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Structural drivers of sustainability and resilience strategies in small(ish) cities: a text analysis of comprehensive planning in Indiana

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For decades, the world's largest and most globally significant cities have been pledging to tackle climate change, resilience, sustainable development and social injustices through a proliferating ecology of plans. Far less is understood about what is happening in smaller communities. This study employs an institutional lens and automated text analysis to examine the resilience and sustainability "shared strategies" embedded in local land-use plans, which are used in many countries to guide the spatial distribution of development in metropolitan regions. We find evidence that communities that are more highly educated and less racially diverse focus more on "quality of life" amenities within their plans, such as pedestrian resources and environmental amenities. By contrast, communities that are more racially diverse focus greater attention on green stormwater infrastructure to address flooding. Plan "quality" is negatively associated with an amenities' focus. Taken together, these findings suggest comprehensive land-use planning is both a means for reflecting exclusivity as well as pursuing community needs or goals related to specific resilience or sustainability themes.

Keywords: sustainability; resilience; comprehensive planning; Institutional analysis; text analysis

1. Introduction

For decades, the world's largest and most globally significant cities have been pledging to tackle climate change, sustainable development and social injustices through a proliferating ecology of plans (Woodruff *et al*. 2018). The rhetorical framing used by many of these cities has gradually shifted from sustainability and climate mitigation to adaptation and resilience, as evidenced by efforts such as The Rockefeller Foundation's now-defunct "100 Resilient Cities" and the Bloomberg Philanthropies "American Cities Climate Challenge," (Mart'ın and McTarnaghan 2018; Woodruff *et al*. 2018). This evolution reflects both the ambition of funding organizations but also the pragmatism of local policymakers and managers making efforts to lead on

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such larger-than-local, collective-action challenges (Gunderson 2001; Swann and Deslatte 2018).

A growing number of mid-sized cities are also getting into the act, developing sustainability, resilience and climate-action strategies or goals (Krause 2011; Hawkins, Krause, and Deslatte 2023; Laurian and Crawford 2016; Wheeler 2013). Whether in stand-alone or comprehensive land-use plans, city planning as a process has expanded to tackle topics such as sprawl, infrastructure investment, economic development, sustainability, climate-action and social vulnerability. Some researchers have speculated that this shift in framing belies a broader philosophical evolution to think about looming climate impacts on infrastructure, the environment and society from more of a systems perspective (Rankin *et al*. 2017; Woodruff *et al*. 2018). Such socio-ecological (SES) systems approaches – traditionally used to study common-pool resources such as forests, fisheries and agriculture – are also increasingly finding more relevance in urban studies and planning research (Garcia *et al*. 2019). System resilience, in particular, emphasizes the (in)ability of communities to "bounce back" or absorb exogenous shocks without losing key functionality, and resilience-based government strategies attempt to develop broader, more inclusive policies or programs for weathering climate-related calamities (Meerow and Newell 2019). Conversely, sustainability – often defined as intersectional efforts to safeguard or improve the environment, economy and social equity – reflects some agreed-to, community standards or goals for current and future SES performance (Anderies *et al*. 2013).

In practice, these framings and planning processes vary depending on whether cities are focused on risks from flooding, storms, heatwaves, sea level rise, economic shocks, social unrest, natural disasters, terrorism or other threats (Rankin *et al*. 2017). However, these plans often do not speak to each other, or they apply to the mission, goals and activities of specific departments or units rather than the whole of government. This is problematic for planning given the organization- and community-wide changes needed to make significant gains in equity, environmental restoration, greenhouse-gas reductions or quality-of-life improvements (Wheeler 2013; Swann and Deslatte 2018). Cognisant of this disconnect, some scholars and cities have advocated for "mainstreaming" such goals into general or comprehensive planning documents as a means to integrate planning processes and products (Opp, Mosier, and Osgood 2018). Despite this potential, significant theoretical and empirical gaps remain in our understanding of where and why resilience and sustainability strategies are appearing in comprehensive planning (Zeemering 2018).

This study employs an institutional lens and text analysis to address these gaps. SES research from a variety of disciplines has emphasized that the quality of local institutions, in combination with the community characteristics and biophysical conditions, can influence the sustainability of system outputs (Ostrom 1990). Applying the Institutional Analysis and Development (IAD) framework, this study aims to diagnose the suitability of comprehensive land-use plans common across many developed and developing countries to facilitate the emergence of "shared strategies" to guide urban resilience and sustainability-related efforts. To accomplish this, we first ask: what planning processes deemed important to facilitate effective collective action (i.e. participation, coordination, implementation and monitoring provisions) are present across a sample of plans from cities? The quality of stakeholder engagement, clarity and equity of costs and benefits for actions, and enforceability of agreements have been identified by both planning practitioners and institutional scholars as desirable criteria for

fostering resilient or sustainable systems. Using data from a sample of 159 Indiana municipal governments, we adapt a methodology developed in the urban planning literature for evaluating quality criteria of their comprehensive plans and find a broad array of energy-efficiency, land-use, water and natural resource policy goals (Berke and Godschalk 2009; Woodruff *et al*. 2021).

Our second research objective aims to examine the relationship between contextual features and the proportional emphasis on specific strategies. Here, we ask: How do biophysical conditions and community attributes relate to the prevalence of resilience or sustainability strategies in comprehensive plans? To address this question, we first examine the clusters of terms or concepts that emerge, and determine whether they meaningfully align with key components of urban resilience or "dimensions" of sustainability research, such as environmental, economy and equity goals (Opp, Mosier, and Osgood 2018). We accomplish this using Natural Language Processing methods to identify clustered "topics" within the plans (Kim and Gil 2019).

We then combine data on the biophysical and community characteristics with the clustered topics from the text analysis of the plans. We find evidence that specific community attributes and built-environment conditions facilitate distinct strategies for the delivery of public goods (Paiva 1977). Specifically, we find communities that are more highly educated and less racially diverse focus more on "quality of life" amenities within their plans, while communities that are more racially diverse focus greater attention on green stormwater infrastructure and housing strategies. Plan "quality" is negatively associated with an amenities' focus, as is the "town" form of government – which in Indiana, is restricted to smaller municipalities. Taken together, these findings suggest comprehensive planning may serve as a means for institutionalizing exclusivity, as well as pursuing social sustainability or resilience goals.

2. Resilience, rules and planning

The concept of resilience has multiple uses in planning and other fields depending on whether it refers to ecological, biophysical or psychological bounce-back capabilities of ecologies, societies or individuals (Anderies *et al*. 2013; Fitzgibbons and Mitchell 2019; McCabe *et al.* 2022; Meerow and Newell 2019). Applied to city planning, it is often used to characterize built-environment or social system components. For instance, land-use planning can shape the built environment of a community over many decades, determine the qualities and location of development, and where and how the robustness of transportation systems and other infrastructure are enhanced or diversified (Alfasi, Almagor, and Benenson 2012; Anderies *et al*. 2013). As such, land-use strategies can have a direct bearing on the resilience of a community when it is impacted by a disturbance such as flooding or heat variability and intensity. However, strategies are only as good as their ability to link aspirations or challenges to community capacities. In this sense, planning or organizing to address resilience depends on institutionalizing expectations for collective behavior (Mart'ın and McTarnaghan 2018).

Scholars studying the management of common-pool resources (CPR) such as fisheries, irrigation systems or forests have amassed considerable evidence of effective rules for overcoming the short-sightedness and social dilemmas which precipitate resource-system collapse (Anderies and Janssen 2013; Cox, Arnold, and Villamayor Tom'as 2010; Ostrom 1990). The "design principles" which emerged from this effort offer a starting point for assessing the ability of a community to sustainably manage

its resources and services. These principles include whether the boundaries of a specific resource system and the individuals with rights to use them are clearly defined; whether some equivalence between the costs and benefits exists; the inclusion of affected individuals or groups in decision-making; and the presence of monitoring, sanctions and conflict-resolution mechanisms (Ostrom 1990).

By most of these measures, recent evidence has found contemporary climate and resilience plans lacking (Woodruff *et al*. 2018). In particular, early adopters of these plans in the US have unevenly incorporated equitable participation processes in planning and robust implementation and monitoring mechanisms (Woodruff *et al*. 2018). Part of the difficulty with resilience planning is that many of the drivers and consequences are often "larger than local," in that individual jurisdictions may be unable to effectively influence them (i.e. regional or global transportation, energy production, suburban sprawl, inequality). However, local governments do have considerable leeway for how land is regulated - and land use is a critical component to community resilience (Woodruff *et al*. 2021). For instance, land-use tools such as zoning impact property rights by determining what may, must or must not happen on a given parcel. Land is assessed for taxation based on specific uses, thereby attempting to achieve some proportionality between costs imposed by development and the private benefits the development generates. Most land-use decisions play out in public processes which ostensibly allow affected parties to – albeit unevenly – participate. Land-use systems are also subjected to legal scrutiny, monitoring by local government and community actors alike, and provide avenues for conflict-resolution (Berke *et al*. 2006). Accordingly, the policies and institutions that govern land-use may reflect some of the same design principles characteristic of common-pool resources, with the caveat that property rights render it easier to exclude potential users. We posit that land-use planning reflects efforts to institutionalize tailored 'shared strategies' intended to preserve or improve community conditions. As such, comprehensive planning – as spatial or land-use planning is called in the US – offers a glimpse into the system services a community has or hopes to offer, and a starting point for diagnosing the fit of its institutions to its biophysical and community characteristics.

3. Planning the sustainability of system services

While resilience refers to system-wide conditions, sustainability in planning often describes collectively agreed-upon measures of system performance, such as ecosystem services, parks and urban forests, drinking water delivery, housing, transit, or other economic development and social services (Anderies *et al*. 2013; Deslatte *et al.* 2022). Because most cities in urban areas around the world exist within constellations of other local governments, sustainability planning has become one way in which cities develop their own unique "baskets of goods" to attract citizens and investment (Ostrom, Tiebout, and Warren 1961; Paiva 1977; Ostrom 1983).

Ultimately, the value of such planning depends on how effectively they facilitate collective action to render agreed-upon services more sustainable over some planning horizon – in other words, how effectively they institutionalize rules for governing resources, resolving disputes and enforcing agreements (Ostrom 1990). Institutional analysts have long sought to distinguish between adhered-to rules, such as laws which must be followed, and the informal norms and shared strategies, which may or may not impose weaker sanctions for disregarding them (Ostrom 1990). The myriad of

local governments' plans often produce the latter – shared strategies, or instructions about (un)desirable potential futures and steps for reaching or avoiding them. These plans can be a means for confronting social dilemmas, provided they become institutionalized into organizational routines or actions.

Land-use plans are widely used within developed and developing countries to spatially organize human activities, with more than 100,000 plans identified amongst 32 countries who were members of the Organisation for Economic Co-operation and Development in 2015 (OECD 2017). At the same time, there is significant variability in the topics, tools and scope of spatial and land-use planning, with at least 229 different types of plans identified across those 32 OECD countries (OECD 2017).

In the US, comprehensive plans function as a primary instrument for spatial and land-use policy guidance. Comprehensive plans typically adopt a longer, decades-long planning horizon, which makes them ideally suited for identifying longer-term sustainability threats and opportunities (Deslatte, Swann, and Feiock 2017). The comprehensive planning process typically requires broader organizational and community engagement, and can address themes related to land use, transportation, utilities, infrastructure, quality of life, livability, and even inter-organizational coordination (Berke *et al*. 2006; Levy 2016; Redaelli 2021). While the legally required elements of comprehensive plans can vary by state, Godschalk and Anderson (2012) argue that comprehensive planning should generally attempt to satisfy six principles, including: a livable built environment; harmony with nature; a resilient economy; interwoven social equity; community health; and 'responsible regionalism' (Godschalk and Anderson 2012). Planning processes should further feature "authentic" stakeholder participation and sufficient implementation details, so that policymakers and managers could be held accountable for adherence (Godschalk and Anderson 2012). These planning criteria have evolved in recent years to more closely adhere to resilience and sustainability goals (Woodruff *et al*. 2018) and closely overlap with the aforementioned institutional design principles (Ostrom 2011).

Given the increasing convergence of planning scholarship and practice, we contend that the IAD framework (depicted in Figure 1) can be a useful theoretical tool for conceptualizing and categorizing features deemed important for the sustainability goals of communities (Deslatte *et al.* 2022; McGinnis 2011). The IAD framework was developed by Elinor Ostrom and colleagues (1990) to focus on the collective interactions of individuals and groups across a range of focal activities, such as resource management and urban service delivery (Ostrom 2011). Planning processes are composed of similar "action situations," in which sets of participants are authorized to make choices,

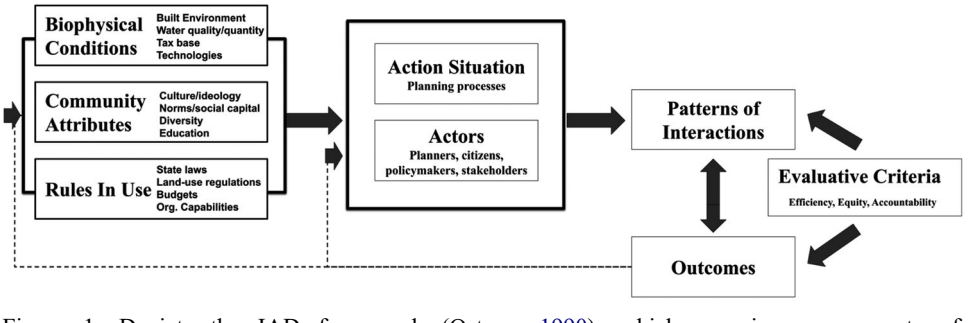

Figure 1. Depicts the IAD framework (Ostrom 1990), which organizes components of institutional systems for managing common-pool resources in sustainable ways. The framework focuses on the action situation in which actors may allocate resources and assess outcomes.

identify a scope of (un)desirable future outcomes and determine expected payoffs. While developed separately, the institutional design principles and professional planning criteria both share a common focus on the importance of action situations featuring inclusive engagement, coordination of effort across silos, equitable division of costs and benefits, and the importance of monitoring results (Berke and Godschalk 2009; Ostrom 1990; Woodruff *et al*. 2018). The plans themselves are artifacts of these processes, which pass instructions on to others in the form of strategies.

The strategies that emerge from well-managed planning processes should be responsive to their biophysical conditions, community characteristics, and the higher-order rules, such as state or federal laws, which are depicted by the IAD as "exogenous" groupings of variables which may influence collective-action (Ostrom 1990; Schlager and Cox 2018). In this sense, we use the IAD framework to organize the variables from the biophysical world and community which are likely to influence strategies for the sustainability of services in urban settings.

'Biophysical conditions' can include components of natural resource systems, the built environment, the fiscal resources or tax base and available technologies. City planning is often heavily dependent on infrastructure such as roadways, sewers and potable water systems, and available land for development (Berke and Conroy 2000). For instance, as climate change increases flooding and high-heat events in cities, sustaining public health and ecosystem services may necessitate increased use of green stormwater infrastructure and permeable or high solar-reflective pavements to adapt (Meerow and Newell 2019). Older communities may have substantial infill or redevelopment needs as housing stocks decline, and competition for jobs and economic development intensifies through the use of a wider range of taxpayer incentives (Stokan and Deslatte 2020). A key sustainability consideration here is whether the type of good or service provided is excludable and exhaustible – whether individuals may be excluded from using it, and whether one person's use of the good subtracts from the ability of another to use it. The bundles of outputs cities provide can include traditional public goods (public safety and health), along with services that might resemble club or toll goods (roads, recycling, water and sewer services) and common-pool resources (parks and green space or infrastructure). Cities also often function under austerity conditions with resources committed to specific activities, such as economic development tax incentives, which are difficult to re-allocate to other uses. The biophysical or material characteristics, in this sense, may necessitate strategies intended to conserve, re-allocate or generate new resources.

'Community attributes' can include the prevailing culture or norms of individuals living in a community, the homogeneity of preferences for public goods, as well as community size and ethnic or demographic diversity (Hendrick and Shi 2015; Ostrom, Tiebout, and Warren 1961). The prevailing cultural attributes of a community are also likely to shape the strategies it has developed, such as preserving quality of life or welcoming diversity (Godschalk and Anderson 2012). When metropolitan populations sort themselves into more ethnically or income-homogenous collectivities, they may also be more protective of social identities and less accepting of changes perceived as threats, such as greater in-migration of minorities or low-income populations (Deslatte *et al.* 2022; Trounstine 2020). When cultural norms encourage more active participation in planning processes, strategies may be more likely to incorporate a broader assortment of viewpoints and goals. Population size itself can also be an important community attribute, because larger communities may rely less on trust and reciprocity and more on monitoring and enforcement of rules.

The 'rules-in-use' category of the IAD may be existing state constitutional or statutory requirements, the land-use regulations and budgets which constrain or enable actions, and the capabilities of the local government which have developed over time (Siddiki *et al*. 2022). While this is not an exhaustive list, all planning processes work within institutionally defined rules of what is allowed, prohibited or required of government actors (Deslatte *et al.* 2022).

Although a growing number of cities have adopted stand-alone sustainability and resilience plans (Opp, Mosier, and Osgood 2018), survey data suggest they remain a distinct minority among the approximately 19,495 municipal governments incorporated in the US (2017 US Census of Governments). Moreover, we have little evidence about what strategies smaller local governments are adopting, because they are frequently excluded from national surveys. However, many more US cities – large and small – have engaged in some form of comprehensive planning. An unanswered question is whether these plans are suitable vehicles for resilience or sustainability-related policies (Campbell 1996, 2016). Drawing from a subset of small to mid-sized US municipalities in Indiana, we explore the relationships between these components through a text analysis of comprehensive plans.

4. Data and methodology

4.1. Indiana background

We focus on local government planning in one US state in order to control for the higher order constitutional or regulatory rules for land-use planning which are likely to vary by state. Indiana represents a "hard case" for this study due to its economic and environmental challenges along with an historical reluctance to embrace professional planning (Lindsey *et al*. 2005). Indiana faces several long-term social and environmental challenges (McCabe *et al.* 2022). Like much of the US Midwest with post-industrial legacy cities, the state has experienced slow economic and population growth in recent years[1], and releases more chemicals and pollutants per square mile into the air, water and land than any other state.[2] In 2018, Indiana ranked second in the nation for coal consumed in electricity generation, and third in the nation for coal usage in the industrial sector. Indiana is the eighth-largest coal producer in the nation.[3]

Despite these socio-environmental challenges, dozens of Indiana cities and towns have set a course in recent years to try to address resilience- and sustainability-related issues. Since 2019, more than two dozen local governments have conducted inventories of the GHG emissions of their communities and government activities, and more are planning to adopt climate-action plans (CAPs) which would map out strategies for achieving carbon reduction goals. Small municipalities tend to be ignored in academic research on urban sustainability and resilience (Levesque, Bell, and Calhoun 2017; Portney 2013). Yet, an indeterminate number of cities have also begun efforts to include sustainability, resilience and climate change-related goals or strategies within their comprehensive plans.

Unlike many European countries which feature coordinated or overlapping national, regional and local spatial and land-use planning, most US local governments are not generally required to coordinate with other governments on spatial planning and states are free to set their own local planning requirements. Indiana does not require municipalities to conduct comprehensive planning and abolished its state-planning agency in 1981 (Lindsey *et al*. 2005). Roughly half of the state's 305 cities and towns with 1,000

in population or greater had adopted comprehensive plans to guide development during the study period (1990-2022). The only requirements for local comprehensive plans are that they include a statement of (1) future development, (2) land use, and (3) public utilities and infrastructure.[4] Cities are free to adopt many other optional plan elements, including parks and recreation, flood control, transit, natural resource protection, conservation, farmland protection, education, health and wellness, and redevelopment of blighted areas.[5] This flexibility makes them important potential vehicles for resilience and sustainability strategies.

4.2. Data development and text analysis methods

The sampling frame consists of all Indiana cities and towns with populations of 1,000 or greater in the 2020 US Census (N ¼ 305). For each of these municipalities, we compiled social, economic, demographic and government financial data from the 2010 and 2020 US Census and the 2017 US Census of Governments. These data allow us to create measures of the form of government for municipalities (a town, which is typically below 3,000 in population in Indiana, versus a city with a mayor-council form of government); the percentage of the population who are Black; the percentage of the population who are homeowners; the percentage who are below the federal poverty level; and the percentage with four-year degrees or higher. Finally, we include the percentage of the municipality's land area which is in agricultural use and the developed land area within a 100-year or 500-year floodplain in 2010, using flood hazard data from the US Federal Emergency Management Agency (FEMA). Descriptive statistics are reported in Table 1.

We then collected 159 publicly available comprehensive plans by visiting the government websites or contacting public officials for each local government through emails and phone calls. We collected plans from August 2020 until April 2022 and attempted to compile the newest version of comprehensive plans. The plans were then pre-processed in R to extract text and create the corpus for analysis. The average age of the plan in 2022 was 9.7 years old.

The analysis proceeded in three stages of supervised and unsupervised methods. First, using a dictionary method, we auto-coded the corpus to evaluate aspects of "plan quality." This stage aims to examine the strengths and weaknesses of the planning process and elements, including its: (1) Goals; (2) Fact base; (3) Policy objectives; (4) Public Participation; (5) Inter-organizational coordination; and (6) Implementation and Monitoring.

Table 1. Descriptive statistics for Indiana municipalities (N ¼ 295).

	Mean	Min.	Max.
% Black	0.032	0	0.784
% Poverty	0.133	0.011	0.321
% College	0.113	0.011	0.406
% Homeowner	0.731	0.095	1
% Town	0.60	0	1
Population	14,203	864	864,447
% Agriculture	0.151	0	1
% Floodplain	0.79	0	0.95

As previously discussed, plan quality evaluation is a methodology which uses content analysis to measure the strengths and weaknesses of plans (Berke and Godschalk 2009; Woodruff and Stults 2016; Woodruff *et al*. 2018). This allows us to quantitatively assess the thoroughness of the planning process in each jurisdiction.

This plan evaluation method has been typically conducted via hand-coding and used for qualitative evaluation of planning content and quantitative measurement for comparison and statistical analysis (Woodruff *et al*. 2021; Berke and Godschalk 2009; Meerow and Newell 2019). This study is the first of which we are aware of to automate the coding of a subset of these criteria – goals, public participation, fact base, strategies and implementation – using a dictionary-based, auto-text analysis algorithm. Table 2 reports the 19 metrics coded.

Using the R *quanteda* package, we first selected sentences that include keywords that correspond with each metric. Then, we created a logical function to determine whether keywords were used and described in a proper context and in accordance with each metric. For each of these metrics, the plans were coded "1" if the metric was present and "0" if it was absent. From this, we calculated the percentage of the 19 metrics present in each plan by aggregating the dichotomous values across criteria in the plan and dividing by 19. These scores were merged with US Census data on local government financial, social and economic conditions. This allows us to initially assess some strengths and weaknesses within a municipality's planning process and identify underlying relationships between planning and community and biophysical conditions.

The second stage of the analysis relies on recent advancements in the use of Natural Language Processing (NLP) for studying comprehensive plans (Brinkley and Stahmer 2021). Topic modeling is becoming an increasingly utilized method within the social sciences for analyzing large unstructured text collections (Boussalis and Coan 2016; Grimmer and Stewart 2013). The most common type of topic model is the latent Dirichl *et al.* location (LDA), introduced by Blei, Ng, and Jordan (2003), in which a latent "topic" is reflected as a discrete distribution over words with a probability vector, and each document in a corpus is assumed to have its own distribution over the topics (Wallach *et al*. 2009). In essence, this approach is one way to explore and analyze large collections of textual data, making an assumption that the interdependence between words in a document is explained by the latent topics it contains (Blei, Ng, and Jordan 2003; Blei and Lafferty 2009).

LDA is a Bayesian mixed model used for discrete data in which each document is modeled as a mixture of topics, with the number of topics being determined *a priori* by a topic-by-document distribution parameter (Blei, Ng, and Jordan 2003). In statistical applications such as the *lda* package in R, the model is used to determine clusters of words associated with topics, which topics are present across a corpus of documents, and the likelihood of any given topic being present in a specific text, thus giving us some picture of the underlying themes which emerge within and across a corpus of government documents (Anastasopoulos, Moldogaziev, and Scott 2020). As such, it is an unsupervised modeling algorithm which depends on humans to both interpret the meaning of the clusters and to set values for three hyperparameters prior to estimation: the number of topics; the expected distribution of topics across documents (alpha); and the commonality of specific words across clusters (beta).

Based on diagnostic results reported in Appendix A (online supplementary material), we created topic models with 10 topics using the *topicmodels* R package. The visualized Dendrogram in the Appendix displays the clustering of topics. Three topics

Table 2. Plan quality metrics by evaluation criterion ($N = 159$).

Metric	Description	Adoption %
Goals		
Plan Purpose	States the purpose of the plan.	93.71
Vision Statement	Includes a vision statement, which establishes an overall image of a desired future (Berke *et al*. 2006).	71.07
Participation		
Participation techniques	Mentions participation techniques used to create the plan, such as meetings, surveys, charettes, public comments on drafts, etc.	88.05
Public meeting	States that meetings were used to engage stakeholders and that these meetings were open to the public.	66.67
Steering Committee	States that a steering committee or advisory committee was used to guide plan creation.	69.18
Coordination		
Federal Agencies	States that federal agencies were engaged in the planning process.	19.50
State Agencies	States that state agencies were engaged in the planning process.	37.11
Fact Base		
National Study	States that national studies were used to inform the plan. Studies may include climate, demographics, economic projections, etc.	84.91
International study	States that international studies were used to inform the plan. Studies may include climate, demographics, economic projections, etc.	0.0
Presidentially declared disaster	Indicates that the community has experienced a presidentially declared disaster.	0.0
Vulnerability	Clearly indicates that a vulnerability assessment was undertaken as part of the planning process. A vulnerability assessment includes an analysis of exposure, sensitivity, and adaptive capacity.	5.03
Risk Assessment	Clearly indicates that a risk assessment was undertaken as part of the planning process. A risk assessment includes an assessment of the likelihood and consequence of an event	1.26
Strategies		
Energy Conservation	Includes strategies to reduce energy consumption.	16.98
Green Infrastructure	Includes green infrastructure strategies aimed at providing protection from climate hazards.	20.75
Land Use Strategy	Includes land use strategies focused on preparing for climate change.	91.19
Water Conservation	Includes strategies focused on reducing water consumption.	8.18
GHG Mitigation	Strategies that explicitly focus on reducing greenhouse gas emissions.	9.43
Implementation		
Responsibilities	Assigns responsibility for policies broadly to organizations or agencies.	21.38
Mainstreaming	Discusses integration of climate adaptation into other sector policies or plans.	0.63

were of particular relevance to this analysis: "Topic 1: quality of life," "Topic 10: green stormwater infrastructure," and "Topic 3: housing." We then estimated Heckman selection models to examine whether these topics are correlated with biophysical and community characteristics drawn from the IAD framework. We elaborate on these topics and the selection models in the results section.

5. Results

We find evidence that the strategies embedded within comprehensive plans do "mainstream" community preferences for lifestyle amenities as well as some responses to extreme weather vulnerability. As such, long-range land-use plans are serving as a vehicle for embedding resilience or sustainability strategies. Heterogeneous group preferences appear to play an important part, which runs counter to one narrative that such plans are merely symbolic or generic products which "sit on a shelf," (Berke and Godschalk 2009). Specifically, we find that communities that are more highly educated and less racially diverse focus more on "quality of life" amenities within their plans. By contrast, communities that are more racially diverse focus greater attention on green stormwater infrastructure and housing, which are considered more environmental and social sustainability-related themes.

Cities with more developed land within floodplains are less likely to focus on green stormwater infrastructure and more likely to focus on housing, which may reflect a "lock in" effect from past development patterns. Meanwhile, plan "quality" is negatively associated with an amenities' focus, suggesting cities that codify such quality of life goals may focus less on incorporating a diverse cross-stitch of citizenry in planning, coordinating with stakeholders and adopting climate-related policies. Taken together, these findings indicate that comprehensive planning can serve as both a means for re-enforcing exclusivity as well as highlighting community needs related to resilience challenges or sustainability goals.

5.1. Supervised method: plan quality evaluation

The first stage of the analysis finds wide variability in the "quality" of comprehensive plans, which may speak to the exhaustiveness and inclusivity of their planning processes. We find that, in the presence of greater social needs, plan quality is also generally higher. In diagnosing the presence of the 19 metrics capturing planning and management criteria, we find the mean score of the plans was 37.1%, with a maximum value of 63.2%. This means that the vast majority of municipal plans contain less than half the metrics, which would indicate "high-quality" planning. The plans scored the highest in goals (82.4% of the total points possible) and public participation (74.6%), followed by policy objectives (29.3%), coordination (28.3%), fact base (18.2%) and implementation and monitoring (11%). This suggests comprehensive land-use planning processes devote more attention to developing aspirational visions or goals for the future and pay less attention to the specific pathways or capabilities for achieving them. Despite the overall low score, the analysis identified subsets of municipalities that have embedded energy conservation (17%), green infrastructure (20.7%), water conservation (8.1%) and greenhouse-gas emissions reduction strategies (9.4%). A large majority of the plans also featured land-use strategies that could be used to address climate change by reducing vehicle-miles traveled.

We then estimated a Heckman selection model to identify correlates of plan quality. Because the analysis focuses on Indiana municipalities that have adopted comprehensive plans, the dependent variable of planning quality is unobserved for roughly half the 305 cities and towns in our sample frame. This is incidental truncation, in which sample selection bias can occur as the dependent variable is observed only if other variables take on particular values (Semykina and Wooldridge 2013). In this case, we expect that municipalities with larger populations will have the capacities and demands to engage in planning, so we use population data (natural log transformed) from the 2010 US Census as a predictor of whether cities "selected" into the planning process.

The Heckman selection model accounts for the age of the plan, the percentage of the population with at least a four-year college degree, the percentage of the population who are Black, the percentage of households who are homeowners, whether the municipality was a town form of government, development is the floodplain and in agricultural use, and the percentage of the population below the federal poverty line. Table 3 reports the results. As expected, population has a positive, statistically significant association with the adoption of a comprehensive plan ðb ¼ 0:574, t ¼ 7:77, $p < 0:000$Þ: The age of the plan was negatively associated with plan quality in the full model ðb ¼ −0:116, t ¼ −4:89, $p < 0:000$Þ: Meanwhile, the percentage of the population in poverty was positively associated with plan quality ðb ¼ 8:4, t ¼ 2:21, $p < 0:01$Þ:

Generally, this suggests municipalities that are larger are more likely to adopt plans, while plans that were newer were more likely to display a higher overall quality score. The poverty finding also suggests – given the metrics captured in the outcome measure – that communities with greater social needs generally incorporate a broader array of participation, coordination, policy and implementation methods. In other words, they are generally more thorough in linking plan aspirations to implementation realities.

5.2. *Unsupervised method: plan topics*

The second stage of the analysis focuses on the substantive prevalence of specific strategies. We identify three relevant shared strategies via topic modeling, which we

Table 3. Heckman selection model for comprehensive planning quality.

	Coef.	S.E.	*p*-value
Plan score			
Black (%)	0.987	5.57	0.85
Poverty (%)	8.47	3.83	0.027*
College (%)	2.58	2.97	0.385
Plan age	−0.116	0.023	1.67e-06***
Homeowners (%)	0.525	1.12	0.64
Town FOG	0.033	0.475	0.943
Agriculture (%)	−0.669	0.749	0.372
Floodplain Dev. (%)	0.163	0.277	0.557
Comp. plan selection			
Population (logged)	0.574	0.073	1.48e-13***
Intercept	−4.793	0.621	2.15e-13***
Inverse Mills Ratio	−1.875	0.757	0.0138*

Note: No. of observations ¼ 295, Censored observations ¼ 144, Selected observations ¼ 151.
*$p<0.05$; **$p<0.01$; ***$p<0.001$.

argue may reflect resilience or sustainability concerns: green stormwater infrastructure (GSI); quality of life (QoL); and housing. Word clouds for these topics are displayed below (see Figures 2-4). To examine the biophysical and community characteristics associated with these topics, we then generated three outcome variables by calculating the proportion of the terms in each of the three topics relative to the total number of terms within the plan. Similar to the previous plan quality model, we then estimate Heckman selection models with these concentrations of topic terms as the outcome.

The first shared strategy we examine (topic 10) we label "green stormwater infrastructure" or GSI. Green infrastructure refers to the use of landscape- or site-scale natural improvements such as green roofs, rain gardens, bioretention systems and tree canopies to restore a range of ecosystem services (Woodruff *et al*. 2021). GI can provide a range of climate-mitigation, heat reduction, flooding control and wildlife habitat improvements, so much so that many national governments and planning organizations have sought to mainstream GI principles within the land-use and development planning of local governments. In the US, GI strategies tend to focus on stormwater management, in which green improvements are aimed at mimicking the natural flow of water on undeveloped surfaces, and thus reduce flooding and pollution releases from combined sewer overflows (CSOs) which occur frequently in aging sewer/stormwater systems (Matsler et al. 2021; Meerow 2020). Indiana has more than 100 communities experiencing CSOs, which are overseen by state and federal agencies.[6] We see evidence in Figure 2 that Indiana's comprehensive plans do appear to incorporate GSI terms such as "stormwater management," "green infrastructure," "green urbanism," and "sanitary district" into a single comprehensive planning topic. The colors are assigned based on their relative frequency. Bigrams in gray have the relatively highest

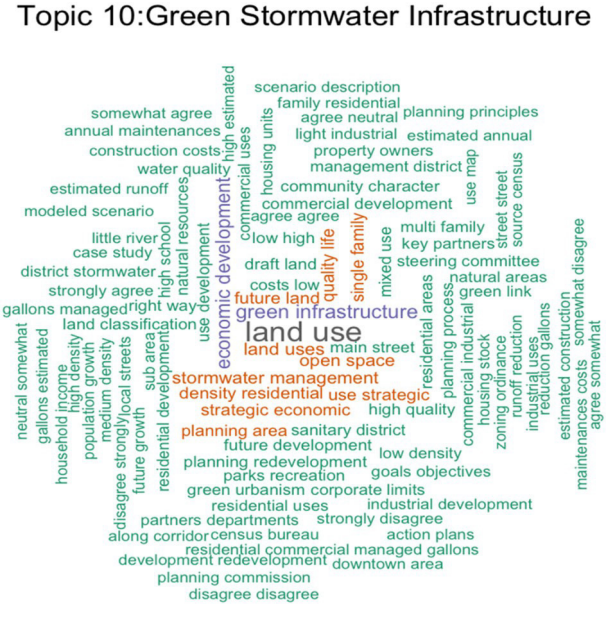

Figure 2. Green stormwater infrastructure terms include stormwater management, sanitary district, green urbanism, and green infrastructure. Colors are assigned based on their relative frequency. Bigrams in gray have a relatively higher frequency than those in purple and orange. Phrases colored in green have a relatively lower frequency than those in other colors. Colour online.

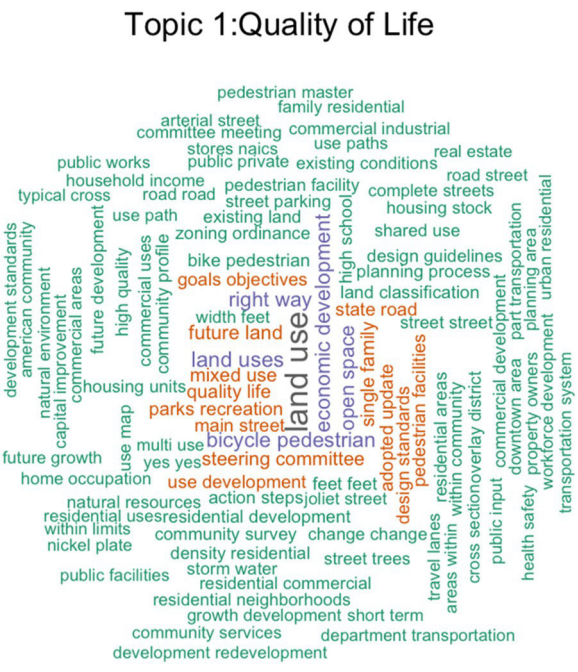

Figure 3. This quality of life topic displays the highest-frequency terms focusing on lifestyle amenities such as cycling, pedestrian infrastructure, open space, parks and street landscaping.

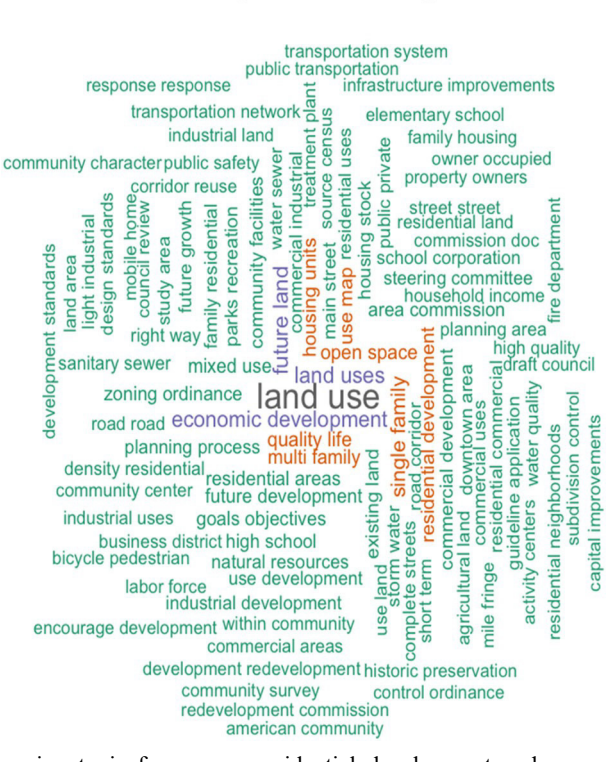

Figure 4. This housing topic focuses on residential development and encompasses highest-frequency terms such as single-family housing, multi-family housing and mixed-use development.

frequency and green have the lowest. Despite no requirement that Indiana comprehensive plans address flooding or water pollution, this result indicates a number of cities are going beyond the bare minimum requirements of state law.

Results from the GSI Heckman selection model are reported in Table 4. Pertaining to biophysical characteristics, we find that the percentage of land in agricultural use is positively associated with GSI ðb ¼ 0:014, t ¼ 2:4, $p < 0:05$Þ, while the percentage of developed land in a 100-year or 500-year floodplain is negatively associated with GSI ðb ¼ −0:007, t ¼ −3:5, $p < 0:000$Þ: A possible explanation for this result is that cities with more land in agricultural production tend to be less developed, meaning they have more land available for GSI. Agricultural production also tends to increase fertilizer and waste-based nutrient runoff into water systems, increasing the need for GSI to serve as a potential natural pollution filter. Conversely, cities that are more developed face greater flooding risks from heavy rain events and may theoretically benefit from GSI options, but also have less available land for these types of projects.

Pertaining to community characteristics, we find evidence that communities that are more racially diverse had plans with greater concentrations of GSI. The percentage of the population who were Black was positively associated with the GSI topic concentration ðb ¼ 0:19, t ¼ 9:09, $p < 0:000$Þ: We find some evidence that the level of education in the community is also negatively associated with GSI, although the significance of this finding is weaker ðb ¼ −0:04, t ¼ −1:85, $p < 0:1$Þ: This suggests communities with greater concentrations of historically marginalized or vulnerable populations are generally more likely to adopt GSI strategies to ameliorate environmental threats.

As with the plan quality model, population size is a statistically significant factor in municipal decisions to select into the comprehensive planning process, although plan quality and plan age (which are related) do not appear to influence the prevalence of the GSI topic.

Table 4. Heckman selection model for green infrastructure strategies.

	Coef.	S.E.	p-value
GSI			
QoL	4.930e-01	1.060e-01	5.16e-06***
Housing	2.565e-01	1.112e-01	0.021*
Plan score	-4.025e-05	6.200e-04	0.948
Black (%)	1.926e-01	2.120e-02	< 2e-16***
Poverty (%)	-2.917e-02	2.947e-02	0.323
College (%)	-4.160e-02	2.254e-02	0.06
Plan age	2.194e-04	2.013e-04	0.276
Homeowners (%)	-1.374e-03	8.475e-03	0.871
Town FOG	-1.802e-03	3.615e-03	0.618
Agriculture (%)	1.352e-02	5.631e-03	0.016^
Floodplain Dev. (%)	-7.333e-03	2.072e-03	0.0005***
Comp. plan selection			
Population (logged)	0.574	0.0739	1.51e-13***
Intercept	−4.79	0.621	2.19e-13^^^
Inverse Mills Ratio	0.015	0.005	0.006**

Note: No. of observations ¼ 295, Censored observations ¼ 144, Selected observations ¼ 151.
*p<0.05; **p<0.0; ***p<0.001.

Table 5. Heckman selection model for quality of life strategies.

	Coef.	S.E.	*p*-value
QoL			
GSI	0.274	0.056	1.76e-06***
Housing	−0.089	0.084	0.28
Plan score	−0.001	0.001	0.034*
Black (%)	−0.075	0.018	4.10e-05***
Poverty (%)	−0.006	0.021	0.752
College (%)	0.039	0.016	0.0207*
Plan age	−0.0001	0.0001	0.479
Homeowners (%)	0.0012	0.006	0.853
Town FOG	−0.004	0.003	0.106
Agriculture (%)	−0.001	0.004	0.819
Floodplain Dev. (%)	0.001	0.002	0.5
Comp. plan selection			
Population (logged)	0.574	0.073	1.51e-13***
Intercept	−4.79	0.621	2.19e-13***
Inverse Mills Ratio	−0.011	0.004	0.007**

Note: No. of observations ¼ 295, Censored observations ¼ 144, Selected observations ¼ 151.
*$p<0.05$; **$p<0.01$; ***$p<0.001$.

The second relevant shared strategy we examine (topic 1) is labeled "quality of life." Figure 3 features a clustering of bigrams that can refer to lifestyle amenities such as "quality life," "pedestrian bicycle," "open space," "complete streets," "pedestrian facilities," "natural resources," and "high quality." We surmise this topic captures a planning focus on community liveability but could also capture exclusivity or NIMBYism (Not In My Back Yard) land-use or growth motives which typify upper-income, "bedroom" or suburban communities. In the US, suburban communities have historically tended to draw more affluent and white households and have a long legacy of using land-use regulations for exclusionary purposes (Trounstine 2020).

Table 5 reports the Quality of Life model results. We find the percentage of the population who are Black is negatively associated with a concentration of Quality of Life terms ðb ¼ −0:075, z ¼ −4:17, $p < 0:000$Þ, while education level displays a positive association ðb ¼ 0:039, z ¼ 2:33, $p < 0:05$Þ: We also find some evidence that plan quality is negatively associated with QoL ðb ¼ −0:001, z ¼ −2:14, $p < 0:05$Þ: Generally, communities more focused on QoL within their comprehensive planning were more educated and less racially diverse than their peers. Their plans were also generally less thorough, according to planning quality criteria.

The third relevant shared strategy we examine (topic 3) is labeled "housing" given the concentration of terms such as "single family," "multi-family," "residential neighborhoods," "subdivision control," "future development," and "residential land." While it is important to reiterate that many prevalent bigrams (i.e. land use, mixed use, economic development) appeared across multiple topics, the concentration of housing-related text should reasonably indicate that this topic is more concentrated in communities expressing greater housing needs or demands.

The Housing Heckman model reported in Table 6 shows that plan age is positively associated with greater focus on housing issues ðb ¼ 0:001, t ¼ 3:64, $p < 0:000$Þ: Generally, older plans focus more on housing needs or issues, which is consistent with

Table 6. Heckman selection model for housing strategies.

	Coef.	S.E.	*p*-value
Housing			
GSI	1.285e-01	5.667e-02	0.024*
QoL	-8.038e-02	7.723e-02	0.29
Plan score	-1.043e-04	4.411e-04	0.81
Black (%)	-2.625e-02	1.734e-02	0.131
Poverty (%)	-4.369e-03	2.082e-02	0.833
College (%)	8.570e-03	1.619e-02	0.597
Plan age	5.026e-04	1.382e-04	0.0003***
Homeowners (%)	4.678e-03	6.048e-03	0.439
Town FOG	4.166e-05	2.566e-03	0.987
Agriculture (%)	1.345e-03	4.239e-03	0.751
Floodplain Dev. (%)	3.086e-03	1.552e-03	0.047*
Comp. plan selection			
Population (logged)	0.574	0.073	1.51e-13***
Intercept	−4.793	0.621	2.19e-13***
Inverse Mills Ratio	−0.003	0.004	0.47

Note: No. of observations ¼ 295, Censored observations ¼ 144, Selected observations ¼ 151.
*$p<0.05$; **$p<0.01$; ***$p<0.001$.

the notion that communities have more recently begun incorporating broader themes in their plans. The percentage of developed land in a floodplain is also positively associated with the housing focus ðb ¼ 0:003, t ¼ 1:98, $p < 0:05$Þ: Although population is again positively associated with selecting into planning, the Housing model is the only model in which the inverse mills ratio is not statistically significant. These results indicate that housing issues were generally a more prominent feature of older plans as well as for communities willing to allow construction in more flood-prone areas.

6. Discussion and conclusion

Planning for the complexity of climate change is becoming a ubiquitous endeavor across many larger cities in urban regions. This increased attention to systems-thinking and sustainability raises several important by under-addressed concerns. First, we know little about how or why cities integrate planning or differentiate new resilience and sustainability efforts from the pre-existing planning processes they employ. Are land-use planning efforts already in place adequate for mitigating and adapting to the aforementioned multi-hazard risks created by the climate crisis? If not, how can policymakers and managers coordinate across ecologies of plans to deal with myriad social, ecological and economic spillovers?

Moreover, little is known about the planning efforts of smaller and more policy- or resource-constrained local governments. Determining how these communities adapt (or fail to do so) will be critical to addressing disparities of climate impacts across urban and rural divides. The findings from this study hint at some potential answers, but much work to extend and build upon the findings is warranted. Our first research question asked: what objective planning and management criteria (i.e. goals, strategies, fact base, participation) are common within smaller US cities? This is important for establishing some baseline understanding of the comprehensiveness, thoughtfulness and inclusivity of planning processes, and where they might be improved. Our findings

suggest that plan quality is improving over time, and public participation mechanisms are strengths. However, strategies geared toward dealing explicitly with climate risks and environmental change are rare. Moreover, population size was an important predictor of whether cities and towns in the sample had a plan at all. While some cities in the sample have engaged in sustainability, climate and multi-hazard mitigation planning outside of their comprehensive planning framework, many of the largest sustainability-related challenges local governments can influence involve land use. Thus, comprehensive land-use planning is an under-utilized process for making these challenges more explicit and embedding their consideration in political decision-making. Land-use planning centers on the spatial investments in infrastructure which drive growth and influence many of the sustainability-related performance metrics cities purport to prioritize. This is evidenced by the frequency with which the bi-grams "land use" and "economic development" appear throughout the plans. Improving the quality of comprehensive planning processes – through more rigorous use of available science and data, and explicit climate-related strategies – is a necessary first step toward integrating planning into sustainability management and performance. Future research extensions should focus on the extent to which planning strategies are translated into policy and programmatic actions.

Our second research question asked whether cities were using the flexibility of planning parameters to focus on cross-cutting or multidimensional topics. We found evidence from the topic modeling that green stormwater infrastructure is one such cross-cutting shared strategy that cities are incorporating through their land-use plans. We also identified housing and quality-of-life as strategies which appeared more concentrated or clustered. This suggests that cities and towns in Indiana were moving beyond the "bare minimum" comprehensive planning elements required by state law. They are willing to use comprehensive planning to tackle some systems-level issues.

Cities are complex social-environmental systems, and planning is one theoretical and practical method policymakers and public managers have for attempting to monitor and guide resource investments. The conceptual fuzziness around sustainability and resilience notwithstanding, it is clear cities use planning processes to influence both social and environmental system components, although researchers still lack many generalizable insights about how planning efforts impact the sustainability of services cities wish to preserve. Future research here can examine the extent to which planning strategies link aspirations to organizational capacities and specific performance metrics.

Finally, we examined biophysical and community characteristics which appeared to influence the inclusion of these topics. We find that comprehensive planning has the potential to function as both a means for addressing environmental injustices as well as preserving various forms of exclusivity within communities. The fact that localities with more racial diversity were more likely to focus on GSI in their plans could indicate that these communities were more likely to be urban and suffering from greater environmental pollution. Many of Indiana's most diverse cities – including Gary, South Bend and Indianapolis – are also under consent orders through the US Environmental Protection Agency to reduce the combined sewer overflows which have fouled their waterways. GSI is often a lower-cost and more co-beneficial approach for addressing stormwater issues. Meanwhile, communities with less racial diversity and higher educational attainment were more likely to focus on the quality-of-life amenities which likely serve to attract more affluent residents and maintain or improve property values. The low priority placed on themes such as affordable housing across the plans

indicates that social-equity is not a high priority across Indiana plans, although housing generally – through multi-family, mixed use and other terms – does feature prominently in some older plans.

In conclusion, we find strong evidence that comprehensive plans across a sample of smaller US municipalities are not monolithic documents. They do vary in their emphasis and have been used to signal or address varied resilience and sustainability-related strategies. What remains to be theoretically and empirically developed is the limit of their potential to serve as organizing processes for guiding implementation and performance management in cities. This reflects the institutionalization of shared-strategies, as conceptualized within the IAD. Thanks to advancements in textual analysis and data science, future research can and should consider the extent to which these shared-strategies are translated into policy and programmatic actions and outcomes.

Notes

1. https://news.iu.edu/stories/2022/03/iub/releases/24-indiana-census-smallest-population-increase.html
2. https://www.epa.gov/toxics-release-inventory-tri-program
3. https://www.eia.gov/state/?sid=IN#:~:text=In%202020%2C%20Indiana%20ranked%20third,generation%2C%20after%20Texas%20and%20Missouri.
4. IC 36-7-4; IC 36-7-1
5. https://indiana.planning.org/knowledge-center/citizen-planners-guide/
6. https://www.in.gov/idem/cleanwater/information-about/combined-sewer-overflow-cso-program/

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Supplemental data

Supplemental data for this article can be accessed online at https://doi.org/10.1080/09640568.2023.2240951

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