

Dashboard e Indicatori sul Climate Change per i Planning Decision Support Systems

Climate Change Dashboard and Indicators for Planning Decision Support Systems

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Received: February 2026 / Accepted:
June 2026 | © 2026 Author(s).
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Firenze University Press.
DOI: 10.36253/contest-17163
www.fupress.net/index.php/contesti/

keywords

planning decision support
system
urban visual analytics
geospatial dashboards
monitoring (city)
performance
data visualization

1. Introduction and Method

There is still considerable confusion among various visualisation techniques and technologies. It's often difficult to distinguish between

an infographic, a web GIS, a website, or any other navigable platform with interactive data visualisation. At the same time, people talk interchangeably about Urban Visual Analytics, City (or Regional) Dashboards, and Geospatial Dashboards for Monitoring City (or Regional) Performance. The rationale behind these definitions is often different, misunderstood, or not yet publicly available. This latter aspect requires careful attention, especially methodologically, if the

What are geospatial dashboards, and how can they support planning and Planning Decision Support Systems (PDSS) addressing Climate Change (CC)? Starting from the literature, the paper analyses dashboards and their indicators as used in planning, proposing criteria for an integrated, dynamic, and operational PDSS for diverse plan recipients at local and global scales. The research employs an exploratory design in three steps: a historical-conceptual review of the dashboard tool; a comparative analysis of eleven dashboards classified by layout

style (one-page vs. drill-down), user action type (visualisation vs interaction), and objectives (operational, analytical, strategic) according to Jing et al. (2019); and a benchmark of CC indicators from scientific literature and international organisations. The results reveal ongoing trends and the lack of shared protocols. The paper concludes by emphasising the temporal mismatch between real-time dashboards and the longer timescales of planning.

tool is intended for a planning decision support system (PDSS). The situation is further complicated if the data visualisation concerns Climate Change (CC), as the core sets of indicators used are still heterogeneous and far from an international standard.

The paper follows an exploratory research design structured around three sequential steps, aimed at identifying a reference framework and criteria for the conceptual prototype of a geospatial dashboard for planning and PDSS, which also consider the issue of CC.

The first step is a historical and conceptual literature review of dashboards, tracing their genealogy from the historical origin as public transport's instruments to contemporary smart city platforms.

The second step is a comparative analysis and typological study of geospatial dashboards. Starting from the distinctions between dashboard types (operational, analytical, strategic) and GUI styles (one-page and drill-down) and

using the sample of Jing et al. (2019), composed by ten international cases (London CityDashboard, UK; Dublin Dashboard, Ireland; Bandung Dashboard, Indonesia; Edmonton Citizen Dashboard, Canada; Boston Performance Management, USA; Skopje Dashboard, North Macedonia; Sydney CityDashboard, Australia; Iowa Dashboard, USA; Alaska HMIS Dashboard, USA; and OSU Columbus Dashboard, USA), plus the DATA2GO.NYC of New York (discussed here as a paradigmatic analytical drill-down case), a typology of dashboard were produced.

The third step is an overview and benchmark of Climate Change indicators used in dashboards at various scales, drawing on scientific publications and the reporting frameworks of major international organisations (OECD, EU, IMF, Asian Development Bank). This review maps the most widely used CC indicator categories, highlights the absence of a shared international protocol, and identifies the gaps between existing CC dashboards and the requirements of a PDSS. The three steps together yield: a descriptive typology of existing geospatial dashboards (Tab. 1); a comparative overview of CC indicators; and a set of criteria (Tab. 2) to inform the development of an integrated, dynamic, and operational dashboard prototype for planning and PDSS applications.

2. Brief historical-interpretative review

“A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance” (Few, 2007, p. 1). This definition has various practical applications, partly due to the tool’s diverse origins and hybridisations over time, especially in the context of urban and civic data communication. Three different founding reasons for dashboards can be identified: i) private urban transport in the 19th century; ii) control rooms at the beginning of the last century; and iii) visual (and electronic) analytics in urban and smart city settings starting in the late 1990s. Many dictionaries, including the Oxford English Dictionary, trace the term’s origin to 1847 (or 1846, according to Mattern, 2015). Originally, the term referred to traditional animal-drawn transportation systems (horse-drawn carriages) and, at times, to mechanical transportation systems (early automobiles). The Merriam-Webster Dictionary clearly defines it as i) a screen on the front of a usually horse-drawn vehicle to intercept water, mud, or snow (the originally dashboard); ii) a panel extending across the interior of a vehicle (such as an automobile) below the windshield and usually containing instruments and controls; iii) a graphical report (as on a website) of various data relevant to a particular business, group, decision-maker, etc. The first Control Rooms were created in the 1920s in factories and energy plants.

Other milestones include Churchill’s War Room (active 1938–1945), the Cape Canaveral operations room (1960s), the OpsRoom of the Chilean Cybersyn project (1970s), and the Bloomberg terminal (1982).

The urban turn, which began in the 1990s, evolved through three distinct phases (Jing et al., 2019). The early 1990s focused on technical/KPI development and the introduction of the term “digital dashboard.” The late 1990s to the end of the 2000s saw the emergence of geospatial visualisation and statistical modelling for data extraction and analysis. Key examples include: Compstat (1994), which mapped crime statistics in New York City; the Balanced Scorecard applied to city performance in Charlotte, North Carolina (1994); CitiStat in Baltimore (1999); DCStat (2005); StateStat Maryland (2007); NYCStat (2008); and the Open Michigan Mi Dashboard (2010), which offered open data on education, healthcare, infrastructure, employment, public safety, energy, and finance. From 2010 to the present, geospatial analysis has benefited from greater accessibility through simplified graphical interfaces and increased computing power, including big data capabilities. Noteworthy prototypes include the London City Dashboard (2012), a web platform delivering real-time data on weather, air quality, public transport, and social media, integrated with city agency data and the CASA platform; and the Dublin Dashboard (2014), which combines data from Dublin City Council, the Dublinked regional

initiative, the Central Statistics Office, Eurostat, and various government departments. These platforms enable the visualisation of historical and real-time data, as well as interactive maps, for citizens, politicians, and businesses.

Following these prototypes, numerous urban dashboards—including participatory ones—have emerged. Two notable platforms are urbanAPI (Europe), which supports planners and citizens in urban development decisions, and Citizens Connect (Boston, USA), which enhances civic awareness and enables residents to report issues such as potholes, damaged signs, and graffiti.

3. Styles and possibilities offered by (urban) geospatial dashboards

Jing et al. (2019) distinguish dashboards based on their purposes (Operational, Analytical, Strategic) and Graphical User Interface styles (one-page or drill-down). For operational purposes, the one-page design is most used, offering a synoptic view of information. The London CityDashboard¹ is the canonical example: it displays data from the CASA platform, traffic cameras, monitoring stations, smart grids, newspapers, and social media simultaneously on a single screen, but does not allow selection, exploration, or analysis. It produces a synoptic, passive, and descriptive view – neutral and without reference to specific objectives.

In addition to legitimacy issues of the chosen data model, this type of dashboard suffers from

technical issues related to database connectivity, the unavailability of some data at certain times, and the lack of social learning from the model. The drill-down style, by contrast, is used for analytical purposes and in-depth analysis, often via drop-down menus. Although not included in Jing et al. (2019), DATA2GO.NYC² exemplifies this opposite pole very well: it allows users to explore data and their interactions, choose topics and levels of detail, compare data at various scales (boroughs, community districts, neighborhoods), export results, and understand correlations. With over 400 indicators and the American Human Development Index across 59 community districts, it generates social learning and citizen awareness, stimulates engagement, and could also be used by public agencies. It is a nonpartisan research and advocacy initiative, free and easy to use online. In many cases, however, the boundary between the one-page and drill-down styles is blurred.

Considering this bipartition and the possibility of visualising or manipulating data, it is possible to construct a descriptive classification of dashboard types and produce further reflections (see Tab. 1). Reading the matrix as a whole reveals key patterns. The one-page/visualization quadrant is the most populated – London CityDashboard, Edmonton, Sydney, OSU Columbus, and Bandung in its command-centre mode – confirming that the predominant paradigm in urban dashboarding remains real-time, synoptic, and essentially passive monitoring of city conditions.

These dashboards share low cognitive demand, prioritising speed of perception over depth of analysis, and are addressed to a broad, non-specialised public or to operational managers requiring situational awareness. The drill-down/interaction cell – occupied by Dublin (in its analytical modules), Alaska HMIS, and DATA2GO.NYC – represents the most analytically sophisticated type, enabling multi-level, cross-domain interrogation of large datasets. It is also the type closest to the requirements of a PDSS, allowing users to formulate and test hypotheses, select indicators relevant to specific planning questions, and compare conditions across spatial units. The one-page/interaction quadrant (Bandung, Boston, Iowa) occupies an intermediate position: it retains the single-screen logic but enriches it with filter functions and KPI tracking against targets, making it useful for performance management and accountability. The near-absence of genuinely strategic dashboards across the full sample – tools explicitly designed to monitor the implementation of long-term spatial or sectoral plans – confirms that the PDSS function remains a largely unfulfilled promise in current practice. Transport, environment, and real-time infrastructure monitoring dominate indicator sets, while spatial planning, housing affordability, social equity, and CC adaptation remain marginal, with partial exceptions in Dublin, DATA2GO.NYC, and Alaska HMIS. In addition to operational and analytical purposes, strategic dashboards – related to management

and plan accountability – are the least widespread at the urban scale, likely due to their strong connection to politics, the management of plan actions, and governance accountability. In the eleven dashboards analysed, this type of purpose is almost exclusively linked to transportation management, a fact that indicates this function remains underdeveloped outside of control rooms and/or strictly related to the variability of politics.

4. Climate Change indicators used in dashboards

The key components of a dashboard are its data visualisation capabilities and the information it conveys – precisely these two aspects make the issue of indicators crucial. Indicators serve to measure the level of performance of a given topic, think of the 17 United Nations Sustainable Development Goals. There are different classifications of indicators based on i) their construction (raw data, composite indicators, indices, etc.); ii) their use, whether descriptive, diagnostic, or predictive (Kitchin and McArdle, 2016); iii) their political, thematic, systemic objectives (Alibegovic et al., 2006). It is therefore necessary to use appropriate indicators applied to different dashboards, depending on the level of information exposure to the various targets. This is even more true for indicators and geo-spatial dashboards for Planning and the PDSS, which are contingent, relational tools that function at the level of exchange that politics allows.

User Action \ Dashboard Style	One-Page Style	Drill-Down Style	
Visualization	Synoptic information display PASSIVE, SIMPLE, AND IMPLICIT MONITORING OF URBAN PERFORMANCE London CityDashboard (UK) Edmonton Citizen Dashboard (Canada) Sydney CityDashboard (Australia) OSU Columbus Dashboard (USA)	Structured and Separate Information display PASSIVE, COMPLICATED, AND IMPLICIT MONITORING OF URBAN PERFORMANCE Dublin Dashboard (Ireland) Skopje Dashboard (North Macedonia) Alaska HMIS Dashboard (USA)	
	Interaction Synoptic information visualization and interaction ACTIVE, COMPLEX, AND EXPLICIT MONITORING OF URBAN PERFORMANCE Bandung Dashboard (Indonesia) Boston Performance Management (USA) Iowa Dashboard (USA)	Structured and separate information visualization and interaction ACTIVE, COMPLICATED, AND EXPLICIT MONITORING OF URBAN PERFORMANCE Dublin Dashboard (Ireland) Alaska HMIS Dashboard (USA) New York DATA2GO.NYC (USA)	
Dashboard	Domains (incl. Planning)	Target Users	Key Indicators
London CityDashboard (UK)	Transport, environment, energy demand, urban planning, social media, weather	Citizens, public workers, businesses	Tube line status, air quality, noise levels, river levels, weather, Twitter trends, traffic cameras, number of bicycles, energy grids
Dublin Dashboard (Ireland)	Urban planning, housing, economy, transport, environment, health, crime, community services	Citizens, public sector workers, businesses, researchers	Planning applications, house/rent prices, travel times, parking, air quality, hospital waiting lists, crime rate, unemployment
Bandung Dashboard (Indonesia)	Urban planning, public services, infrastructure, smart city governance	Citizens, local government officials	Public service delivery metrics, infrastructure status, city governance KPIs, population data
Edmonton Citizen Dashboard (Canada)	Transport, urban planning, public services, strategic city goals (The Way Ahead)	Citizens, municipal administrators	Traffic injury rates, pothole repair rates, on-time bus arrivals, KPI progress toward city strategic targets
Boston Performance Management (USA)	Urban planning, public administration, city services, finance, infrastructure	Public managers, city officials, citizens	Service request completion rates, budget expenditure, infrastructure maintenance, public safety response times
Skopje Dashboard (North Macedonia)	Urban planning, environment, mobility, public space management, smart city governance	City planners, public sector, researchers	Citizen mobility heat maps, air quality, noise levels, public space usage, configurable sub-indicators per district
Sydney CityDashboard (Australia)	Transport, environment, urban planning, energy, infrastructure, liveability	Citizens, businesses, urban planners	Traffic conditions, energy demand, environmental quality, real-time event data



Dashboard	Domains (incl. Planning)	Target Users	Key Indicators
Iowa Dashboard (USA)	Public administration, finance, transport, urban planning, education, health, infrastructure	State government officials, public administrators, citizens	State-wide KPIs across departments; chart and graph-based visualisation with advanced filter functions for cross-domain analysis
Alaska HMIS Dashboard (USA)	Social services, housing, health, homelessness management (planning support)	Social service agencies, public health administrators, policy makers	Homelessness counts, shelter utilisation rates, service access metrics, demographic breakdowns
OSU Columbus Dashboard (USA)	Smart mobility, urban planning, infrastructure, environment, community development	Urban researchers, city planners, public administrators	Mobility metrics, connected vehicle data, environmental indicators, neighbourhood-level urban performance
New York DATA2GO.NYC (USA)	Health, education, income/economy, environment, public safety, housing, urban planning, political engagement, social services	Citizens, community organisations, non-profits, policy makers, researchers, public administrators	~350 indicators across 59 community districts and 150+ at census-tract level: American Human Development Index, poverty rate, educational attainment, cancer mortality, pre-term births, median income, housing, public safety, political engagement; customisable dashboard with MAPS, DASHBOARDS, and CONNECTIONS (correlation analysis) modules

Classification of (urban) geospatial dashboards by user action type and layout style, with detailed overview of each dashboards.

Source: our own elaboration, based in Jing et al. 2019
Tab. 1

Even the selection of data and visualisation options are never neutral and objective, but always contextual and situational within the various moments of consultation and/or negotiation in the complex public decision-making process. This is one reason (along with technical issues) why the literature lacks standard data visualisation tools directly and operationally connected to Planning.

There are no known cases of urban dashboards simultaneously connected to Planning and CC at the urban or local level. CC dashboards are most common at large scales (regional, national, or global) and are not anchored to planning issues.

In Italy, the most well-known and accessible climate dashboards are those of the Regional Environmental Protection Agencies (ARPA). The indicators used – surveys from monitoring stations, measurements, or calculations – can monitor climate conditions and changes (physical, ecological, and social), assess risks, climate vulnerabilities, and resilience, and provide early warnings (Martin, 2025).

From a literature review (Whitney et al., 2020; Refianti et al., 2024; Sinha and Rathore, 2025; Ascione et al., 2026) and an analysis of CC dashboards used by various international bodies and organisations (OECD as paradigm of other

institution, such as EU, US, Canada, Asian Development Bank, IMF, etc.), it is possible to draw some conclusions regarding the most widely used CC indicators, without claiming to be exhaustive. What immediately emerges is the diversity of indicators, highlighting the lack of a core set and/or a protocol shared internationally and within the scientific community. The most used indicators relate to macro-categories of Temperature and Precipitation, but also Wind. These include common indicators (average temperatures in °C; monthly or annual rainfall in mm), relative indicators constructed against baselines and/or time intervals (average annual air temperature; average air temperatures >1.5°C by 2050), point indicators for specific areas (decrease ~9% in sea surface salinity at the mouth of the Homathko River; etc.), complex indices (UNEP Aridity Index; Population Heat stress exposure; Burnt area by land cover type; Standard deviation of rainfall days per month), and different thresholds for similar problems (thermal comfort <25°C and Heat stress >32°C).

In short, the issue of indicators – and CC indicators – is fundamental, but must be considered within Innes and Booher's (2000) framework: indicators should not be used simplistically to measure only policy interventions and planning, as these are too general and limited, and the effects of policies and planning are too diverse and complex. They are indicators, not responses. They must be considered within a social pact, with the broadest possible sharing of indicators and

protocols and taking into account the best possible trade-off between impacts and benefits.

5. Reflections on an integrated, dynamic, and operational tool for the Planning Decision Support System

Despite the widespread adoption of visualisation technologies, geospatial dashboards remain far from serving planning effectively. Unresolved questions persist: should dashboards be reserved for specialised stakeholders or opened to broader audiences – enabling communication, social learning, and accountability monitoring? A third approach is possible: multiple dashboards with varying degrees of openness and purpose, raising the trade-off between standardising indicators and contextual specificity. Wide customisability can improve a user's span of control (Kitchen et al., 2015), making dashboards relevant for politicians, officials, and citizens alike – but also exposing the risk of mass manipulation that no PDSS design can ignore.

The four dashboard types identified in Tab. 1 must be read against the temporal structures of planning. One-page/visualisation dashboards operate in real-time or sub-daily cycles – well aligned with operational decision-making (traffic, energy, emergency response) – but their temporality is that of the event: immediate, reactive, ephemeral. Spatial and strategic plans, by contrast, unfold across five-to-fifteen-year horizons, punctuated by review cycles, public consultation phases, and legal procedures.

Categories of Climate Change Indicator	Whitney et al. (2020)	OECD (2023)
Temperature	-Average air temperatures > 1.5°C by 2050, 2.5°C by 2080, ~8.5°C (low emissions, RCP2.6) to ~12°C (high emissions, RCP8.5) by 2091-2100 -Warm days in 2050 and 2080 -Freeze-free days in 2050 and 2080	-Temperature (°C) -Number of hot days -Number of tropical nights -Number of icing days
Sea Surface Temperature	-Average sea surface temperature ~11°C with RCP 2.6 and ~14°C with RCP 8.5 by 2091-2100 compared to 1961-1990 baseline -Increasing sea surface temperature by ~1.8°C and average temperature ~11-13°C by 2065-2078 compared to 1995-2008 baseline	
Sea Surface Salinity	-Declining sea surface salinity by ~1.5% with RCP 2.6 and ~3% with RCP 8.5 by 2091-2100 compared to 1961-1990 baseline; -Declining sea surface salinity by ~1% by 2065-2078 compared to 1995-2008 baseline -decrease ~9% in sea surface salinity at the mouth of the Homathko River -Increase ~2.5% in sea salinity (~0.6 increase in psu unit) at Johnstone Strait by Port Neville	
Humidity (%)		
Precipitation	-Average annual precipitation > 6% by 2050 and 8% by 2080 -decrease ~10% in summer -up ~15% more (low emissions RCP2.6) and ~21% (high emissions, RCP8.5) by 2091-2100 (relative to 1961-1990) -Winter snowfall may decrease by ~25% by 2050 and ~33% by 2080	-Cumulated precipitation (refers to the accumulated liquid and frozen water, including rain and snow, that falls to the Earth's surface, respect to the baseline 1981-2010) -Extreme precipitation days (>20 mm, respect to the baseline 1981-2010)
Sunshine		
Wind	-Stronger Vancouver Island Coastal Current	
Evapo-transpiration		

Refianti et al. (2024)	Sinha and Rathore (2025)	Ascione et al. (2026)
-Minimum temperature (°C) -Maximum temperature (°C) -Average temperature (°C)	-Temperature (°C)	-Average annual temperature -Maximum annual temperature -Cooling degrees days (Summation over a year of the days with average temperature in excess of thermal comfort, 25 °C)
-Average humidity (%)		
-Rainfall (mm)	-Rainfall (mm)	-Maximum monthly average of mm of precipitation -Average number of days per month when a rain event occurred
-Duration of sunshine (jam)	-Slope aspect	
-Maximum wind speed (m/s) -Wind direction with maximum speed (°) -Average wind speed (m/s) -Mostly wind direction (°)	-Wind speed at 10 m height (m/s)	-Maximum wind speed (m/s, annual) -Average wind speed (m/s, annual)
	-Potential Evapo-transpiration (mm)	



Categories of Climate Change Indicator	Whitney et al. (2020)	OECD (2023)
Sea level	Rise of Sea level from 0.6m to 0.9m by 2100	
Wave & Storm	-Storm surge -Flooding as mean sea level increases estimated 75.3cm -Storm surge height for a 100-year storm surge event	-Violent storms
Complex Indicators & Indexes		-Population Heat stress exposure (>32°C) -Urban heat island intensity (daytime and night-time) -Population exposure to fires -Burnt area by land cover type -Forest exposure to wildfire danger -Population exposure to river flooding -Population exposure to coastal flooding -Agricultural drought -Built-up exposure to violent storms (area for at least 1 hour exposed to the wind gust speed >28.6 m/s, threshold based on the Beaufort scale)
Pollution measures		-GHG emissions

A proposal of a CC core indicators for PDSS.

Source: our own elaboration, from different sources
Tab. 2

-UNEP Aridity Index

-Standard deviation of the number of days per month in which a rainfall event occurred
-Difference between the average temperature of urban and rural area

The temporal mismatch between the real-time dashboard and the long-cycle plan is not merely technical but epistemological: situational awareness differs structurally from what strategic planning requires – trend interpretation, scenario construction, policy evaluation, long-term accountability. The drill-down/interaction type – Dublin, DATA2GO.NYC, Alaska HMIS – is better suited to planning temporalities, but even these tools are rarely anchored to the monitoring frameworks of a formal plan. Bridging the gap between dashboard as observatory and dashboard as planning instrument requires at minimum: (i) a stable indicator set linked to plan objectives; (ii) integration of real-time feeds and slower-update structured datasets; (iii) differentiated audiences – citizens need near-real-time access; planners need longitudinal depth; politicians need synthetic, goal-referenced indicators updated at politically meaningful intervals. CC indicators add a further layer of temporal complexity. CC phenomena unfold across decadal or centennial scales; their indicators require long baseline series and periodic recalibration against updated RCP/SSP (Representative Concentration Pathways/ Shared Socioeconomic Pathways) scenarios. Real-time architectures, privileging data freshness over temporal depth, are poorly suited to CC monitoring. A PDSS genuinely integrating CC must operate across three temporal registers: the real-time (hazard monitoring: heat events, flood alerts); the medium-term (tracking adaptation and mitigation within the plan cycle);

and the long-term (scenario visualisation against Paris Agreement goals and national adaptation plans). No existing dashboard fully achieves this integration – this is the core challenge for developing a PDSS that genuinely serves planning. Given these requirements, a CC-attentive PDSS should be built around a core indicator set (Table 2), adaptable by objectives, timescales, and targets to monitor plan actions and enable transparency, participation, and accountability. The framework in Table 2 covers eight thematic families, defined with respect to OECD (2023), IPCC AR6 WGI/WGII/WGIII (2021-2022), and scientific literature – Climate Hazard, Exposure & Vulnerability, Water Stress, Mitigation, Adaptation & Green Infrastructure, Land-use, Governance & Accountability, and Scenario & Resilience – operationalising Innes and Booher (2000): indicators are not neutral instruments but social pacts whose legitimacy depends on stakeholder agreement and institutional ownership.

6. Conclusion

This study argues that climate-sensitive dashboards should not be conceived merely as real-time monitoring tools, but as integrative PDSS capable of bridging the temporal and operational gap between climate dynamics and planning processes. While existing dashboards prioritise short-term performance tracking, spatial and strategic planning require instruments that can incorporate uncertainty, long-term trajectories, and multi-scalar territorial vulnerabilities.

Note

The proposed core indicator set represents both a technical framework and a methodological contribution aimed at aligning climate intelligence with planning rationalities. By integrating hazard, exposure, vulnerability, adaptation, mitigation, resilience, and governance dimensions, it offers a transferable basis for evidence-informed planning in climate-sensitive contexts – advancing beyond the biophysical-only focus of most existing CC dashboards and incorporating social vulnerability, equity, and governance dimensions that the IPCC (2022) identifies as primary determinants of climate risk but that remain absent from current practice.

Not a fixed taxonomy, but a flexible yet operational indicator structure adaptable to different territorial contexts, governance arrangements, and planning cultures. The indicators must be grounded in social pacts rather than imposed as technocratic standards (Innes and Booher, 2000). Three possible directions for future research are outlined: (i) empirically testing the indicator set in pilot implementations of PDSS at the municipal level; (ii) developing a shared open data protocol for interoperability between local climate change dashboards and international monitoring frameworks; and (iii) investigating participatory indicator selection processes as mechanisms for building institutional ownership and democratic legitimacy of the taxonomy.

¹ <https://citydashboard.org/london/>.

² <https://www.data2go.nyc>.

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