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Research Paper

Urban agriculture as an interface for policy–practice integration: a landscape-informed, multi-layer framework across Havana, New York city and Chongming Island

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HIGHLIGHTS

- A matrix is developed to assess policy–practice coupling in urban agriculture.
- Three urban agriculture paradigms are compared across ecological and social domains.
- A multi-layered landscape framework is proposed to guide urban agriculutre implementation.
- Urban agriculture is a mediator in human–nature urban systems.

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ABSTRACT

Urban agriculture is increasingly recognized as a multifunctional lever for urban sustainability, yet the mechanisms through which planning policies enable or constrain its integration into city systems remain poorly understood. This gap limits the development of evidence-based frameworks that can bridge policy intent and implementation practice. This study develops a transparent, multilingual content-analysis pipeline and a landscape-informed coupling framework to evaluate urban agriculture policy–practice alignment across three contrasting governance contexts: Havana (Cuba), New York City (USA), and Chongming Island (China). Using a PRISMA-ScR literature synthesis (n = 3145), we construct a five-domain, 40-keyword evaluation matrix and apply it to official policy corpora and flagship project documentation. Results show that human-centered approaches effectively translate social equity and food-provisioning aims but exhibit limited spatial integration; nature-based approaches advance ecological and morphological targets but underperform on participation; and the landscape-informed model achieves more balanced alignment across all five domains, though gaps persist in inter-layer connectivity. Situating these findings within the broader discourse on urban sustainability governance, we propose a multi-layered landscape framework spanning ecological, institutional, social, and spatial dimensions. This framework offers planners a structured diagnostic and prescriptive tool for embedding urban agriculture into integrated urban transitions.

1. Introduction

Urbanization continues to accelerate globally, often in unregulated and unsustainable forms (Roggema, 2020). Both unregulated and regulated forms of urban expansion place unprecedented pressure on natural systems, with urban demand consistently outstripping the Earth's regenerative capacity (Girardet, 2020). On the social front, rapid urban growth intensifies challenges related to poverty, inequality, and public health (McMichael, 2000). The drive for economic development frequently results in overexploitation of environmental resources, leading to ecosystem degradation, biodiversity loss, and amplified climate change impacts (Wu, 2013; Pedroza-Arceo et al., 2022). Consequently, cities face a confluence of critical issues like resource scarcity, food insecurity, urban flooding and heat island effects that stem from a persistent disconnection between human development trajectories and the ecological systems that sustain them. It is within this context that the landscape-informed mechanism emerges as a foundational framework for rethinking the relationship between urban

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development and natural systems (Wu, 2013; Arts et al., 2017).

In response to these mounting sustainability threats, planning paradigms have increasingly shifted toward the “re-naturing” of cities (Lennon & Scott, 2016). Integrating natural systems into urban contexts, however, demands more than superficial greening interventions. It requires a paradigmatic reorientation capable of addressing the complexity and unpredictability of socio-ecological dynamics (Duvall et al., 2018). While originally rooted in rural and regional planning, the approach is increasingly adopted in policy frameworks as a tool to mitigate climate change, promote biodiversity, and enhance livelihood resilience (DeFries & Rosenzweig, 2010; Reed et al., 2021). In this regard, agriculture holds a pivotal position: not only for its role in food provisioning, but also as a critical interface for ecological stewardship, social interaction, and community cohesion within urban landscapes.

Against this backdrop, urban agriculture which is defined as the cultivation of food and related activities in urban and *peri*-urban environments has gained recognition as a multifaceted strategy for sustainable and resilient cities (Lovell, 2010; Morgan, 2015). A growing body of literature documents a wide spectrum of co-benefits from urban agriculture, including improved food security, public health, climate regulation, and community cohesion, alongside the provisioning of green space and localized ecosystem services (de Zeeuw & Drechsel, 2015; Colding & Barthel, 2013). Indeed, urban agriculture is increasingly seen as an exemplar of nature-based solutions that address multiple urban challenges simultaneously (Artmann & Sartison, 2018). In many cities, urban agriculture functions as a living laboratory for sustainability innovation, embodying principles of circular economies, localized production, and participatory governance (Mougeot, 2006; Marini et al., 2023). However, the spatial forms and governance arrangements of urban agriculture vary widely across contexts, shaped by divergent interpretations of the human–nature relationship. The integration of urban and *peri*-urban agriculture into formal planning systems remains uneven, with significant barriers related to land-use classification, zoning, and the absence of dedicated policy frameworks (Cassatella & Gottero, 2025). Human-centered planning approaches foreground urban agriculture's role in alleviating food insecurity, creating jobs, and revitalizing neighborhoods, yet often neglect long-term ecological integrity or integration with the broader landscape (Panagoulia, 2019; Roggema, 2021; Liu et al., 2023). In contrast, nature-based paradigms embed urban agriculture within broader green infrastructure and climate adaptation agendas, emphasizing functions such as biodiversity conservation, flood mitigation, and carbon sequestration (Davis, 2021; Debele et al., 2023). While these ecology-forward approaches offer a more integrative vision of urban metabolism, they can overlook issues of social equity and community agency, sometimes resulting in governance approaches emphasizing technical implementation or exclusionary outcomes (Dorst et al., 2019). In practice, many urban agriculture initiatives remain piecemeal and disconnected from broader landscape planning, often emphasizing either social inclusion or ecological enhancement but rarely both.

These models differ in four key respects. In terms of primary objective, human-centered approaches prioritize immediate food security and social equity; nature-based approaches foreground ecological restoration and biodiversity; landscape-informed approaches integrate both through multifunctional land use (Huan et al., 2024; Artmann & Sartison, 2018). Regarding spatial scale, human-centered models typically operate at the neighborhood or plot scale; nature-based models at the habitat-corridor or city scale; landscape-informed models span all scales simultaneously (Wu, 2013). In terms of governance mode, human-centered models are often state-led or community-driven; nature-based models rely on top-down planning and technical expertise; landscape-informed models emphasize cross-sectoral and participatory governance (Arts et al., 2017). Finally, regarding temporal horizon, human-centered approaches address short-to-medium term provisioning needs; nature-based approaches target long-term ecological outcomes; landscape-informed approaches balance both through adaptive management (Ahern, 2013).This prevailing dichotomy suggests a gap in current urban agriculture conceptualizations: both human- and nature-oriented approaches tend to prioritize either social or ecological functions in isolation, rather than addressing their interdependence across spatial and temporal scales.

The landscape-informed mechanism offers a comprehensive framework capable of integrating ecological and social objectives within urban systems. By conceptualizing the city as a coupled human–natural system, it provides a dynamic way to reinterpret human–nature relationships in spatially and functionally complex urban environments. Increasingly, scholars and practitioners recognize that siloed, single-sector strategies are inadequate for addressing the multifaceted challenges of contemporary urbanization; instead, integrated, cross-sectoral approaches are essential for transformative sustainability outcomes (Arts et al., 2017; Wu, 2013). When applied to urban agriculture, a landscape-informed mechanism holds the potential to simultaneously address land-use optimization, ecosystem service provision, and socio-economic equity. However, the operationalization of this approach in urban agriculture remains nascent and underdeveloped, and existing research has paid limited attention to how urban policy frameworks enable or constrain urban agriculture as a landscape-oriented practice. Recent studies underscore this gap: for instance, urban agriculture’s practical value as a tool for spatial development and its potential as a landscape-based approach have been insufficiently discussed, and a clear framework to guide such integration is lacking (Huan et al., 2024). At the policy level, there are few examples of direct integration of urban agriculture into policies on the food–energy–water nexus (Fox-Kämper et al., 2023). Moreover, urban planning to date has only cautiously integrated urban agriculture, with evidence that current planning systems often do not fully capitalize on urban agriculture’s contributions to sustainability (Langemeyer et al., 2021). This gap presents both a theoretical and practical challenge (Fig. 1). While urban agriculture could serve as a strategic node linking environmental and social systems, its success likely depends on supportive institutional conditions, spatial integration, and governance arrangements that reflect landscape principles. Therefore, a critical examination is needed of how urban policies frame and implement urban agriculture through (or against) a landscape perspective, and how we might develop new frameworks to better integrate urban agriculture into sustainable urban planning. This study addresses this gap by combining a reproducible, multilingual content-analysis pipeline with a landscape-informed coupling framework, advancing both methodological rigor and conceptual integration in the field.

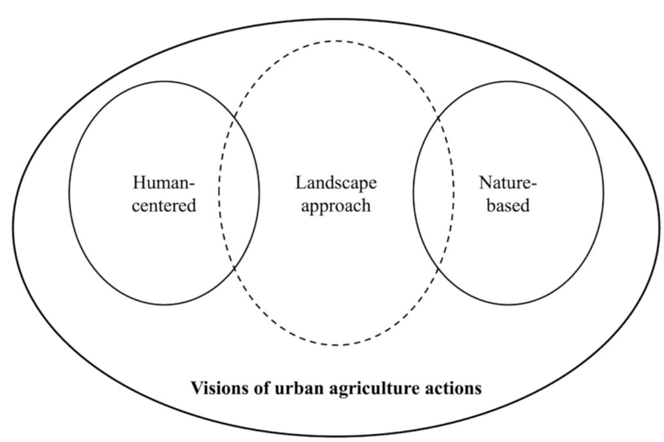

Fig. 1. Thematic framework of human–nature paradigms in urban agriculture. 'Human–nature paradigms' refer to the conceptual spectrum describing the relative weighting of anthropocentric versus ecocentric values in urban agriculture planning approaches, ranging from human-centered (prioritizing social and economic functions) to nature-based (prioritizing ecological functions), with landscape-informed approaches occupying the integrative middle ground.

This study investigates how urban agriculture mediates human–nature relations through policy design and on-the-ground implementation across distinct governance contexts. We pursue two objectives: (i) to develop an auditable, multilingual content-analysis pipeline that characterizes the thematic orientation of urban agriculture policies; and (ii) to test an operable, landscape-informed coupling framework that aligns policy intent with implementation features at project level. Accordingly, we ask: (1) What thematic emphases do urban agriculture policies adopt in international cases when analyzed as parallel corpora? (2) To what extent do flagship projects translate these emphases into practice, and where do misalignments occur? To explore these questions, we compare three urban agriculture paradigms using case studies of Havana (Cuba), New York City (USA), and Chongming Island (China). Each case exemplifies a different model of urban agriculture, respectively a human-centered paradigm, a landscape-oriented approach, and a nature-centered approach. These three cities are deliberately selected to represent each of the three planning models outlined above, enabling structured, typology-anchored comparative analysis across contrasting governance systems, spatial scales, and human–nature orientations. We review official planning documents and flagship urban agriculture projects in each city using a multi-dimensional evaluation matrix, which is a structured analytical tool mapping policy and project features across five thematic domains using a keyword-affinity scoring system to cover ecological functionality, social inclusion, governance, spatial integration, and temporal resilience. We position the landscape-informed mechanism not as the only integrative paradigm, but as a practical, multi-layer mechanism to organize policy–practice integration. Ultimately, this research advances the discourse on urban agriculture by demonstrating its potential as a transdisciplinary platform that reconnects fragmented planning domains and fosters more integrated human–nature systems in urban contexts.

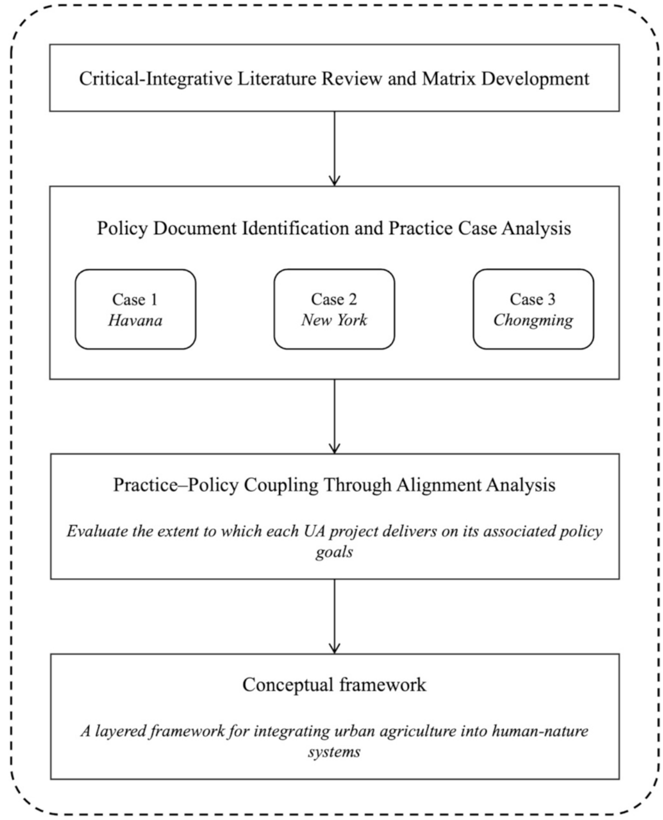

Fig. 2. Workflow of the research methodology.

2. Methods

This study employs a qualitative comparative case study methodology (Yin, 2018), integrating theory-building, policy analysis, and cross-case evaluation. The research design unfolds in four stages (Fig. 2).

2.1. Thematic framework and evaluation matrix construction

To understand how urban agriculture reflects diverse human–nature paradigms, we establish a thematic evaluation framework grounded in landscape planning and sustainability science, beginning with a critical and integrative review of literature spanning urban ecology, planning theory, and sustainability transitions (Ahern, 2013; McPhearson et al., 2016). Using a Boolean search in Scopus (TITLE-ABS-KEY (“urban agriculture” OR “urban farming” OR “*urban food systems”) AND (“policy” OR “planning” OR “governance” OR “policy analysis”) AND (“evaluation” OR “assessment” OR “framework” OR “indicators”) AND PUBYEAR > 2000 AND PUBYEAR < 2024*), we identify a broad corpus of 3145 publications relevant to urban agriculture as a spatial governance tool. Following PRISMA scoping review guidelines (Tricco et al., 2018), we screen titles and abstracts to focus on works explicitly linking urban agriculture to planning or policy and human–nature relationships. This process identifies five consistent thematic dimensions structuring urban agriculture discourse: Ecological Functionality, Social Inclusion, Governance and Participation, Spatial Integration, and Temporal Resilience. These domains recur throughout urban agriculture discourse and align with broader landscape sustainability principles (Wu, 2013; Ahern, 2013). From this literature review, we distill 40 high-frequency keywords (8 per domain) as indicators for the five thematic dimensions.

While the conceptual definition of urban agriculture adopted in this study encompasses *peri*-urban forms, the three flagship projects selected for empirical analysis are all intra-urban, as they were chosen to represent institutionally embedded policy–practice interfaces within defined municipal boundaries. The dynamics of *peri*-urban agriculture represent a valuable avenue for future comparative investigation.

These indicators form an 8 × 5 evaluation matrix, providing a structured lens to assess policy content across the ecological, social, governance, spatial, and temporal aspects of urban agriculture. These dimensions reflect widely adopted urban sustainability criteria and mirror frameworks such as the UN-Habitat City Prosperity Index and the FAO’s urban agroecology principles (FAO, 2021). The matrix serves a dual purpose: (1) identifying the thematic orientation of policy documents, and (2) guiding the construction of expected implementation features in urban agriculture projects. By building a shared analytical language between planning discourse and practice, the matrix enables comparative, domain-specific evaluations across contexts. Table 1 presents the complete keyword matrix, listing the eight indicator terms assigned to each of the five thematic domains.

For terminological consistency throughout this paper: 'planning approach' refers to a strategic methodology; 'model' refers to a specific planning typology (human-centered, landscape-informed, or nature-based); 'paradigm' is reserved for the overarching human–nature

Table 1
Thematic domains and corresponding evaluation keywords used in the urban agriculture policy matrix.

Thematic domain	Evaluation matrix keywords
Ecological Functionality	1. biodiversity; 2. ecosystem; 3. green; 4. pollution; 5. water; 6. air; 7. soil; 8. carbon
Social Inclusion	1. community; 2. equity; 3. inclusion; 4. participation; 5. access; 6. poverty; 7. food security; 8. health
Governance and Participation	1. policy; 2. governance; 3. institution; 4. regulation; 5. planning; 6. stakeholder; 7. management; 8. framework
Spatial Integration	1. land use; 2. zoning; 3. infrastructure; 4. spatial; 5. integration; 6. corridor; 7. network; 8. urban form
Temporal Resilience	1. resilience; 2. adaptation; 3. sustainability; 4. long-term; 5. continuity; 6. climate; 7. durability; 8. future

conceptual spectrum; and 'landscape-informed mechanism' denotes the integrative framework bridging ecological and social objectives.

2.2. Case selection and policy corpus

We adopt a comparative case study design (Yin, 2018), selecting three cities with distinct urban agriculture paradigms in different socio-political settings. Havana, New York City (NYC), and Chongming Island (Shanghai) each have well-documented urban agriculture initiatives and supportive policies, yet they differ markedly in governance systems and human–nature orientations.

Havana (Cuba) exemplifies a model of urban agriculture rooted in state-led food sovereignty. Since the 1990 s Special Period, Havana has developed extensive urban farms and organopónicos with strong government backing to ensure food security and public welfare. Urban agriculture in Havana is deeply integrated with social policy (e.g., rationing and community nutrition programs) and reflects a welfare-state logic. New York City (USA) represents a model where urban agriculture is embedded within a multifaceted urban infrastructure and policy network. NYC's urban agriculture initiatives are linked to goals of resilience, public health, and social justice. The city's governance context is decentralized and participatory, involving NGOs, community groups, and multiple city agencies. This aligns with a landscape perspective that mediates between environmental and social objectives. Chongming Island (Shanghai, China) represents a model that treats ecological benefits as paramount. Chongming has been officially designated an "Eco-Island," and its development plans emphasize ecological conservation, wetland restoration, and low-carbon living. Urban agriculture on Chongming is intertwined with eco-tourism and conservation zones, featuring projects like organic farms and wetland agriculture. The approach prioritizes ecological function and "re-greening," often under top-down planning directives consistent with China's ecological modernization efforts.

To assess institutional framing, we analyze one core policy document per city where urban agriculture is addressed in strategic planning: Havana's *Plan de Soberanía Alimentaria y Educación Nutricional* (2020), NYC's *Cultivating Urban Agriculture* (2023), and Chongming's *Eco-Island Development Plan* (2004). Each text is coded using the 40-keyword matrix across the five domains. We compute keyword frequencies to gauge thematic emphasis and perform qualitative content analysis to interpret framing and narrative tone. We also apply elements of critical discourse analysis (Fairclough, 2013) to assess how key terms like "resilience" or "sustainability" are used. This mixed-method approach captures both the salience (quantitative presence) and the contextual meaning (qualitative framing) of urban agriculture-related themes within each policy context.

While selecting one flagship project per city enables in-depth, policy-proximate case analysis (Flyvbjerg, 2006), it necessarily limits the representativeness of findings within each city. The selected projects were the most information-rich and institutionally embedded examples available; however, they may not capture the full diversity of urban agriculture practices in each context. This constraint is discussed further in Section 4.4.

2.3. Project universe, selection criteria, and validation

For each city, we assembled a project universe from official inventories, planning documents, and peer-reviewed studies (see Table S1). We then applied a priori criteria to identify a single flagship project per city: (i) policy linkage (explicit connection to a current or recent city-level policy or strategic plan); (ii) minimum operational years ($\geq$5) to ensure continuity and observable outcomes; (iii) scale (area or multi-site coverage) reflective of city-wide relevance; (iv) data availability (documentation sufficient for cross-case comparability); and (v) public documentation allowing independent verification. To mitigate bias, we triangulated multiple sources and documented decisions in a reproducible log (Doc S1), and we report a brief risk-of-bias assessment for each city.

2.4. Concerns-intensity quantification

To examine the thematic focus of each city's urban agriculture policy, we conduct a structured content analysis integrating computational keyword frequency mapping and interpretive contextual analysis. This hybrid approach aligns with established qualitative content methodologies and critical discourse analysis principles (Mayring, 2019). We analyze the policy documents as a parallel corpus. The Chongming and New York documents are in English, while the Havana document is in Spanish and required translation into English. Therefore, the Havana document (Spanish) is first machine-translated, then reviewed and corrected by a bilingual researcher with urban planning expertise. A random sample of 20% of coded passages is back translated into Spanish and independently verified for semantic equivalence. Chongming documents follows the same protocol with a different bilingual reviewer. Any translation ambiguities affecting keyword-coding decisions are flagged and resolved by consensus among the full research team. This protocol follows established multilingual content analysis practices (Krippendorff, 2018).

To aid methodological transparency, the keyword affinity matrix construction follows four sequential stages: (1) Corpus preparation—policy PDFs are processed using PyMuPDF to extract clean text; (2) Dictionary development—40 keywords are organized into five thematic domains based on the PRISMA-ScR synthesis; (3) Keyword scoring—exact-match frequencies are computed and normalized per domain; (4) Affinity weighting and coupling—each keyword is assigned cross-domain affinity weights summing to 1.0, enabling distributed intensity calculation via the geometric mean formula (Section 2.4). As a brief worked example: the phrase 'community garden access points integrated into the city's green corridor network' would be coded as follows—'community' and 'access' activate Social Inclusion (K1, K5); 'green corridor' and 'network' activate Spatial Integration (K6, K7); the composite entry is distributed across both domains with an affinity weighting of 0.6/0.4 respectively.

Using PyMuPDF for text extraction and regular expressions for pattern matching, we parse English-language PDFs of the selected policies and count exact matches for each keyword across all documents. To ensure interpretability beyond raw frequency, we triangulate these counts with qualitative reading of keyword context. Keywords are not only counted but interpreted in their narrative setting. This practice draws from Fairclough's (2003) discourse analytic model, emphasizing the institutional meanings and performative roles of policy language. The results are compiled into a DataFrame (via pandas) and visualized as a heatmap using Seaborn, enabling comparative visualization of thematic emphases across the three city policies. These matrices serve as a data-informed lens for identifying which policy domains are emphasized or neglected, forming a structured basis for subsequent practice alignment analysis. This mixed-method strategy balances computational objectivity and discursive sensitivity, offering a robust mechanism for tracing how cities conceptualize urban agriculture within their broader human–nature paradigms.

We quantify how practice cases express policy priorities by constructing a matrix for each city. Rows correspond to the eight keywords K1–K8 defined in Table 1. For each city and keyword, we combine policy salience from the policy corpus with practice alignment from project-level coding (scores of 0, 1, 2) using a geometric mean:

$$I_{city,kw} = \sqrt{P_{city,kw} \times R_{city,kw}},$$

where P is the policy percentage and $R = 100 \times \frac{\overline{alignment}}{2}$ is the practice alignment score normalized to 100. We then distribute intensity across themes using keyword–theme affinity vectors whose weights sum to 1 per keyword, producing a complete 8×5 grid with no empty cells. For visualization only, intensities are multiplied by a constant factor to enhance legibility while preserving relative magnitudes. Numerical values therefore remain rank- and ratio-consistent with the underlying measurements.

2.5. Practice–policy coupling through alignment analysis

To evaluate the extent to which each urban agriculture project delivers on its associated policy goals, we use a goal–outcome alignment method. This approach treats policies as structured sets of expectations, and projects as their empirical expressions (Nilsson et al., 2012). From the coded policy documents, we extract domain-specific goals or priority actions (e.g., community participation, biodiversity support), which we reframe as implementation benchmarks.

For each urban agriculture project, we systematically map observable features against policy-derived benchmarks. Two researchers independently code spatial, social, and governance features from project reports, site documentation, and grey literature. Coded outputs are subsequently cross-checked. Disagreements are resolved through iterative consensus discussion until 100% agreement is reached on each domain classification. “Fully Aligned,” “Partially Aligned,” or “Not Aligned” are used to code the correspondence per domain. This reduces subjectivity by referencing only documented policy intents and verifiable project characteristics. The result is a coupling matrix highlighting convergence and divergence between policy intention and practice realization. This alignment framework enables structured comparison across cities and avoids the pitfalls of subjective scoring. It also surfaces implementation gaps (e.g., strong ecological planning but weak social inclusion) and reveals where urban agriculture practice may exceed, lag, or reinterpret policy guidance.

2.6. Comparative synthesis and interpretation

After coding both the policy documents and practice implementations, we develop a comparative synthesis to evaluate cross-case patterns and policy–practice coherence. Using the domain-level alignment ratings from Section 2.4, we construct a policy–practice coupling matrix for each city. This matrix facilitates systematic comparison of domain-wise convergence (“both High”), partial translation (“policy High, practice Low”), or innovation (“practice exceeds policy”).

We then categorize these patterns across cases to identify thematic strengths, implementation gaps, and policy inertia. For example, a consistent misalignment in “Governance and Participation” across cities could indicate a structural difficulty in translating participatory ideals into operational models. Conversely, full alignment in “Spatial Integration” may suggest institutional capacity or planning tradition in that domain. This synthesis process follows established methods in planning evaluation and sustainability governance (Alexander & Faludi, 1989; Healey, 2006; Newig et al., 2019), emphasizing multi-layered coherence across policy–practice systems. It also sets the stage for proposing layer-specific interventions in later discussion.

3. Results

3.1. Development of a thematic evaluation matrix

The evaluation matrix constructed in Section 2.1 is applied here to the three case study cities. As noted, five thematic domains structure the matrix: Ecological Functionality, Social Inclusion, Governance and Participation, Spatial Integration, and Temporal Resilience. Each domain is represented by eight high-frequency indicator terms, yielding a total of 40 keywords systematically organized into an 8 × 5 evaluation matrix (Table 1, see Section 2.1). TF–IDF rankings and topic proportions indicate a higher salience of ecological terminology compared with spatial-form terms ($\chi\hat{A}^{2}$ test, $p < 0.05$). The matrix captures the multi-dimensional nature of urban agriculture, integrating ecological, social, institutional, spatial, and temporal lenses into a single analytical framework.

Keyword selection followed an iterative expert review process grounded in established urban agriculture indicator frameworks (Barthel et al., 2019; Doan et al., 2022). Keywords with potential cross-domain ambiguity were assigned to the domain with the strongest theoretical grounding. 15 borderline cases are documented in Supplementary Note S2, including the consensus rationale for each assignment. We acknowledge that keyword categorization involves inherent interpretive risk, which constitutes one limitation of the content-analysis approach.

Using this matrix, we first examine the overall orientation of the literature itself. We calculate the total frequency of keyword appearances in the corpus for each of the five categories. Fig. 3 shows that ecological themes dominate the literature, followed by social inclusion and governance themes, whereas spatial integration and long-term resilience receive comparatively less attention. This suggests that urban agriculture scholarship has focused strongly on environmental and community benefits, with relatively less focus on spatial planning and future resilience considerations. To provide another perspective on the lexical landscape of the field, we generate a word cloud from all 40 keywords. Fig. 4 illustrates that terms like biodiversity, ecosystem, green, and pollution occupy prominent positions, visually reinforcing the centrality of ecological themes in urban agriculture scholarship. Social and governance terms (such as community or participation) also appear, though in smaller font, whereas words related to spatial design (infrastructure, zoning) or temporal aspects (long-term, climate) are relatively subdued. This suggests that the academic discourse has heavily spotlighted certain dimensions (especially ecology), potentially mirroring funding and research trends in sustainable cities, while leaving some integrative topics less explored. In the subsections that follow, we apply this matrix to the three case study cities to evaluate how their urban agriculture policies align with or diverge from these thematic domains.

3.2. Urban agriculture policy quantitative content evaluation

We apply the 40-keyword evaluation matrix to quantify the content orientation of urban agriculture policies in Havana, New York City, and Chongming Island. By calculating keyword frequencies across five thematic domains and qualitatively reading the policy documents, we identify each city’s thematic priorities and how urban agriculture is operationalized in practice. Fig. 5 shows the percentage distribution of keyword frequencies for each city’s policy, reflecting the relative emphasis on five domains: Ecological Functionality, Social Inclusion, Governance and Participation, Spatial Integration, and Temporal Resilience. Although derived from word counts, these proportions serve as indicative proxies of focus, revealing distinct policy orientations across the three cities.

Chongming Island’s policy exhibits a strong emphasis on Ecological Functionality and Spatial Integration. Keywords like “biodiversity,” “green,” and “land use” dominate, indicating that urban agriculture is conceived primarily as an ecological intervention embedded in broader green infrastructure and eco-tourism plans. Frequent spatial references reinforce a deliberate effort to integrate urban agriculture into planned environmental corridors and development zones. By contrast, governance- and society-related terms are minimal, consistent with Chongming’s top-down, nature-centric planning paradigm where citizen participation is secondary to ecological branding and restoration. This focus on environmental performance implies robust provision of certain ecosystem services (e.g. habitat creation, climate regulation) but a neglect of social benefits, reflecting a potential inequity in how different communities experience these interventions.

Havana’s policy, by comparison, shows a more balanced distribution across Ecological Functionality, Social Inclusion, and Governance and Participation. Prominent references to “pollution,” “access,”

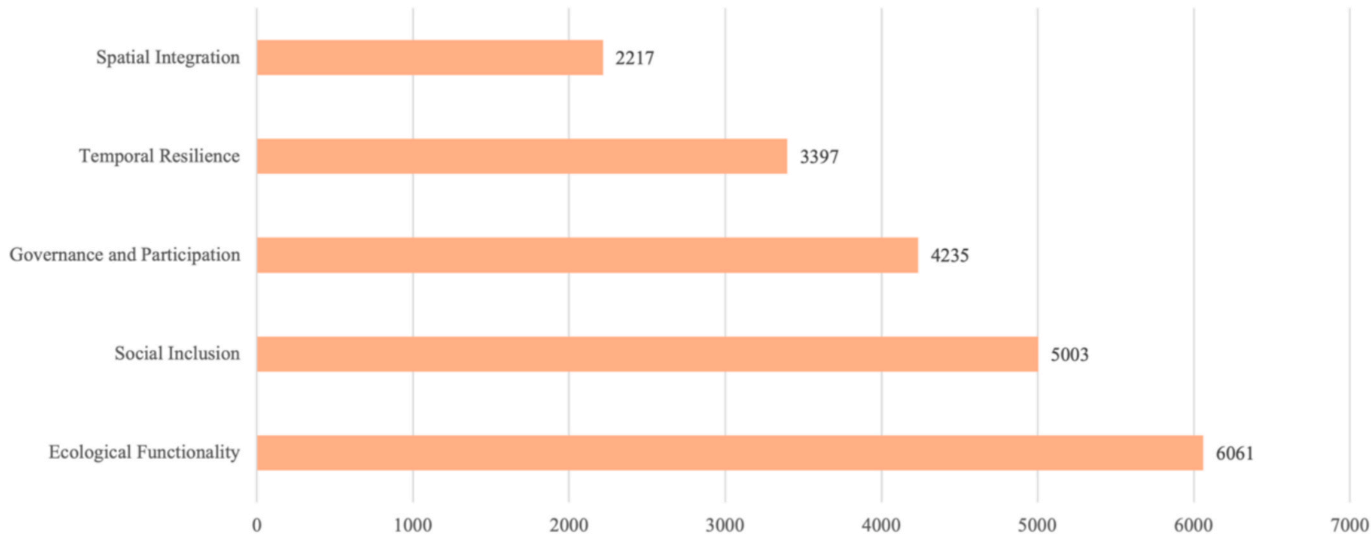

Fig. 3. Frequency distribution of 40 evaluation matrix keywords across five thematic domains in the urban agriculture literature corpus (n = 3145 publications). Domain keywords: Ecological Functionality (biodiversity, ecosystem, green, pollution, water, air, soil, carbon); Social Inclusion (community, equity, inclusion, participation, access, poverty, food security, health); Governance and Participation (policy, governance, institution, regulation, planning, stakeholder, management, framework); Spatial Integration (land use, zoning, infrastructure, spatial, integration, corridor, network, urban form); Temporal Resilience (resilience, adaptation, sustainability, long-term, continuity, climate, durability, future). Ecological themes dominate, with Temporal Resilience and Spatial Integration comparatively under-represented. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

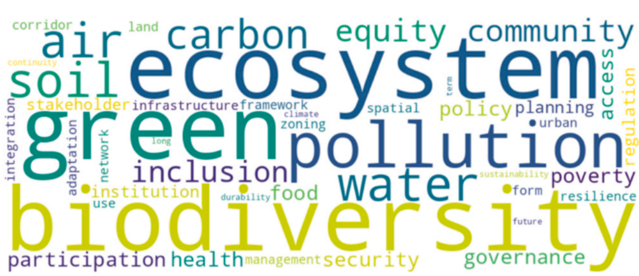

Fig. 4. Word cloud of the 40 evaluation matrix keywords, illustrating their relative frequency in urban agriculture literature. Larger words indicate higher frequency. Notably, ecological terms (e.g. "biodiversity," "ecosystem," "green") are most prominent, highlighting the strong environmental focus in urban agriculture discourse, while terms related to spatial planning and long-term resilience appear smaller. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

"participation," and "planning" reflect a model in which urban agriculture supports food sovereignty, social welfare, and coordinated state management. While Spatial Integration and Temporal Resilience are less dominant, the presence of terms like "urban planning" and "long-term" indicates an awareness of urban agriculture's spatial role and future orientation. This pattern aligns with Havana's human-centered approach: under strong state guidance, urban agriculture is leveraged to advance social equity and public health. The moderate presence of ecological and spatial terms suggests a focus on immediate human needs, which may limit the city-wide ecological reach of urban agriculture and lead to some spatial gaps in the provision of green services.

New York City's policy reveals a highly balanced pattern, especially across Social Inclusion, Governance and Participation, and Temporal Resilience. Keywords such as "community," "equity," "resilience," and "infrastructure" underscore that urban agriculture is embedded in climate adaptation, food justice, and participatory governance agendas. Ecological and spatial themes are present but not central, indicating that NYC views urban agriculture as part of a multifunctional urban system rather than an isolated green intervention. This reflects a landscape-oriented strategy in which urban agriculture serves as a nexus linking environmental, social, and infrastructural priorities. Such an integrative positioning suggests that both ecological and social benefits are more broadly distributed, making urban agriculture a bridge to mitigate the trade-offs inherent in more single-focused models.

Overall, our comparative analysis highlights the malleability of urban agriculture as a policy tool, with its implementation shaped by each city's institutional context and strategic goals. From Chongming's eco-branded landscape model to Havana's state-led provisioning and NYC's pluralistic governance model, urban agriculture manifests in diverse configurations of space, power, and purpose. Importantly, these differences also expose where certain ecosystem services or groups receive insufficient attention, revealing imbalances in urban ecosystem service provision. Identifying such gaps provides a spatial strategy basis for targeted green interventions. For example, research suggests that dispersing urban agriculture projects, rather than clustering them, can distribute ecosystem service benefits more equitably to reach more residents (Newell et al., 2022). By uncovering each paradigm's strengths and omissions, this evaluation directly deepens our understanding of how urban agriculture mediates human–nature relationships in different contexts and guides planners on which areas to reinforce, thereby offering practical direction for devising strategies that achieve more balanced social–ecological outcomes.

3.3. Project universe and selection outcomes

We assembled a project universe for Havana, New York City, and Chongming using municipal inventories, policy documents, program/NGO portals, and peer-reviewed literature (Table S1). Applying five a priori criteria: (i) explicit policy linkage, (ii) operational longevity (≥5 years), (iii) scale (area or multi-site coverage), (iv) public documentation, and (v) data availability, we reduced the universe to an eligible subset, from which one flagship per city is selected.

In Havana, the flagship Organopónico Vivero Alamar (OVA) meets all criteria. It is directly connected to the national Urban, Suburban & Family Agriculture program, has operated well beyond the longevity threshold, and achieves multi-hectare scale with traceable outputs and governance documentation. Multiple independent sources and program materials converge on its scale and cooperative model, supporting its use as a city-relevant exemplar (evidence dossier in Doc S1). For New York City, Brooklyn Grange satisfies prominence through its multi-site

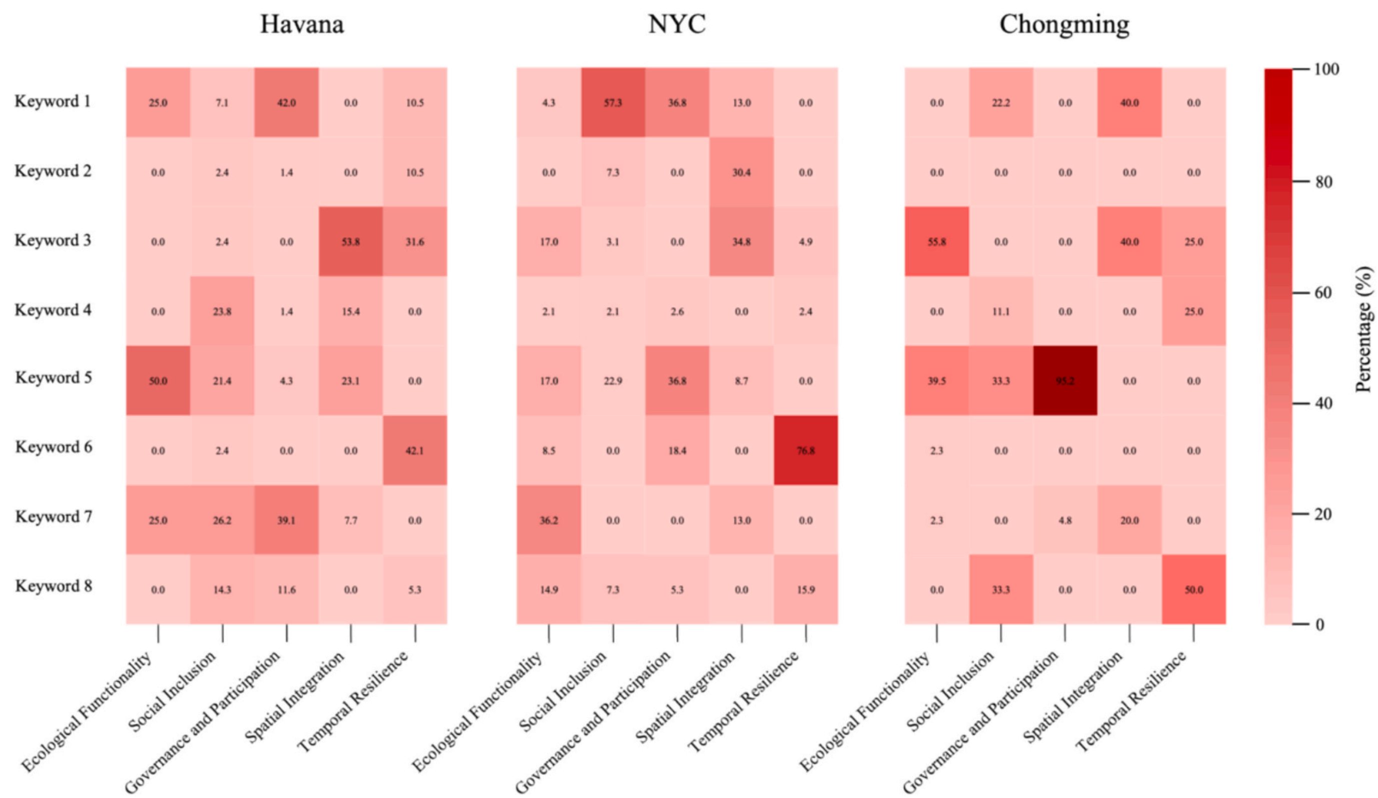

Fig. 5. Thematic composition of urban agriculture policy documents: keyword percentage heatmap across five domains for Havana, New York City, and Chongming Island (keywords K1–K8 per domain as defined in Table 1). Key patterns: Chongming exhibits the highest concentration in Ecological Functionality and Spatial Integration; Havana shows a more even spread across Ecological, Social, and Governance domains; NYC displays the most balanced distribution across all five domains, with notable strength in Social Inclusion, Governance, and Temporal Resilience. Cells with the three highest values per city are annotated in the revised figure.

operation (three rooftop farms) and clear connections to municipal sustainability and green-infrastructure agendas. The project is extensively documented by the operator, city agencies, and independent evaluations, with triangulable figures for area, programming, and ecosystem-service contributions (Doc S1). In Chongming, Chongming Modern Agricultural Park aligns with the eco-island strategy and demonstrates ecological and spatial outcomes at a scale suitable for cross-case comparison. Public planning texts and program reports provide independent verification of policy integration and operational scope (Doc S1).

3.4. Practice case concerns intensity analysis

Fig. 6 shows the results of the intensity of attention in the practical case. Havana exhibits a pattern dominated by ecological and social concerns, with consistently high intensities for food, biodiversity, and water and strong signals for equity. Participation is present but more modest, and morphology-oriented keywords register lower values, indicating comparatively weaker attention to city-wide spatial form and connectivity. Resilience sits between these poles. Taken together, this profile mirrors Havana’s cooperative, food-security-oriented practice regime, where ecological provisioning and social inclusion are foregrounded, and where spatial integration mechanisms remain less explicitly embedded in project design.

New York City displays a comparatively balanced distribution across keywords and themes. Ecological items and participation are simultaneously prominent, consistent with programmatic education, volunteering and partnership mechanisms that translate policy aims into practice. Equity and resilience show mid-to-upper intensities, while morphology-related keywords register moderate values, reflecting distributed sites and green-infrastructure linkages that are present but not uniformly system-scale. Overall, NYC’s matrix indicates multi-stakeholder practice that couples ecosystem functions and community interfaces without a single dominant thematic concentration.

Chongming’s matrix is characterized by strong ecological and spatial expressions. Keywords tied to water, biodiversity and spatial form/connectivity are consistently high across the theme columns, and resilience is also comparatively strong. In contrast, equity and participation are lower, indicating that bottom-up social interfaces are less emphasized relative to planning-led ecological restoration and territorial structuring. This configuration aligns with an eco-island strategy that prioritizes ecological baselines and morphological continuity over participatory co-production.

A cross-case reading of the three matrices reveals three robust tendencies. First, ecological primacy holds across cities, but the mode of realization differs: cooperative agroecology in Havana, green-infrastructure and educational programming in New York City, and island-scale ecological and spatial restructuring in Chongming. Second, the data suggest that Havana's practice profile foregrounds social inclusion, with comparatively lower signals for spatial connectivity; Chongming's profile emphasizes morphological and ecological dimensions, with thinner participatory signals; and New York City's profile is more evenly distributed across domains. Third, resilience emerges as a secondary but pervasive concern; where it is higher (e.g., Chongming), it is often anchored in planning mandates rather than community continuity mechanisms. These patterns echo the policy heatmap in Fig. 5 while sharpening the view at the keyword level.

We conducted several checks to support robustness. Using a geometric mean ensures that high intensity arises only where policy salience and practice alignment both register strongly, reducing false positives from one-sided signals. The keyword–theme affinity is column-normalized, preventing inflation from distributional artifacts; sensitivity

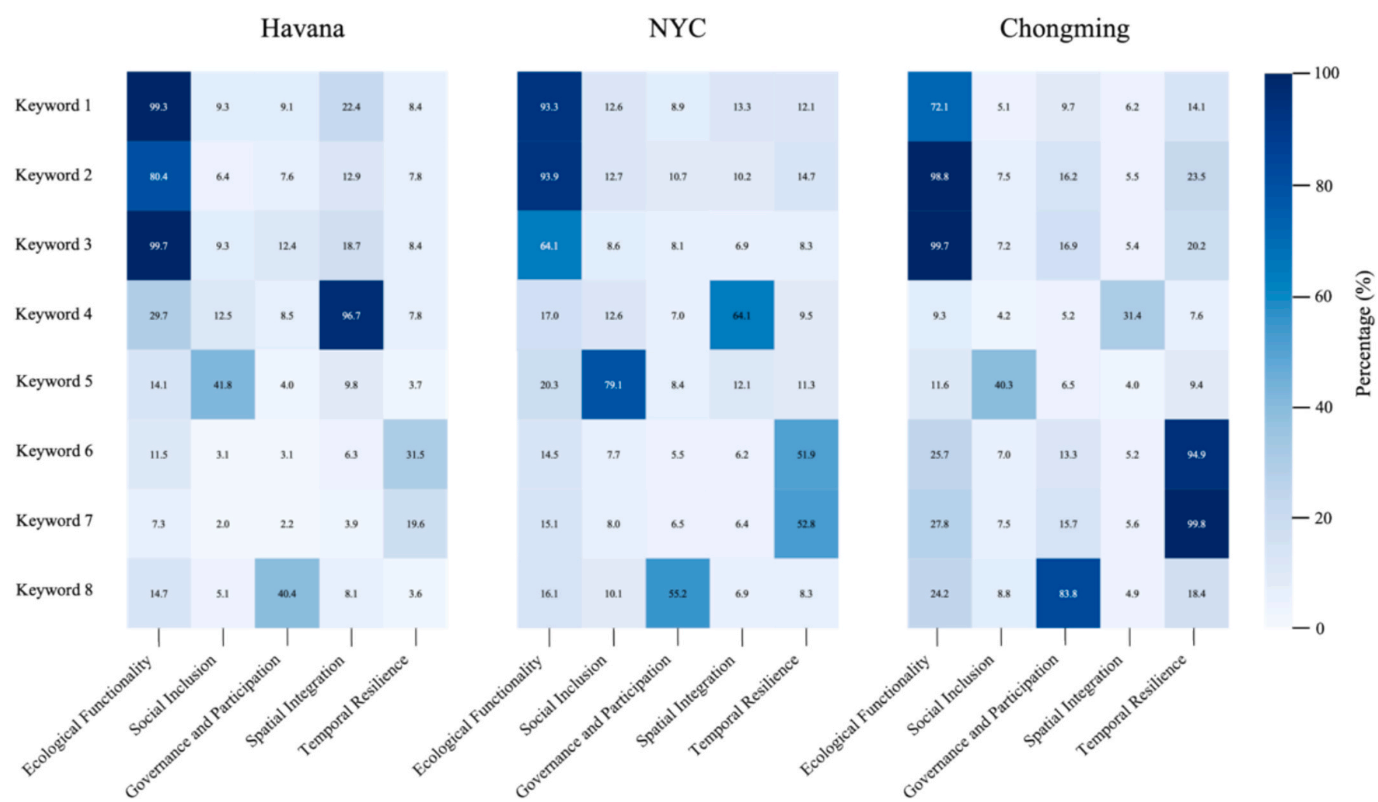

Fig. 6. Practice-case concerns-intensity heatmaps for Havana (left), New York City (centre), and Chongming Island (right). Each heatmap is an 8 × 5 matrix in which rows correspond to the eight evaluation keywords K1–K8 (Table 1) and columns represent the five thematic domains: Ecological Functionality (EF), Social Inclusion (SI), Governance and Participation (GP), Spatial Integration (SpI), and Temporal Resilience (TR). Cell colour intensity reflects the geometric-mean coupling score I ~ *city,kw* ~ derived from policy salience (P) and normalised practice alignment (R); deeper blue indicates stronger policy–practice coupling. Values are rescaled by a constant factor for visual legibility; relative magnitudes and rank-orderings are preserved. Key patterns: Havana exhibits high intensities in EF and SI with weaker SpI signals; NYC shows the most balanced distribution across all five domains; Chongming displays the strongest signals in EF and SpI, with comparatively lower SI and GP intensities. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

tests with alternative affinity profiles preserved the relative ordering of high- and low-signal cells. The constant rescaling applied to Fig. 6 affects only visualization, not the underlying values, and leaves all relative comparisons intact. Full matrices for each city are provided as CSV files to enable independent inspection and replication (Supplementary Data).

Finally, the 8 × 5 concerns-intensity matrices directly inform the policy–practice coupling assessment reported in Fig. 7. By comparing the keyword-level intensities with project-level evidence thresholds, we distinguish full alignment from partial or absent alignment in a manner consistent with both the thematic architecture and the empirical emphasis patterns. This linkage clarifies where each city’s practice already realizes articulated policy aims and where targeted adjustments would most efficiently close the remaining gaps.

3.5. Policy–practice coupling analysis

Before presenting cross-case comparisons, it is important to acknowledge that Havana (Cuba), New York City (USA), and Chongming Island (China) operate within fundamentally different socio-political and institutional systems. Direct normative comparisons are therefore approached with caution: observed differences in participatory governance, community involvement, or spatial integration may reflect legitimate context-specific adaptations rather than deficiencies. Collective governance structures in China may constitute valid alternative forms of community engagement not fully captured by indicators calibrated to Western participatory planning traditions.

Applying the coupling framework described in Section 2, Fig. 7 presents the policy–practice alignment matrix for each city's flagship project across the five thematic domains.

Havana's policy emphasizes social inclusion and food sovereignty, with high keyword salience for 'community', 'equity', 'participation', and 'food security'. Vivero Alamar demonstrates strong operational alignment with these social priorities through its cooperative governance model and community provisioning mechanisms. Alignment is highest in the Social Inclusion domain; scores drop sharply for Spatial Integration keywords (e.g. 'zoning', 'urban form', 'corridor') and are moderate and uneven for Ecological Functionality ('biodiversity', 'climate' underrepresented). This profile reflects Havana's immediate food-security imperatives and suggests that spatial and ecological dimensions, while not absent from policy, are not systematically translated into project design.

NYC's policy document explicitly articulates this integrative vision: Cultivating Urban Agriculture in New York City (2023) states that urban agriculture shall function as 'a tool for building community resilience, advancing food justice, and strengthening green infrastructure across all five boroughs', directly encoding multi-domain alignment as a policy objective. Brooklyn Grange in New York City exhibits consistently high coupling across most domains. Ecological and spatial keywords such as “green,” “infrastructure,” and “integration” score well, alongside participatory and governance terms like “stakeholder,” “framework,” and “planning.” The project effectively operationalizes a multifunctional policy vision that balances environmental, social, and design objectives. Only a few terms (e.g. “corridor,” “urban form”) show partial alignment, suggesting that although citywide spatial connectivity remains a technical challenge, the project’s innovative governance model and partnerships enable broad consistency with New York’s integrated urban agriculture strategy. This high degree of alignment indicates that multiple ecosystem services are being delivered in tandem through the

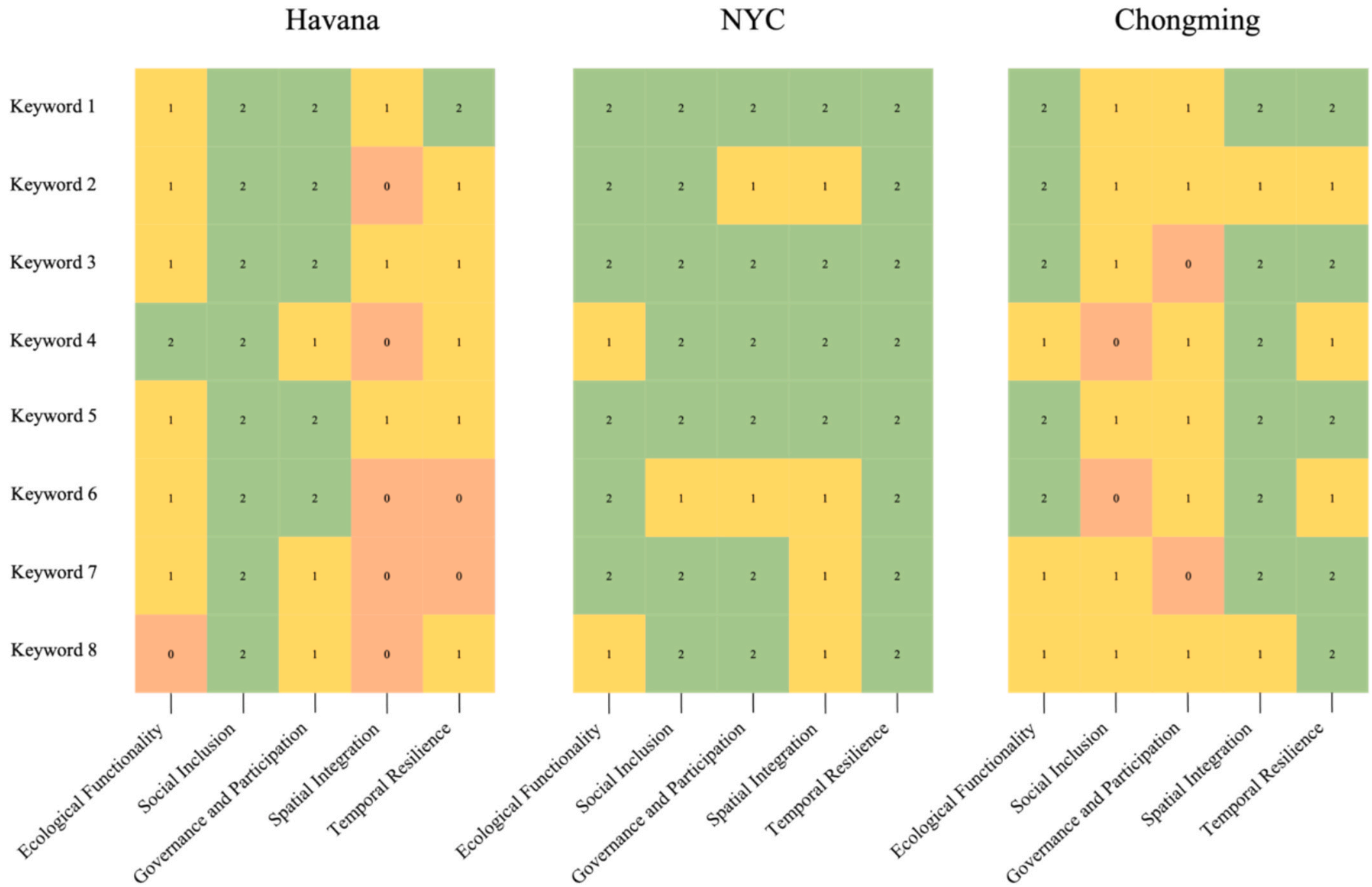

Fig. 7. Policy–Practice Coupling Matrix for Urban Agriculture Projects. 2 (green) = Full alignment: the project clearly implements the policy objective; 1 (yellow) = Partial alignment: the objective is addressed but not comprehensively; 0 (red) = No alignment: the objective is not reflected in practice. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

project, exemplifying how a landscape-oriented approach can holistically reconcile human–nature interactions in practice.

Chongming's policy foregrounds Ecological Functionality and Spatial Integration, with dominant keywords including 'biodiversity', 'ecosystem', 'zoning', and 'infrastructure'; social and governance terms are comparatively sparse. Chongming Modern Agricultural Park demonstrates clear alignment with these ecological and spatial targets, operating within a planning-led framework that prioritizes habitat conservation and territorial structuring. Alignment is strong for Ecological Functionality and Spatial Integration; weak for Social Inclusion ('participation', 'inclusion', 'poverty') and Governance ('stakeholder', 'framework'). This pattern is consistent with China's ecological modernization approach, in which planning-mandated implementation may serve functions analogous to participatory co-management in other institutional contexts, though bottom-up social interfaces remain limited.

4. Discussion

4.1. Urban agriculture as a functional bridge between humans and nature

The comparative analysis demonstrates that while the rhetoric and objectives of urban agriculture policy differ, they consistently employ urban agriculture to navigate tensions between urban development and environmental stewardship. Whether urban agriculture is used to address social vulnerability, enhance ecological resilience, or integrate fragmented land systems, it operates as a multifunctional boundary object, adaptable to different urban governance paradigms. This validates urban agriculture not simply as a technique or land use, but as a conceptual device that materializes diverse understandings of what human–nature reconciliation means in the city. The following sections explore how this conceptual function translates into differentiated policy frameworks and the degree to which those frameworks are implemented on the ground.

The projects tend to implement what their respective policies emphasize most, while under-performing in aspects that are not well-articulated or are more structurally challenging. The coupling matrix thus reveals the internal consistency of each city's policy approach, as well as the operational gaps that emerge in translation to practice. These findings provide a diagnostic basis to pinpoint where policy adjustments or implementation support are most needed. For example, introducing greater community engagement in nature-oriented models, or strengthening spatial design integration in socially oriented models. By highlighting where urban agriculture initiatives fail to deliver certain ecological or social functions, the coupling analysis deepens our understanding of the misalignments that contribute to inequities in urban ecosystem service provision. More importantly, this approach demonstrates how linking policy and practice evaluation can inform the development of a more integrated strategic framework. In other words, the policy–practice coupling perspective allows us to pinpoint the specific interventions required to better synchronize human and natural objectives, laying the groundwork for the landscape-oriented implementation framework proposed in the next section.

4.2. Urban agriculture as a diagnostic lens for policy orientations

The comparative keyword analysis not only reveals distinct thematic priorities in each city's policy framework but also positions urban agriculture within a broader conceptual spectrum that reflects differing interpretations of the human–nature relationship. Drawing on the model illustrated in Fig. 8, we propose that urban agriculture can be understood through three functional roles: as a human-centered tool, as a nature-based solution, or as a landscape-integrated interface.

In Havana, urban agriculture assumes a predominantly human-centered role. Policy emphasis on community, equity, food security, and participation illustrates how urban farming is leveraged to address social vulnerability. For instance, Havana's Plan de Soberanía Alimentaria (2020) states that urban agriculture shall serve as 'un instrumento de justicia alimentaria y participación comunitaria', directly encoding social inclusion as the primary objective. Urban agriculture here acts as a vehicle for short-term socio-economic resilience, often embedded within informal or semi-formal structures. Its ecological and spatial dimensions are not absent but are subordinated to welfare-oriented goals. As shown in the left zone of Fig. 8, this orientation places stronger emphasis on immediate food provisioning, social inclusion, and shorter-horizon policy goals. This should be interpreted as a contextual pattern rather than a geographically fixed or development-stage-specific model. Chongming Island represents the other end of the spectrum. Urban agriculture is framed primarily as a nature-based infrastructure, embedded in ecological restoration programs and sustainability targets. Policy language emphasizes biodiversity, ecosystem services, infrastructure, and zoning, while social terms like participation and inclusion are sparse. The Chongming Eco-Island Development Plan (2004) typifies this orientation, framing agricultural development as serving 'ecological conservation and green corridor construction' without articulating participatory governance mechanisms. The result is a governance approach emphasizing technical and top-down implementation, where urban agriculture serves primarily to meet environmental performance targets; mechanisms for civic engagement and social innovation are comparatively limited within this model. This pattern aligns with the nature-based end of the spectrum in Fig. 8. While it is tempting to interpret this as a limitation relative to more socially balanced models, it is equally plausible that within China's institutional context and the specific developmental goals of Chongming's eco-island designation, this technically driven approach constitutes an effective and contextually legitimate strategy. In particular, the food security and food sovereignty dimensions of urban agriculture deserve more explicit attention in how we evaluate and frame urban agriculture success across different governance systems (Crush & Frayne, 2011; Dubbeling et al., 2017; Poulot, 2014). New York City's policy discourse, by contrast, shows balanced keyword intensity across all five domains: ecological, social, spatial, governance, and temporal. Urban agriculture is framed simultaneously as green infrastructure, civic asset, and planning instrument. This hybrid character situates NYC at the center of the landscape-informed mechanism in Fig. 8, demonstrating the integrative potential of urban agriculture when governance mechanisms support cross-scalar, multifunctional implementation.

Through this comparison, we demonstrate that urban agriculture is not a singular category but a diagnostic lens through which to examine the shifting balance between human and ecological priorities in urban policy. More importantly, the landscape-centered model, exemplified by NYC, reveals the unique capacity of urban agriculture to act as an interface, rather than a tool, reconciling both ends of the spectrum. It avoids the narrowness of function that often constrains either human-centered (Havana) or ecology-centered (Chongming) models. Among the three cases examined, the planning approach most closely aligned with landscape-informed principles demonstrated the highest multi-dimensional coupling scores across the five thematic domains. This suggests that an integrated, landscape-oriented approach may offer greater adaptive capacity and systemic coherence, a finding consistent with green infrastructure literature emphasizing cross-scalar multi-functionality (Ahern, 2013; Lovell & Taylor, 2013). Caution is nonetheless warranted in generalizing from three cases. These findings justify a shift in emphasis from viewing urban agriculture as either a social safety net or ecological infrastructure toward positioning it as a landscape-based governance strategy. This reframing opens new possibilities for urban agriculture to mediate multiple urban objectives simultaneously, and it forms the foundation for the conceptual-practical framework outlined.

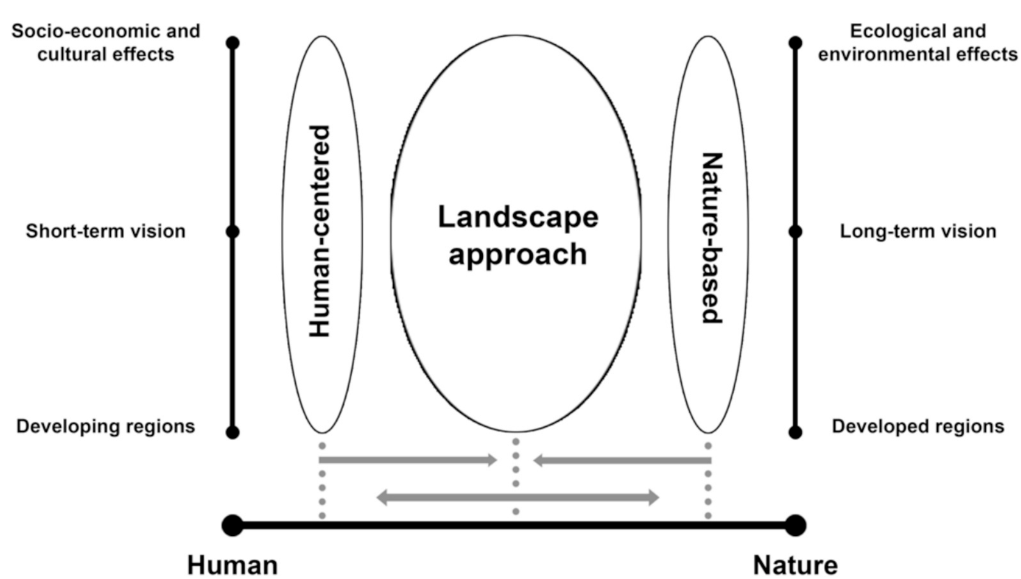

Fig. 8. Conceptual positioning of urban agriculture along the human–nature spectrum. This diagram illustrates the spectrum of urban agriculture conceptualizations in relation to human and ecological priorities. As a tendential pattern observed in the literature (Dubbeling et al., 2017; Lwasa et al., 2015; FAO, 2019), human-centered approaches are more frequently documented in Global South contexts where immediate food-security and livelihood imperatives predominate; nature-based approaches are more commonly reported in Global North contexts where ecological restoration and long-term sustainability targets are institutionally prioritized. This represents a generalization subject to significant inter- and intra-regional variation and does not imply a deterministic link between development status and planning approach. The arrows at the base of the figure indicate the directionality of the spectrum from human-centered (left) to nature-based (right), with the landscape-informed mechanism occupying the integrative center.

4.3. Toward a landscape-based framework for urban agriculture implementation

The comparative coupling analysis revealed gaps between policy intent and practical implementation across all three case studies. These gaps highlight the limitations of sectoral approaches to urban agriculture and the need for an integrative planning framework that can mediate between policy visions and grounded realities. Building on this insight, we propose a landscape-based, multi-layered framework to operationalize urban agriculture within urban systems and guide its translation from discourse to practice. This model synthesizes the thematic domains identified in our evaluation matrix with foundational thinking in landscape systems planning (Wu, 2013; Nijhuis, 2020). It conceptualizes urban agriculture as a multi-scalar, multifunctional phenomenon situated at the intersection of four interdependent layers: Ecological Base, Institutional Structure, Social Interface, and Spatial Form (Fig. 9). These layers reflect the deep structure of the urban landscape, each carrying distinct dynamics, constraints, and opportunities.

Ecological Base refers to the foundational biophysical systems of the city, such as soil, water, air, vegetation, and biodiversity. Planning urban agriculture at this level involves identifying and aligning with ecological functions, such as flood mitigation, habitat restoration, or microclimate regulation. Our results show that projects like Chongming Modern Agricultural Park perform well in this layer but often lack upward integration into governance and social design, illustrating a Layer 1 strength without Layer 2–3 connectivity. Institutional Structure encompasses zoning codes, land tenure systems, funding mechanisms, and policy instruments that legitimize and support urban agriculture. Cities like New York, where urban agriculture is embedded in comprehensive planning and institutional collaboration, demonstrate stronger vertical alignment and policy–practice coherence across this layer. In contrast, the absence of clear institutional support often leads to fragmented or marginal practices, as observed in Havana. Social Interface focuses on community engagement, local knowledge, civic participation, and cultural relevance. This layer proved strongest in Havana, where urban agriculture serves as a platform for food sovereignty, identity, and inclusion, but weaker in Chongming, where civic agency is constrained by governance approaches emphasizing technical and top-down implementation. Social alignment is essential for equity, legitimacy, and long-term resilience. Spatial Form captures the physical manifestation of urban agriculture in the built environment from distribution, typologies, and integration into urban morphology. Brooklyn Grange originated as a grassroots initiative before being incorporated into the city's green-infrastructure agenda; its spatial articulation across multiple rooftop sites and the formalization of green-infrastructure linkages through subsequent policy frameworks illustrate how bottom-up initiatives can be institutionally scaled, enhancing both functional performance and symbolic presence (Harada et al., 2018). Spatial gaps, by contrast, limit connectivity, visibility, and scalability.

Importantly, this multi-layered landscape framework is not purely theoretical; it resonates with successful urban greening practices worldwide. In Paris, the municipal "Parisculteurs" program launched in 2016 systematically identified underused urban spaces – from rooftops to vacant lots – for agriculture (spatial identification), evaluated each site's potential for food production, biodiversity gains, and cooling (functional diagnosis), and then matched the sites with appropriate urban farming projects through public tenders (intervention matching).

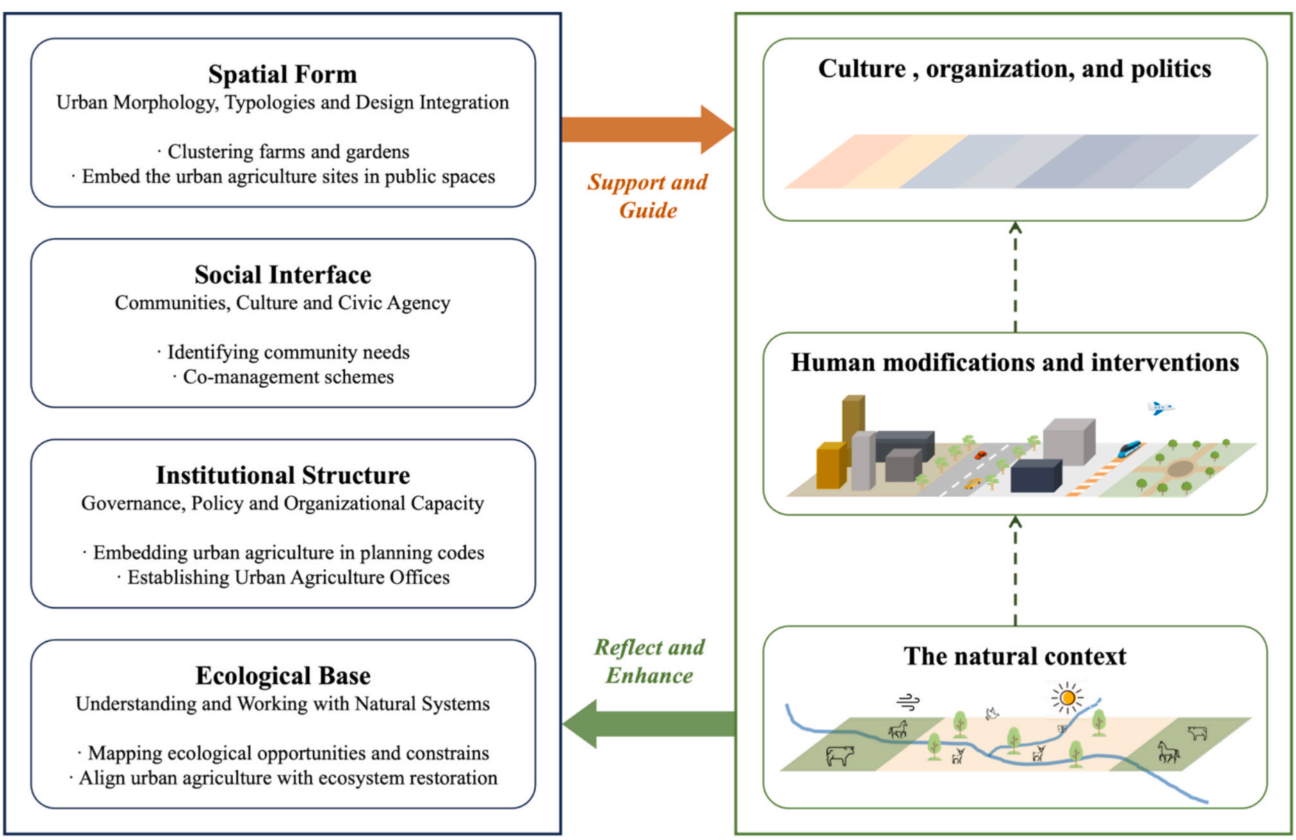

Fig. 9. A multi-layered landscape framework for implementing urban agriculture. A multi-layered landscape framework for implementing urban agriculture. The four layers integrate and synthesize the five thematic domains of the evaluation matrix: the Ecological Base layer primarily encompasses Ecological Functionality and Temporal Resilience domains; the Institutional Structure layer corresponds to Governance and Participation; the Social Interface layer maps to Social Inclusion; and the Spatial Form layer addresses Spatial Integration. The framework thus operationalizes the matrix's five dimensions at the implementation level rather than replacing them.

Since its launch, the program has approved over 100 projects (78 already implemented) covering more than 21 ha, yielding significant environmental and social benefits such as local food supply, rooftop cooling, rainwater retention, and community education (Aubry & Kebir, 2013; Poulot, 2014).

Together, these four layers structure a landscape-based logic that bridges strategic evaluation and implementation pathways. By using this framework, cities can better diagnose systemic weaknesses, allocate interventions appropriately, and ensure that urban agriculture evolves as a resilient, just, and ecologically productive part of the urban fabric. Critically, it overcomes the binaries identified in our typology by enabling a layered integration of values, scales, and actors. In doing so, it revitalizes the landscape-informed mechanism as a practical governance tool for embedding urban agriculture into sustainable urban transitions.

4.4. Limitations and scope

This study is subject to several limitations that should be considered when interpreting findings. First, the analysis is based on three case cities, each represented by a single flagship project. While these were selected for maximum information content (Flyvbjerg, 2006) and policy proximity, they may not represent the full diversity of urban agriculture practices within each city or across other global contexts. The conceptual framework proposed in Figs. 8 and 9 should therefore be understood as a heuristic tool requiring empirical testing across a broader set of cities before claims of generalizability can be made. Second, this study underweights the food security and food sovereignty dimensions of urban agriculture, particularly in developing-country contexts. In cities like Havana, urban agriculture is fundamentally driven by food security imperatives (Crush & Frayne, 2011; Dubbeling et al., 2017) that the current five-domain matrix may not fully capture. We propose food sovereignty as a candidate for a sixth thematic domain in future extensions of the framework. More broadly, the social sphere deserves stronger representation in evaluation frameworks applied to Global South urban agriculture (Lwasa et al., 2015; FAO, 2019). Third, residual semantic drift in the multilingual corpus, dependency of topic-model outputs on preprocessing choices, and the inherent interpretive limitations of keyword-based content analysis all constitute methodological constraints. Future work should triangulate content-analysis findings with ground-measured ecosystem-service indicators and ethnographic or interview-based data on community experiences.

4.5. From evaluation to intervention: policy recommendations

Building on the layered landscape framework proposed above, this section outlines practical pathways to translate evaluation insights into actionable governance. Repositioning urban agriculture as a lever for landscape-scale transformation requires deliberate changes in policy and practice. Based on our findings, we offer three overarching recommendations for urban policymakers and planners to better integrate urban agriculture through a landscape-informed mechanism.

First, mainstream urban agriculture into formal spatial planning mechanisms. Despite growing recognition of urban agriculture's multifunctionality, many municipalities still regard it as an informal or auxiliary activity. We recommend embedding urban agriculture into zoning codes, comprehensive plans, and urban design guidelines to legitimize it as a formal land use. This could include creating explicit urban agriculture zones or overlays on city land-use maps, requiring or incentivizing food-producing green space (such as rooftop gardens or community gardens) in new developments, and integrating edible landscaping into public space standards. For example, cities might adopt ordinances that protect community garden sites from redevelopment or provide density bonuses to developments that incorporate publicly accessible agriculture. Public land inventories could earmark vacant lots for leasing to urban farmers. As Davies et al. (2021) argue, such statutory recognition anchors urban agriculture within broader frameworks of green infrastructure and climate adaptation, transforming it from a marginal grassroots activity into a structural component of urban sustainability planning. Recent analyses of urban planning have echoed this need, noting that urban agriculture deserves stronger consideration and inclusion in land-use planning (Langemeyer et al., 2021). By formally planning for agriculture, cities can ensure that the ecological and social benefits of urban agriculture are realized at scale and maintained over the long term.

Second, strengthen cross-sectoral governance models for urban agriculture. Urban agriculture inherently intersects with multiple sectors and thus demands coordination across traditionally siloed departments. Cities should consider creating interagency working groups or dedicated Urban Agriculture Offices to align policies and pool resources across sectors (food policy councils are one such mechanism). Such bodies can oversee urban agriculture integration in initiatives ranging from waste management (e.g., composting programs) to school curricula (garden-based learning) to climate resilience projects (green infrastructure). Collaboration should extend beyond government: including NGOs, urban farmer networks, academia, and private sector partners will bring additional expertise and legitimacy. Embedding urban agriculture initiatives within existing programs creates system-wide synergies. By sharing ownership across public, private, and civil society actors, urban agriculture becomes more resilient and impactful, as no single entity bears sole responsibility. As Reed et al. (2021) emphasize, integrated governance structures are essential to unlock urban agriculture's full potential. This approach echoes the network governance observed in NYC's case and aligns with the landscape governance tradition used in large-scale environmental conservation (Scarlett & McKinney, 2016). In practice, a city might convene a regular "Urban Agriculture Task Force" that includes city planners, parks officials, public health officers, community representatives, and researchers to collaboratively guide the urban agriculture agenda.

Third, cultivate inclusive participation and clarify the conceptual framing in urban agriculture policy. Effective governance of urban agriculture requires mechanisms for tiered public participation – engaging stakeholders from the grassroots to the institutional level. Cities should empower community members through advisory boards, participatory budgeting for urban agriculture projects, and co-management arrangements for public land used in agriculture. This ensures that those who tend the gardens and rely on their outputs have a voice in decision-making, which can enhance the social interface layer of our framework. At the same time, our analysis showed that key terms like "resilience" or "equity" can be interpreted differently across paradigms, which risks confusion or diluted accountability if left ambiguous. Therefore, we recommend that city policies clearly define their use of such concepts possibly by including glossaries or explanatory sections in policy documents. For instance, if a city's urban agriculture plan claims to advance "resilience," it should specify whether this refers to community food resilience, ecological resilience to climate impacts, or economic resilience of urban farmers (or all of the above). Clarifying the intent and scope of these buzzwords fosters better alignment across departments and enables more transparent evaluation of outcomes. This clarity, combined with broad-based participation, can improve trust and mutual understanding among stakeholders. Together, these recommendations offer a roadmap for operationalizing the landscape-informed mechanism through urban agriculture and translate strategic paradigms into spatially grounded, socially inclusive, and institutionally embedded interventions. In doing so, they bridge the conceptual gaps identified in our cross-case analysis and lay the groundwork for adaptive, multilayered governance of urban sustainability.

5. Conclusion

This study reconceptualizes urban agriculture as more than a technical solution or food provision strategy, positioning it instead as a multifunctional interface between human and ecological systems.

Through a comparative analysis of three distinct urban paradigms we have demonstrated that urban agriculture reflects differing interpretations of the human–nature relationship. These orientations are embedded in policy language, governance structures, and implementation patterns, as revealed by our five-domain evaluation matrix and coupling analysis.

Our findings reveal that the thematic emphases of urban agriculture policies shape the pattern of implementation gaps: dimensions that are explicitly prioritized tend to translate into practice, while those that are under-articulated consistently manifest as gaps. Crucially, this is not a self-evident observation but a diagnostic finding: the evaluation matrix makes these trade-offs visible and attributable, enabling planners to make context-specific prioritization choices explicit rather than allowing them to remain implicit and unexamined. This divergence reinforces the need for a more holistic planning logic. In response, we proposed a landscape-based, multi-layered framework that integrates the ecological, institutional, social, and spatial dimensions of urban agriculture. This framework not only provides a structure for diagnosing misalignments between policy and practice but also offers actionable pathways for embedding urban agriculture into urban sustainability agendas.

By bridging fragmented governance domains and reconciling socio-ecological objectives, the landscape-informed mechanism offers a viable governance paradigm for cities seeking to implement urban agriculture in a more integrated and resilient manner. The proposed framework translates high-level principles into grounded spatial strategies, participatory mechanisms, and institutional arrangements. Moreover, the study's findings suggest that cities adopting this layered approach are more likely to produce urban agriculture systems that are adaptive, inclusive, and environmentally effective.

The study is subject to methodological and scope limitations discussed in Section 4.4, including residual semantic drift, topic-model sensitivity, and restricted generalizability across city contexts. Ultimately, urban agriculture holds promise not just as a green intervention, but as a strategic policy platform for advancing integrated landscape planning in cities. The landscape-informed, multi-layer framework proposed here offers a transferable diagnostic and prescriptive tool for cities seeking to embed urban agriculture into integrated sustainability governance. Its utility depends on continued empirical testing across diverse governance contexts, and the development of cross-layer performance metrics represents a priority for the next generation of urban agriculture planning research.

CRediT authorship contribution statement

Yu Huan: Writing – original draft, Visualization, Software, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Steffen Nijhuis:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Investigation, Conceptualization. **Nico Tillie:** Writing – review & editing, Validation, Supervision, Project administration, Investigation, Conceptualization.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2026.105687.

Data availability

Data will be made available on request.

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