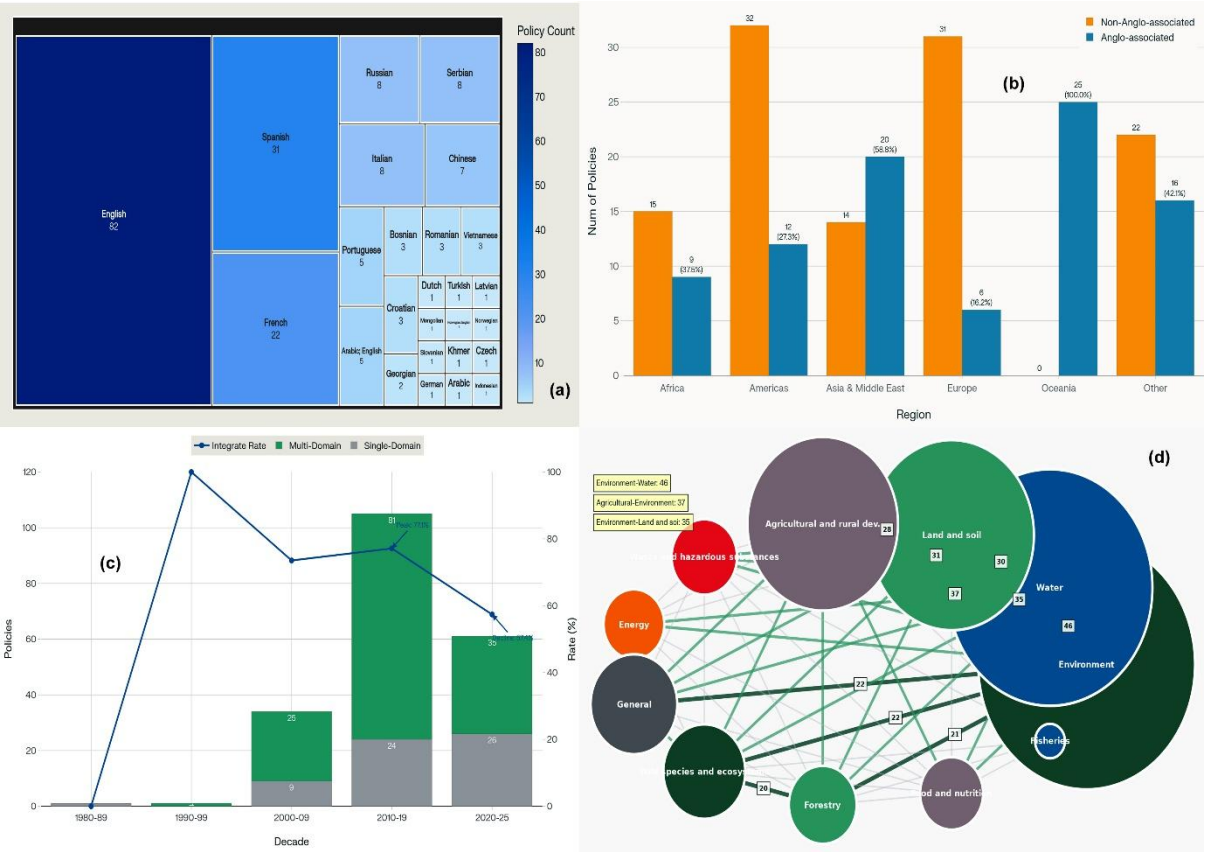

Figure 1. Linguistic diversity and policy integration in global urban environmental governance.

(a) Language treemap showing all 26 languages, sized by policy count. English, Spanish, and French dominate, revealing colonial language concentration and marginalization of Indigenous languages.

(b) Regional Anglo-association across six regions shows 11 times disparity: Oceania's complete uniformity versus Europe's autonomy, exposing colonial legacies structuring policy discourse. Africa shows Francophone-Anglophone binary with zero African language representation.

(c) Temporal domain integration 1980–2025: single- versus multi-domain policies. Multi-domain integration changed from 0→77.1→57.4% (1980s→2010s→2020s), a decline coinciding with biodiversity crises and Kunming-Montreal Framework adoption (2022).

(d) Cross-domain network showing co-occurrence among 16 FAOLEX domains. Node sizes=domain frequency; edge weights=co-occurrence strength. Environment-Water dominates, followed by Agriculture-Environment, Environment-Land, and Land-Water-Waste infrastructure triad. Integration prioritizes infrastructure-service delivery over ecological protection; biodiversity domains (Wild species/ecosystems, Forestry, Fisheries) occupy peripheral positions despite requiring highest coordination.

4.3. *Latent Dirichlet Allocation (LDA)*:

Latent Dirichlet Allocation (**Supplementary File 3**) identified 12 thematic clusters, revealing a stark developmental bias in the field of urban environmental governance. Sustainable Development & Planning dominated at 27.2% (n=55), followed by Transport and Mobility at 18.3% (n=37), and Community Development and Social Programs at 13.9% (n=28). Developmental topics, encompassing sustainable development, transport, community programs, economic investment, infrastructure, and housing, collectively constitute 77.7% of policy discourse, while explicit environmental/conservation topics (Climate Change & Environmental Protection, Land Use & Spatial Planning, Water Resources & Sanitation) represent only 9.4%. This 8.3:1 developmental dominance over conservation quantifies the study's central paradox: urban policies prioritize broad socioeconomic frameworks while systematically marginalizing targeted biodiversity protection despite ecological crisis intensification.

Most strikingly, Climate Change and Environmental Protection ranked 11th among the 12 topics at 1.5% (n=3), exceeded even by Energy and Resource Management (1.5%, n=3), and dramatically overshadowed by Transport and Mobility (12.3 times higher) and Sustainable Development (18.3 times higher). While a Housing & Human Settlements topic (6.9%, n=14) contains conservation-related keywords (management, conservation, species, native, biodiversity), its dominant focus remains housing provision rather than ecosystem protection, illustrating how biodiversity language becomes subordinated within developmental agendas (**Fig 2a**).

Temporal trajectory: The 2020s fragmentation: Temporal analysis across 2000-2025 exposes three critical paradoxes coinciding with escalating biodiversity crises. First, Sustainable Development & Planning intensified 28.1% from 20.3% (2000s) to 26.1% (2020s), demonstrating rhetorical commitment to sustainability frameworks. However, this broad sustainability discourse paradoxically coincides with the near-complete disappearance of targeted conservation topics: Climate Change & Environmental Protection stagnated at 3.5-3.6% across all decades, with zero documents assigned in 2020-25.

Second, Economic Development & Investment surged 159.7%, from 5.3% (2000s) to 13.7% (2020s, n=9), establishing a 3.8:1 ratio over Climate & Environmental Protection in the 2020s. This economic prioritization during intensifying ecological crises (2020-2025 marks accelerating biodiversity loss, climate impacts, and the Kunming-Montreal Framework adoption) reveals policy discourse retreating from conservation toward growth-oriented development, directly contradicting the urgency articulated in global biodiversity agreements.

Third, Urban Governance & Administration collapsed 61.6%, from 10.2% (2000s, n=4) to 3.9% (2020s, n=1), suggesting governance capacity erosion precisely when integrated coordination mechanisms become critical for biodiversity conservation. Simultaneously, Transport & Mobility declined by 65.4% from 26% (2000s) to 9% (2020s), partially replaced by economic development rather than conservation priorities. Topic diversity (Shannon entropy) peaked at

2.28 (2010s) before declining to 2.22 (2020s), indicating thematic convergence around sustainability rhetoric at the expense of specialized conservation discourse (**Fig 2b**).

Geographic fragmentation and national specializations: Regional topic specializations reveal fragmented priorities that undermine coordinated biodiversity responses. Africa demonstrates the highest Sustainable Development (29.7%) and Transport & Mobility (32%) intensities globally, reflecting infrastructure deficits that supersede conservation efforts. Oceania exhibits an exceptional concentration of Housing and Human Settlements (27.6%, the highest globally) alongside elevated Climate and Environmental Protection (9.6%, 6.5fold above the global average), creating a unique regional signature. Europe prioritizes Economic Development (28.8%, the highest globally) over environmental themes, while Asia and the Middle East emphasize Infrastructure & Public Services (18.8%). The Americas balance Sustainable Development (26.2%) with Transport (12.4%), demonstrating relative thematic equilibrium but lacking conservation specificity (**Fig 2c**).

Country-level analyses reveal extreme specialization, reflecting localized pressures rather than biodiversity urgency. Australia concentrates 45.4% of discourse on Housing & Human Settlements (the highest globally), with Climate & Environmental Protection at only 7.8%, despite exceptional biodiversity values. Bosnia and Herzegovina dedicates 72.3% to Economic Development driven by post-conflict reconstruction, with Climate & Environment at 3.5%. Italy emphasizes Water Resources (52%), responding to Mediterranean scarcity and EU directives, while the United Arab Emirates focuses on Infrastructure & Public Services (36.2%), exemplifying Gulf smart city initiatives. Burkina Faso balances Transport (38.8%) and Sustainable Development (38.4%), illustrating the prioritization of African infrastructure. This country-level heterogeneity demonstrates that immediate socioeconomic pressures, housing crises, post-conflict recovery, water stress, infrastructure gaps, systematically override global conservation imperatives, fragmenting international biodiversity governance coherence (**Fig 2d**).

Administrative scale paradoxes: Governance scale analysis revealed three structural contradictions. First, national policies prioritize Sustainable Development (26.3%) and Transport & Mobility (16.7%), establishing broad strategic frameworks, while sub-national policies concentrate on Housing & Human Settlements (18.3%, 22.9fold higher than the national level) and Economic Development (14.8%, 2.5fold higher), addressing immediate implementation challenges. This scalar divergence creates governance gaps: national rhetoric emphasizes sustainability without operational specificity, while implementation responsibility devolves to sub-national authorities pursuing narrow sectoral agendas disconnected from conservation targets.

Second, multinational policies demonstrate extreme Transport & Mobility concentration (45.3%), with Climate & Environmental Protection at only 2.6% and Agriculture & Rural-Urban Integration at 19.8% of policies. This 17.4:1 infrastructure-to-conservation ratio in transnational coordination reveals that international cooperation prioritizes cross-border mobility over ecological protection, undermining multilateral biodiversity commitments.

Third, Housing & Human Settlements exhibit inverse scaling: near-absent in national frameworks (0.8%) and multinational agreements (1.5%), but dominant in sub-national policies (18.3%). This pattern demonstrates that critical urban challenges requiring integrated biodiversity considerations, housing densification impacts on green space, settlement expansion into natural habitats, lack strategic guidance from higher governance levels, resulting in fragmented local responses that cumulatively drive biodiversity loss.

These LDA findings substantiate the biodiversity paradox: as ecological crises intensify through 2020-2025, policy discourse increasingly emphasizes generic sustainability frameworks (27.2%), economic development (6.4% → 13.7% in the 2020s), and infrastructure (18.3% transport), while explicit conservation topics stagnated at 1.5-2%, representing an 8.3:1 developmental dominance that rendered biodiversity concerns rhetorically invisible despite their governance urgency.

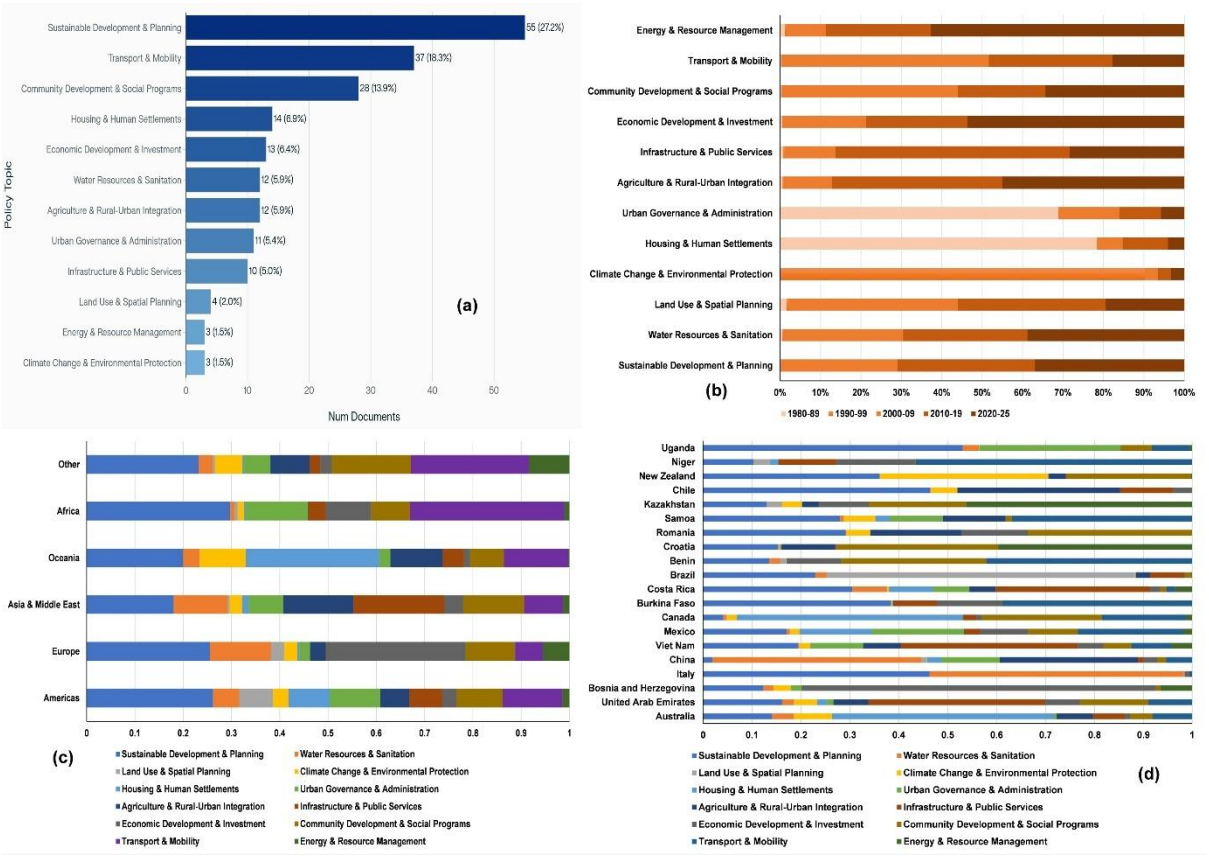

Figure 2. Latent Dirichlet Allocation (LDA) analysis of global urban environmental policies. (a) Topic distribution across 12 clusters, ranked by frequency. Sustainable Development Planning dominates, followed by Transport and Mobility and Community Development. Climate Change Protection ranks lower than Transport and Sustainable Development.
(b) Temporal trajectories 2000–2025 showing 2020s conservation collapse. Sustainable Development intensified; Climate Change Protection stagnated, reaching zero in 2020–25. Economic Development surged over climate/environmental protection. Urban Governance

collapsed; Transport declined. Shannon entropy peaked at 2010s, declining in 2020s, thematic convergence toward sustainability rhetoric during intensifying crises (coinciding with Kunming-Montreal Framework 2022).
(c) Regional specializations showing fragmented priorities. Africa: highest Sustainable Development and Transport; Oceania: Housing concentration plus elevated Climate Protection; Europe: Economic Development priority; Asia/Middle East: Infrastructure emphasis; Americas: Sustainable Development with Transport.
(d) Country-level intensities showing socioeconomic pressures overriding conservation. Australia: Housing, Climate Protection despite biodiversity values; Bosnia-Herzegovina: Economic Development (post-conflict); Italy: Water (Mediterranean scarcity); UAE: Infrastructure (smart cities); Burkina Faso: Transport, Sustainable Development (infrastructure priority). LDA parameters: α=0.1, β=0.01, 1,000 iterations, CV=0.52, random state=42.

4.4. *Non-negative matrix factorization (NMF)*:

Non-negative matrix factorization (**Supplementary File 4**) applied via TF-IDF vectorization (1,500 features) with coordinate descent optimization identified 12 thematic components with sharper sectoral boundaries than LDA's probabilistic model. Integrated Infrastructure & Spatial Planning dominated at 19.8% (n=4), followed by Capacity Building & Institutional Frameworks at 12.9% (n=26), a governance dimension entirely absent in the LDA, and water resource management and groundwater at 11.4% (n=23). Infrastructure and institutional topics collectively constitute 63.4%, while explicit conservation topics (Ecosystem Conservation & Native Species, Biodiversity & Pest Management, Climate Change Adaptation & Infrastructure) represent only 15.3%, establishing a 4.1:1 infrastructure-to-conservation dominance.

Most critically, Ecosystem Conservation & Native Species constitutes the smallest topic at 2.5% (n=5), 8.0 times smaller than Integrated Infrastructure, ranking 11th among the 12 topics. Biodiversity and Pest Management (5%, n=1) ranked 9th, and combined these explicit biodiversity topics (7.4%, n=15) exceeded even Waste Management and Circular Economy (8.4%, n=17), demonstrating that urban policies prioritize waste disposal over native species preservation, despite escalating extinction threats. This NMF decomposition exposes biodiversity's marginal position with unprecedented clarity, confirming the study's central paradox through deterministic factorization complementing LDA's probabilistic findings.

The 2010s peak and the 2020s conservation collapse: temporal analysis revealed a catastrophic conservation decline coinciding with the intensification of the biodiversity crisis. The 2010s represented a policy boom (n=105), where combined conservation topics (Ecosystem Conservation, Biodiversity Management, Climate Adaptation) reached 21 policies (20% of the decade total), with Biodiversity & Pest Management peaking at n=7 and Climate Adaptation at n=11 policies. However, the 2020s demonstrate selective retention: conservation topics collapsed 61.9% to n=8 (13.1% of 61 policies), with Ecosystem Conservation declining 66.7% (n=3→1), Biodiversity & Pest Management down 57.1% (n=7→3), and Climate Adaptation down 63.6% (n=11→4).

This conservation collapse starkly contrasts with sectoral priorities. Rural Development & Agriculture surged 200% from n=3 (2.9% in the 2010s) to n=9 (14.8% in the 2020s), while Integrated Infrastructure declined moderately by 47.8% from n=23 to n=12, maintaining 19.7% of the 2020s discourse. Capacity Building & Institutional Frameworks declined 86.7% from n=15 to n=2, suggesting governance capacity erosion precisely when coordination mechanisms become critical. This temporal trajectory reveals that as global biodiversity frameworks (Kunming-Montreal 2022) call for urgent action, policy discourse selectively abandons conservation while retaining and even amplifying agricultural and infrastructure priorities, directly contradicting ecological urgency with developmental persistence.

Regional conservation deficits and isolation: Geographic analysis reveals extreme conservation inequality. Africa, despite hosting biodiversity hotspots, demonstrates zero explicit conservation representation in Ecosystem Conservation, Biodiversity & Pest Management, and Climate Change Adaptation, collectively accounting for 0% of regional discourse. Instead, Africa prioritizes Capacity Building (n=8, 33.3% of 24 regional policies, triple the global 12.9% average) and Land Use Planning (n=6, 25%), revealing that institutional development supersedes ecological priorities in regions facing the greatest biodiversity loss.

Oceania exhibits conservation exceptionalism: Ecosystem Conservation (n=3, 12% of the region) and Biodiversity & Pest Management (n=6, 24%) combine for 36% regional concentration, 2.4fold higher than the global 15.3% average. However, this exceptionalism remains geographically isolated, with no other region exceeding 10% combined conservation, and Australia's dominance suggests a single-nation driver, rather than global mainstreaming. Europe emphasizes Integrated Infrastructure (n=11, 29.7%), Waste Management (n=8, 21.6%), and Rural Development (n=8, 21.6%), prioritizing sectoral implementation over conservation. In contrast, Asia and the Middle East focus on Infrastructure and Public Services (18.8% intensity). This regional fragmentation demonstrates that conservation discourse remains confined to wealthy Anglophone nations while biodiversity-rich developing regions pursue institutional and agricultural development, undermining coordinated international biodiversity governance.

4.5. *Semantic similarity and clustering*:

Hierarchical agglomerative clustering (Ward linkage) on TF-IDF vectors (**Supplementary File 5**) identified 98 distinct clusters with a highly fragmented policy landscape: only 25.7% of policies (n=52) formed replicable families (≥3 similar documents), while 18.3% (n=37) remained singletons, isolated, context-specific policies with low similarity to any others. This fragmentation reveals limited policy learning and template replication across the 202-policy corpus, with most urban environmental governance developed independently rather than through coordinated knowledge transfer.

Policy families: what gets replicated versus conservation isolation: Ten policy families (≥3 near-identical policies, cosine similarity >0.9) demonstrated an extreme sectoral bias (**Fig 3a**).

Waste management is dominated by Italy's eight near-identical regional urban waste plans (2010-19) and a 4-policy family spanning Argentina, the Dominican Republic, and the Maldives, collectively representing 5.9% of the corpus. Rural development forms the second-largest family: Bosnia-Herzegovina's eight nearly identical municipal agricultural strategies (2020-25, 0.85 similarity), illustrating subnational policy template replication within a single nation. Water and sanitation policies form West African families: Benin-Mali-Togo (n=4, 2000-09) and Burkina Faso-Djibouti-Togo environmental management frameworks (n=4, 2000-09) demonstrate regional South-South policy transfer.

Only one conservation family exists: Australia's six woodland and grassland conservation strategies (2010-19), representing 3% of the corpus and constituting the sole explicit biodiversity replication cluster globally. This conservation family is geographically isolated with zero cross-national conservation replication, whereas waste management achieves 2fold greater replication (12 policies across Italy and Latin America versus six Australian conservation plans). The remaining policy families address urban development (Cuba-Malawi-Cabo Verde, n=4), energy infrastructure (New Zealand-Ecuador-Gambia, n=4), and UAE aquaculture strategies (n=5), none of which have a conservation focus. This replication asymmetry quantifies the biodiversity paradox: infrastructural and waste policies diffuse internationally while conservation remains country-specific and unreplicated, undermining global biodiversity frameworks requiring coordinated action.

Conservation outliers: biodiversity policies that do not transfer: Outlier analysis (lowest 10% average similarity, isolation score <0.15) identified 21 policies structurally disconnected from the corpus, representing governance innovations or contextual specificities that are difficult to replicate (**Fig 3b**). Conservation topics dominate outliers: Vietnam's genetic resources and benefit-sharing capacity building (2016, similarity=0.079), Australia's Animal Welfare & Management Strategy (2017, similarity=0.092), and Australia's Urban Forest Strategy (2021, similarity=0.096) demonstrate that targeted biodiversity governance remains isolated rather than forming a global template for similar policies. Other outliers include Argentina's land titling program (similarity=0.081), Brazil's critical infrastructure security (similarity=0.088), Canada's drought response plan (similarity=0.091), and Portugal's waste strategy (similarity=0.07, most isolated policy).

This outlier composition reveals a structural paradox: while sectoral policies (waste, water, rural development) achieve high replication forming multi-national families, conservation innovations remain geographically siloed. Even Australia, producing the only conservation family, generates conservation outliers (animal welfare, urban forests) that fail to replicate domestically or internationally, suggesting that biodiversity governance requires context-specific approaches incompatible with policy template diffusion, or alternatively, that conservation lacks the institutional networks and policy transfer mechanisms available to infrastructure sectors.

Cross-national policy transfer and multilateral convergence: The highest cross-national similarity (0.641) involves multilateral fisheries agreements: the LVFO Regional Plan of

Action for Lake Victoria Fishing Capacity (2007) and ASEAN Regional Plan of Action for Fishing Capacity (2017), demonstrating that international environmental agreements drive policy convergence through treaty obligations (**Fig 3c**). African capacity-building strategies show exceptional similarity: Burkina Faso-Chad disaster risk reduction plans (0.574, both 2015) and Burkina Faso-Niger parallel frameworks (0.488, both 2015) illustrate synchronized regional policy adoption, likely reflecting donor coordination or regional organization mandates. Water/sanitation policies achieve cross-national similarities of 0.47-0.54 across Mali-Togo-Benin-Zambia-Nepal networks, confirming sector-specific policy diffusion mechanisms.

Notably absent are high-similarity cross-national conservation policy pairs. The top 20 most similar policy pairs include eight African water/capacity pairs, three energy infrastructure pairs, and zero explicit biodiversity/conservation pairs. This absence confirms that conservation governance lacks the multilateral coordination mechanisms and template diffusion pathways available to water, waste, and capacity-building sectors, structurally marginalizing biodiversity in international policy transfer networks despite Kunming-Montreal Framework calls for coordinated global action.

Regional convergence asymmetries: Within-region similarity analysis reveals counterintuitive patterns. Oceania demonstrates the highest regional convergence (0.216 average similarity, n=25), driven by Australian policy dominance, producing internally consistent conservation and housing frameworks. Africa exhibits comparable convergence (0.214, n=24) despite developmental heterogeneity, reflecting West African francophone water/sanitation policy families and East African capacity-building templates that circulate regionally. Conversely, the Americas show the lowest convergence (0.153, n=44) despite the largest regional corpus, indicating policy fragmentation across Latin American, Caribbean, and North American jurisdictions pursuing divergent developmental priorities without coordinated templates (**Fig 3d**).

Europe (0.169, n=37) and Asia and the Middle East (0.171, n=34) exhibit intermediate convergence, with Bosnia and Herzegovina's rural development replication and Italy's waste management families offset by linguistic and governance diversity, while Asia's convergence reflects UAE aquaculture clustering and China-Vietnam coordination. These regional disparities reveal that policy convergence correlates inversely with geographic scale and linguistic diversity: small, linguistically uniform regions (Oceania, West Africa) achieve higher template replication, while large, multilingual regions (Americas, Europe) maintain policy heterogeneity, with implications for coordinating international biodiversity responses requiring standardized frameworks.

Temporal clustering and the 2010s replication peak: Large clusters (≥3 members) overwhelmingly in 2010-19 (14 of 20 large clusters), with only two emerging in 2020-25 and 4 in 2000-09. This temporal concentration reflects the policy boom documented in previous sections (n=105 policies in the 2010s) but reveals a critical divergence: while the 2010s generated high policy volume enabling template formation, the 2020s demonstrate declining

replication capacity despite continued policy production (n=61). Bosnia-Herzegovina's rural development family (n=8, 2020-25) constitutes one of only two 2020s large clusters, suggesting that recent policy convergence focuses on agricultural/developmental sectors rather than conservation, echoing NMF findings of rural development's 200% surge while biodiversity collapsed 62%.

This clustering analysis substantiates the biodiversity paradox through replication asymmetry: only 3% of policies form conservation families, two times lower than waste management (5.9%), with conservation innovations remaining outliers (14.3% of outliers are conservation-related) rather than templates for global diffusion. Policy learning mechanisms favor infrastructure and sectoral services over ecological protection, creating structural barriers to coordinated international biodiversity governance precisely when Kunming-Montreal targets demand synchronized action.

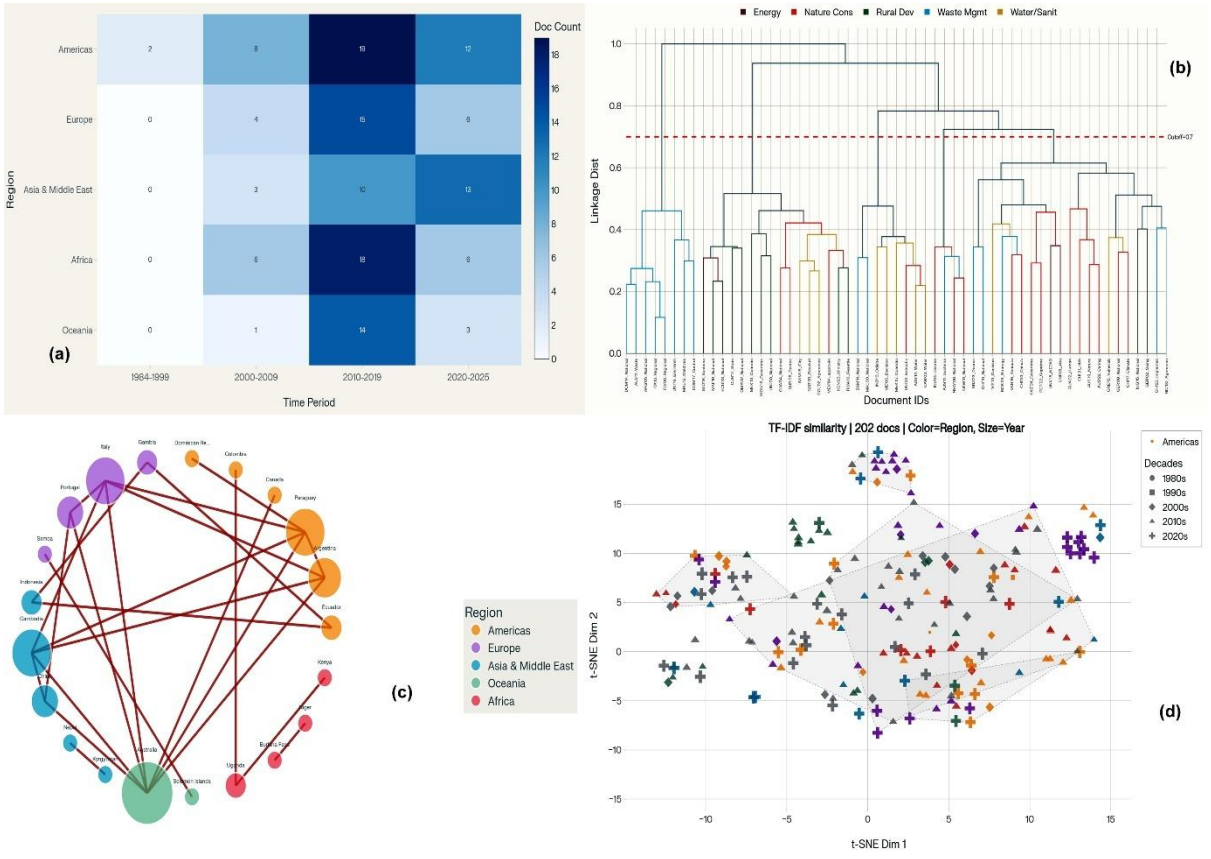

Figure 3. Semantic similarity and clustering analysis of global urban governance.
(a) Spatio-temporal evolution tracking policy families and outliers. Large clusters (≥3 members) concentrate in 2010–19, with only two in 2020–25, indicating declining replication. 2020s convergence focuses on agricultural-developmental sectors rather than conservation, substantiating biodiversity paradox through replication patterns.
(b) Hierarchical dendrogram (Ward linkage, 0.7 threshold) showing clusters with extreme fragmentation, only 25.7% form families (≥3 documents). Major families show sectoral bias. Only one conservation family globally, representing 3% of corpus with zero cross-national

biodiversity replication. Outliers dominated by conservation innovations: confirming biodiversity governance disconnection from global networks.
(c) Regional convergence network showing within-region similarity and cross-national pathways. Oceania highest, Americas lowest.
(d) 2D projection (t-SNE/PCA) color-coded by region, sized by recency. It shows scattered outliers. Within-country policies more similar than between-country, national template replication dominates over cross-national learning. Parameters: TF-IDF (500 features), cosine similarity, mean=0.155, range=0.0–0.851, Ward linkage.

5. Discussion:

This computational analysis of 202 urban environmental policies across 85 countries reveals a fundamental contradiction at the heart of global urban governance: as biodiversity crises intensify, conservation discourse in policy texts systematically declines. The biodiversity paradox documented here shows that ecological urgency and policy representation exist in an inverse relationship, with developmental priorities overwhelming targeted conservation actions across linguistic, thematic, and geographic dimensions (Perino et al., 2022). This "implementation gap" between environmental rhetoric and conservation reality has been documented across multiple governance contexts, from Vietnamese urban planning (Pulliat, 2019) to Australian Indigenous health policies (d'Abbs, 2015), yet remains unquantified at the global urban scale.

5.1. Theoretical Implications

These results counter the common assumptions underlying environmental policy mainstreaming (Redford et al., 2015). While overall discourses of sustainability have increased, this spread paradoxically coincides with the marginalization rather than the integration of conservation efforts (Reber et al., 2022). Sandström et al. (2023) found that mainstreaming in Europe and Central Asia must be pursued and implemented in a stronger and more systematic manner despite decades of policy development. Non-specific, generalized environmental framing diffuses imperatives of biodiversity across multiple sectors with no institutional focus given to them. What might be termed 'discursive dilution' means that increased environmental discourse is related to reduced conservation specificity. This contradicts the mainstreaming hypothesis, which posits that embedding ecological concerns within developmental frameworks enhances conservation outcomes.

Linguistic hegemony, expressed through colonial language dominance (66.8%) and the complete absence of Indigenous languages in African policies, hides structural obstacles to the inclusiveness of biodiversity governance. As multinational cooperation requires uniformity in English, while place-based conservation requires local ecological knowledge systems, the resulting linguistic homogenization systematically excludes precisely those communities that manage critical biodiversity landscapes (Wyborn et al., 2021). This is not just a matter of linguistic-ecological disconnection (Wilson et al., 2016), but also a question of whose

knowledge counts when defining urban nature and whose conservation priorities deserve policy attention (Holmes et al., 2022).

5.2. Governance Implications and Policy Recommendations

The catastrophic the 2020s conservation collapse, with explicit biodiversity topics declining by 61.9% while economic development surged by 200%, requires immediate governance reform. Four strategic interventions emerged from this analysis.

Mandatory biodiversity integration targets: Urban policies should include minimum conservation content thresholds similar to climate impact assessments (Marselle et al., 2021). Policies related to land use, infrastructure, and housing should include explicit quantification of biodiversity implications and mitigation measures beyond rhetorical sustainability commitments to actionable conservation.

Multilingual policy development: This calls for multilingual policy development; wherein institutionalized multilingual frameworks break the scalar gradient showing 100% English requirement for multinational coordination. Regional biodiversity agreements should call for the inclusion of Indigenous and local languages, especially in African and tropical Asian contexts, where linguistic diversity correlates with ecological diversity. Translation alone is insufficient; authentic multilingual co-development processes that value diverse knowledge systems are required.

Cross-national conservation template development: The asymmetry in replication rates-3% of policies forming a conservation family, whereas 5.9% do so for waste management-reveals an absence of policy transfer mechanisms for biodiversity. International organizations should build repositories of conservation templates based on the model of infrastructure best-practice databases and facilitate South-South knowledge exchange, thereby overcoming the geographic isolation that has confined conservation innovation to rich Anglophone nations.

Scalar governance coordination: The disconnection between national-level sustainability rhetoric and subnational developmental implementation requires bridging mechanisms (Milhorance et al., 2022). National biodiversity frameworks should offer operational specificity, not strategic abstraction, while subnational authorities need capacity building and financial wherewithal to implement integrated conservation approaches rather than fragmented, sectoral responses.

5.3. Limitations and Methodological Considerations

Several limitations temper these findings. The FAOLEX database is comprehensive but represents formal policy texts rather than implementation realities, and thus likely overestimates rhetorical commitments and underestimates ground-level action. English-language filtering, necessary for computational processing, reproduces the linguistic hegemony

we critique, possibly excluding non-Anglophone approaches to conservation that resist translation.

Acceptable, though low, topic modeling coherence scores (CV = 0.52) indicate thematic ambiguity, which reflects genuine policy complexity. The moderate LDA-NMF concordance ($\kappa = 0.62$) points to interpretive flexibility in thematic boundaries, although cross-method triangulation strengthens confidence in core findings. Temporal analysis remains constrained by the uneven policy distribution across decades, where assessments of the 2020s represent only 61 policies against 105 in the 2010s, possibly exaggerating recent trends.

Geographic representation is skewed toward Australia, which is the most frequent country across the seven domains, raising questions about whether the identified patterns reflect genuine global trends or Anglophone policy dominance in international databases. However, the zero-conservation representation for Africa may partially reflect database coverage gaps rather than linguistic barriers to inclusion, which substantiate rather than undermine our central argument.

5.4. Future Research Directions

Four research frontiers emerged from this analysis. *First*, full-text policy examination may reveal that there is indeed conservation content in regulatory specifications invisible to the abstract-level analysis, thus possibly challenging or refining the biodiversity paradox thesis. *Second*, implementation studies comparing policy rhetoric with actual conservation outcomes would determine whether discursive marginalization translates into material biodiversity loss or whether effective action proceeds despite linguistic absence (Jarvis et al., 2020). *Third*, non-English policy corpora, notably Spanish, French, and Portuguese urban policies issued in Latin America and Africa, may expose whether conservation discourse thrives in linguistic contexts excluded from Anglophone databases. Fourth, longitudinal tracking of individual cities across policy cycles would reveal whether political transitions, ecological events, or the adoption of international frameworks produce fluctuations in conservation representation.

A comparative analysis with other environmental sectors, climate adaptation plans, circular economy strategies, and nature-based solution frameworks could determine whether the marginalization of conservation represents urban-specific phenomena or reflects broader environmental governance patterns (Toomey et al., 2017). Qualitative discourse analysis examines how policies frame biodiversity as an ecosystem service, intrinsic value, development constraint, or social equity issue, and would complement quantitative content measures with normative interpretation.

6. Conclusion:

The biodiversity paradox documented herein highlights a governance system that is fundamentally misaligned with ecological realities. While urbanization is accelerating to 68% global population concentration by 2050, and with the Kunming-Montreal Framework that

demands that biodiversity loss be halted by 2030, urban environmental policies are increasingly couched in the language of sustainable development, climate resilience, and circular economy, while systematically silencing conservation imperatives. This is not simply a rhetorical omission; it reflects structural failure with existential implications: policies that address symptoms without causes, climate impacts without biodiversity foundations, and seek infrastructure efficiency while eroding ecological integrity. The evidence demands recognition that cities cannot achieve genuine sustainability through climate action alone when the biological systems underpinning urban resilience collapse are unacknowledged in policy discourse. The paradox can be broken by more than the mere addition of biodiversity language to existing frameworks; it requires a fundamental reorientation of the priorities of urban governance, decolonization of policy knowledge systems, and rebuilding of the institutional architectures that currently favor replicable infrastructure templates over context-specific conservation innovations. The question is no longer whether urban policies mention biodiversity, but whether governance systems can transform rapidly enough to prevent the representation crisis documented here from becoming an extinction crisis beyond rhetorical repair.

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