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A Review of Sustainable Urban Infrastructure Development

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Abstract: *Sustainable urban infrastructure encompasses the design, development, and management of urban systems that minimize environmental impact, optimize resource use, and enhance quality of life. This review explores the principles and practices of sustainable urban infrastructure, highlighting strategies for integrating green technologies, renewable energy sources, and resilient materials into urban planning. It examines case studies demonstrating successful implementations, discusses the challenges of balancing economic, social, and ecological goals, and emphasizes the need for interdisciplinary approaches to create resilient cities. The review underscores the importance of stakeholder engagement and innovative policies in advancing sustainable urban infrastructure to address the complex demands of rapidly growing urban areas.*

Keywords: Efficiency, Urban Infrastructure, Waste Management, Green Infrastructure

I. INTRODUCTION

First time in history, most of the world's population lives in cities; 66% may by 2050. 25% of GHGs come from transportation, 32% from the built environment, and 5% from municipal solid waste. The built environment utilizes 25% of global energy and urban transportation 20%. Climate change's impacts on the environment, economy, and people intensify sustainable urban infrastructure (SUI) challenges such water management, heat islands, pavement production, and building.

Urban infrastructure (UI) goes beyond utilities. It covers municipal waste, economic growth, climate change, and local governance. International, national, regional, and local governments may solve UI issues. UI affects regulators, consumers, citizens, businesses, and residences. Water, power, transport, sanitation, information, and built environment engineering systems are included. Dams, locks, canals, irrigation, infrastructure, municipal utilities (electric, telephone, gas, water, wastewater), and urban streets and highways are included. Urban landscapes are pressure points and political and economic hubs as well as services and amenities.

The emerging field of sustainability covers technological, environmental, economic, and social sciences. Sustainability means addressing present needs without jeopardizing future needs, according to the Brundtland Commission [8 and 9]. Triple bottom line (TBL) includes social, economic, and environmental sustainability. Sustainability is human growth throughout time and place, balancing ecological, social, and economic elements in an equitable and safe approach that requires technological, scientific, and political judgment. Martos et al. (p. 480) describe a sustainable, resource-efficient city as one that is largely decoupled from resource extraction and ecological repercussions and is long-term socio-economic and environmentally sustainable.

II. METHODOLOGY

Techniques and data from the systematic literature review (SLR) and longitudinal analysis of topic areas are presented here.

The systematic literature review and basic statistics

We utilized Thomé et al.'s step-by-step SLR. Planning and articulating the topic, searching the literature, data collection, quality evaluation, data analysis and synthesis, interpretation, presenting results, and updating the review are the eight phases of this process.

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First, the paper's authors outlined SUI, research questions, and expected results. This step forecasted a subject taxonomy based on recent advancement and future study.

The second part included choosing databases, search keywords, and publishing exclusion criteria without a deadline. Scopus, Elsevier's massive abstract and citation database of over 22,000 journals, was picked. Initial searches for "urban infrastructure" and "green" found 258 articles. After adding "sustainab*" (any keyword combining "sustainab" and a suffix), 645 documents were found. Adding "environment*" produced 1,180 articles. Searching articles, conference papers, reviews, and in-press publications returned 1,059 papers. 995 papers remained after excluding non-English papers. Request the full bibliographic reference from the author.

In the third and fourth phases, the co-authors utilized Scopus' built-in bibliometric software to calculate research topic areas, publications per year, journals, institutions, citations, and h-index per authors. To assess the effect of a publication, journal, or author in a subject area, the h-index counts articles with citation numbers < h.

SUI's top topic areas span many research fields, demonstrating its multi-disciplinary approach. With 367 and 346 papers, social and environmental sciences make up one third of all publications. Additional articles include 294 in engineering, 130 in earth and planetary sciences, and 114 in computer science. Agriculture, biological sciences, business, management, accounting, energy, and medicine are equally represented in the top 10. Co-citation analysis and SUI techniques by the most cited authors in Section B of the Results are affected by social and environmental sciences publications.

Starting in 1984, three pieces were published yearly until 1995. Growth accelerated after 1996. Document releases have expanded significantly since 1999, peaking at 132 in 2015. Journals distribute papers from 131 transdisciplinary sources. Eight of the most cited journals are urbanization/environmental. No significant correlation exists between publication quantity and total citations, with just one of the top five journals having equal numbers (Pearson-r = 0.39; $p<0.1$). Thus, the most plentiful materials have not always influenced research. The top 10 research institutions by citations include four European, five North American, and one Asian (China).

The fifth and sixth SLR stages analyze and evaluate data. As detailed below, data analysis employs inductive qualitative content analysis and quantitative co-citation and co-word analysis of systematic review papers. This paper shows SLR phase seven findings. Review update is step eight. No updates are included in this study.

Bibliometric analysis of thematic areas

The research assumes co-citation and keyword co-occurrence connect authors and topics. Papers A and B co-cite paper C. Documents with A and B have two keywords. A "core document" contains two or more list keywords. There is one keyword association per "secondary document".

BibExcel created the co-citation and cluster matrix, while Persson's party clustering algorithm created the network analysis. Dynamic co-word longitudinal theme analysis was done using SciMAT. SciMAT presents keyword co-occurrences in a bipartite graph with density and centrality using Callon's thematic strategic diagram. Equivalency index is eij = cij2 / cicj, where cij is the number of documents where keywords i and j co-occur and ci and cj are the numbers of documents where each occurs. The 'simple center algorithm' groups items. Centrality is calculated by $c=10\sum ekh$, where k is a theme keyword and h is a keyword from other themes. Keyword network interaction is measured. Keyword networks represent topics, and centrality assesses theme connections. Use $d=100(\sum eij/w)$ to calculate density, where i and j are theme keywords and w is the total number of keywords. It evaluates internal network or theme strength. The Callon thematic diagram has four quadrants in Figure 1.

From top right clockwise, this graphic illustrates high-centrality and density themes. The subject area's key themes are important yet undeveloped and should be investigated. Low centrality and density reflect new or declining themes. Low-centrality subjects are widely studied yet unimportant to the research area.

Theme longitudinal analysis entails tracking them over time. Measured by inclusion $index = \frac{\#(U \cap V)}{min(\#U, \#V)}$ Bipartite graphs have disjoint sets U and V, hence edges can only link components from U to V. The inclusion index ranges from zero (non-inclusion) to one (V items completely included in U).

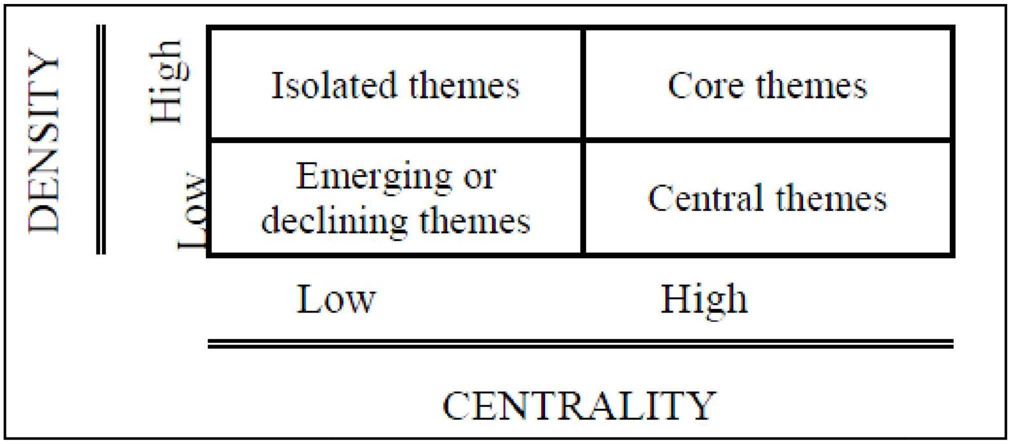

Figure 1 – The Callon's thematic diagram

Results from the citation, co-citation, and co-word analyses

The results section first ranks the most productive and influential SUI authors by publication count and h-index. Co-citation and co-word analyses follow.

The citation analysis

Most of the top 10 writers with more publications are civil and environmental engineers. In Europe, North America, and Asia. Rieradevall, Gabarell, Zhu, and Bamler often collaborate. A high h-index indicates field influence for certain writers. The most prolific writers are not necessarily the most influential (the association between the number of articles and the h-index is not statistically significant, with Pearson-r = - 0.018), as shown in Section A of the Methodology.

The co-citation analysis

Co-citation analysis compares works. This method explains a research subject. Figure 2 illustrates the top 23 most-cited books' co-citation networks. To simplify graphs, just the first author and publication year are shown.

Star, Peck, and Tickell head a large cluster, although four two-node clusters exist. The cluster focused on society and infrastructure. Smaller clusters held modernity, urban metabolism, infrastructure deterioration forecast, and urban ecology. Chronological cluster description.

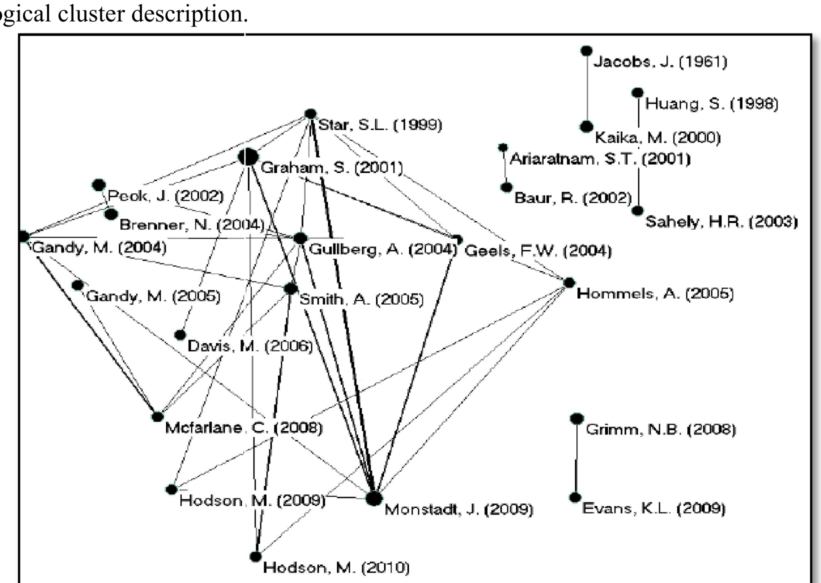

Figure 2 – SUI co-citation network

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The Jacobs cluster favored contemporary style. Jacobs led the cluster by denouncing 1950s modernist urban design for harming inner city communities. Kaika and Swyngedouw say the modernist “ideology of progress” failed as urban technological networks (particularly water) moved from respect in early modernity to obscurity in high modernity.

Huang and Sahely et al. studied urban metabolism. Huang used ecological energy analysis to connect urban economic and ecological systems. Despite neglect, Huang thought both systems were interdependent. Urban metabolism was used to investigate municipal infrastructure by Sahely et al. Both authors used case studies to prove their points.

Star examined ethnography and infrastructure at one cluster end. Star regarded infrastructure as ecological and relational, linking technology to society and the environment. Graham and Marvin supported Star's relational infrastructure concept by addressing privatization's social divides and urban neighborhood repercussions. Graham and Marvin claimed that privatization caused “splintering urbanism” by creating a private infrastructure network for the rich. Star reported Graham and Marvin's discussion of urban networks' “invisibility” till infrastructure breakdown.

In “Planet of Slums,” Davis studied slums' startling and exponential development. He studied the devastating long-term effects of low-income and makeshift housing projects' global economic isolation on cities. MOUT expanded Graham and Marvin's “splintering urbanism” and Davis' ideas.

Gandy supported Star, Graham, and Marvin. Gandy used water systems to demonstrate the wide divide between post-Industrial Revolution urban dreams and realities. Most contemporary municipalities have abandoned 19th-century infrastructure-citizen interaction. Split urban metabolic systems are indicated by infrastructure investment cuts and private-public priorities.

Geels added a social component to sectoral innovation systems to study society, technology, and city socio-technical systems. He used institutional theory to systems and described bottom-up shifts in niches (places of radical inventions), regimes (stabilizing norms and paradigms for innovation), and landscape to develop a hierarchical multi-level perspective (MLP). In the second decade of this century, Hodson, Marvin, and others used the distinction to examine the UI.

Peck and Tickell showed the cluster how neoliberalism might change municipal governance. Neoliberalism may damage local cities, Peck and Tickell stated. Brenner also observed that major cities may influence national changes. He proposed a “rescaling of statehood” and unprecedented city-based administration.

Smith et al. changed socio-technically. Many regime shifts were induced by selective factors. Through regime allegiance, resource circulation, and public expectation, governance influenced transitions. Lack of cross-disciplinary contact and change aversion frustrated him. Hommels felt this discourse was necessary and sought to connect technology and urban studies. Graham and Marvin observed the UI "invisibility," while Hommels underlined urban studies' technology research gap.

Gandy likened cities to cyborgs. Cyborgs, like cities, are “hybrid creatures, composed of organism and machine” with human and technological qualities. Gandy went beyond urban studies to study the “cyborg city”—a city centered on information rather than material mobility. Urban social division and outdated modernity were his emphasis. Gandy alone was co-cited by McFarlane and Rutherford, Gullberg and Kaijser, and Smith et al. McFarlane and Rutherford analyzed fragmentation, inequality, and crises to support Gullberg and Kaijser and Smith et al.'s results on politics and governance's impact on infrastructures. They mentioned Gandy's urban fabric and social infrastructure study rise. McFarlane and Rutherford again utilized Gandy to show municipal infrastructure's “invisibility”. McFarlane and Rutherford disagreed with Gandy: “Infrastructures have always mattered.”

Hodson, Marvin, and Monstadt established ecological sustainability in this cluster, indicating global interest. Urban ecological security was investigated by Marvin and Hodson. Growing worldwide concern for UES and sustainability required novel methods to protect ecological and material development. Hodson and Marvin investigated secure urban and resilient infrastructure (SURI) issues and suggested remedies and research. Infrastructure greatly affected urban environments and other locations in Monstadt's cluster. Like Hodson and Marvin, advocated radical infrastructure reconfiguration for environmental success. Monstadt advised urban and technology studies unite to identify SUI solutions when current methods failed. Finally, Hodson and Marvin, citing Graham and Marvin, claimed UI helps cities prosper. This raised whether cities may influence socio-technical changes. Hodson and Marvin found evidence that several global cities sought to reform governance. Citing Smith et al., they examined MLP city change by terrain, regimes, and innovation niches.

Ariaratnam et al. and Baur and Herz projected infrastructure decline. Based on sewage deterioration models, Ariaratnam et al. devised a method for predicting infrastructure system failure.

UI was first defined by social sciences and then incorporated sustainability. The analysis of the most notable authors in this field based on total citations gives basic and ancient research more weight since older papers have more time to gather citations. By assessing recent additions, the next section's co-word theme development assessment tackles this time lag impact.

The co-word analysis

Papers were divided into 1984-2009 (379 documents) and 2010-2015 (616 documents) for co-word analysis and theme advancement. SciMAT developed theme clusters using Scopus keywords: 1984–2009: cities, investments, urban-area, developing-countries, environmental-impact, and storm-water; 2010–2015: climate-change, urban-infrastructure, cities, storm-water, life-cycle, and vulnerability Keyword co-occurrence was electronically assessed in all 995 publications. After classifying articles into topic clusters, the core papers (those with more than one keyword co-occurrence) comprising up to 80% of total citations in each cluster were hand-selected for full text reading and content analysis We picked 55 documents—20 from the first period and 35 from the second.

Each cluster had core and supplementary texts with one thematic network keyword co-occurrence. The subject area was analyzed using 55 full-text articles representing 80% of total citations in each cluster and period.

Figure 3 illustrates the amount of keywords returned and not returned per month.

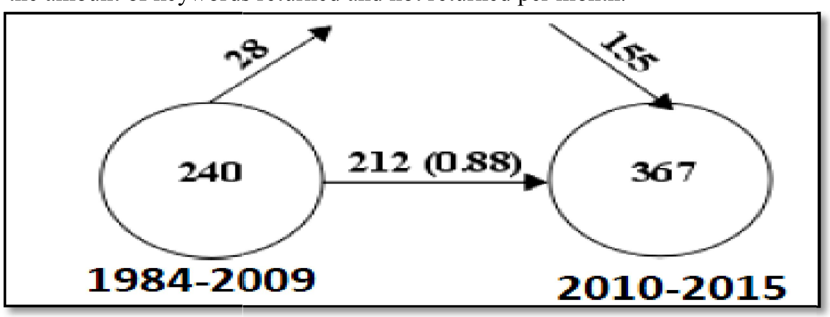

Figure 3 – Overlapping map of keywords of the two periods

Keywords rose 53% from 240 in 1984-2009 to 367 in 2010-2015. It exhibits SUI's subject variety. In the second phase, 88% of the 240 keywords from the first session returned: 28 did not and 212 did. High keyword retention in both periods shows SUI topic area continuity. From 1984-2009 to 2010-2015, 155 new keywords were added, indicative of increasing academic fields.

The continuous lines illustrate name linkages between topic clusters (either two share the same name in subsequent periods or one includes the other), while the dotted lines reveal additional ties. Document count determines sphere size.

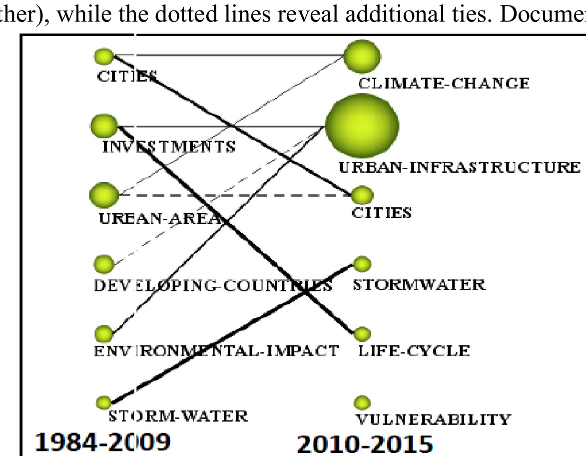

Figure 4 – SUI thematic networks evolution of the two periods

Thematic clusters had rather equal document numbers in the first era. Cities, emerging countries, environmental impact, and storm-water had less publications than investments and metropolitan area. Second-era urban infrastructure has more records than other themes. Climate change followed with fewer records. Fewer studies on cities, stormwater, life cycle, and vulnerability.

1984–2009 cities and urban areas became 2010–2015 cities and climate change. Between 2010 and 2014, investments became urban infrastructure and life cycle, with stronger links to the latter. Urban infrastructure was the key concern in 2010–2015, highlighting the research area's relevance and actuality. Investments, rising countries, and environmental impact from 1984-2009 became urban infrastructure in 2010-2015. Stormwater was assigned to strong theme areas both times. Vulnerability formed a theme cluster between 2010–2015. Figures 5a and 5b depict 1984-2009 and 2010-2015 strategic diagrams.

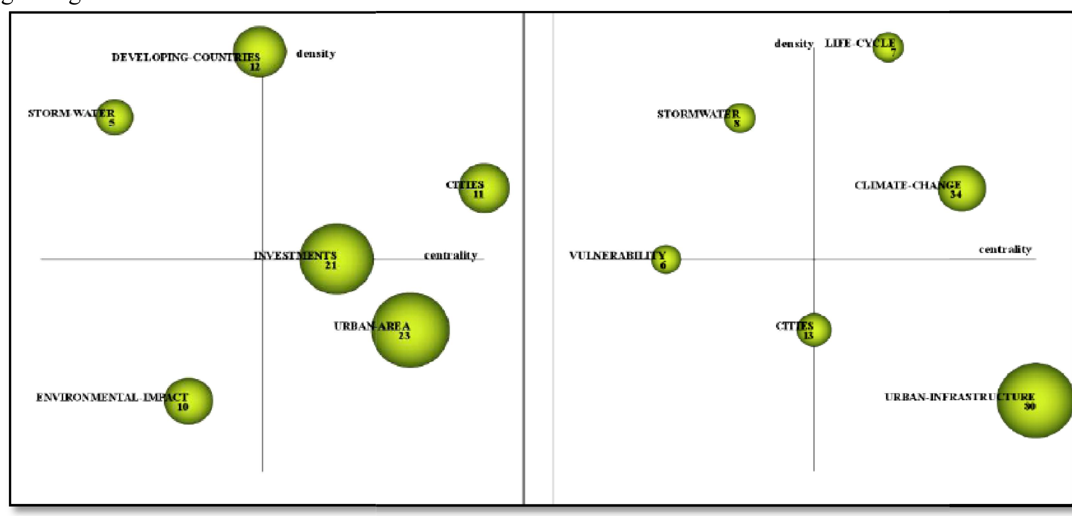

Figure 5a – SUI strategic diagram in 1984-2009 Figure 5b – SUI strategic diagram in 2010-2015

City, investment, and developing country subjects were dense and prominent in 1984–2009, making them often referenced and connected to other SUI themes. Disasters in cities concerned people. After Hurricane Katrina's reconstruction in New Orleans, Kates et al. advised include natural risks in city planning. Qureshi et al. studied healthcare workers' disaster reaction. Better personal safety equipment or urban mobility solutions might overcome many healthcare professionals' response limitations. After reviewing scientific data on the health effects of temperature, rainfall, and catastrophic events, Kovats and Akhtar examined Asian city heat waves and floods. They agreed that cities must enhance infrastructure, notably housing, to resist climate change, but a delay may hinder their effectiveness. Ruth and Coelho utilized complexity theory to examine city climate change and infrastructure for investment and decision-making. Air pollution, river pollution, deforestation, and soil deterioration were Wang's main environmental concerns. He advised state environmental protection laws and public education to fix it.

Clark et al. examined the cost of urban infrastructure upgrades for water systems. Torrance privatized and transformed urban infrastructure. Lee et al. explored how a ‘new paradigm’ of ubiquitous infrastructure ‘an urban infrastructure system where any citizen may access any infrastructure and services via any electronic devices regardless of time and location,’ affected sustainable urban development in Korea. Wang et al. suggested water distribution pump scheduling changes for cost and environmental benefits.

Finally, Bishop et al. advised regulating urban infrastructure growth in developing countries using geographical infrastructure data. Hinks et al. developed 3D models of aerial light detection of urban human settlement for noise, pollution, and disaster prevention.

Urban region has the most documents in 1984–2009 and is an attractive cluster for future study owing to its high centrality and low density. Chang utilized life cycle cost analysis to evaluate disaster mitigation costs and benefits, including urban infrastructure degradation and maintenance, urban development, and social impacts. Ziara et al. prioritized urban infrastructure. In different soil conditions, Sansalone and Teng simulated how a partial exfiltration

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reactor influenced urban rainfall-runoff quantity and quality. Sohail et al. used case studies to analyze urban service operation, maintenance, and sustainability limits in India, Pakistan, and Sri Lanka. Local community-government collaborations improve urban infrastructure operation and sustainability, the authors say. Stapleton et al. measured catchment-derived fluxes of faecal indicator compliance parameters from UK point and diffuse sources for EU water quality control management. Catchment and outflow station for Ribble drainage basin studies. Untreated storm sewage overflows from urban infrastructure and storm-water retention tanks dominate high faecal indicator flow to recipient streams, according to studies. Scalenghe and Marsan studied the harms of impermeable soil sealing in European cities.

Environmental impact dominated last decade. Two articles dominated this cluster with 70% citations. Sahely et al. analyzed Great Toronto, Canada, and other cities in one of the first urban metabolic investigations. Urban metabolism monitored global energy, water, material, and waste fluxes, in and out of cities. Inputs exceeded outputs, polluting and declining urban infrastructure. Denault et al. explored hydraulic infrastructure design and developed a technique to measure climate change-induced short-term rainfall intensity on urban infrastructure and small watershed ecosystems. Results demonstrated high environmental vulnerability and moderate drainage system improvement effort and expense.

The 2010-2015 strategy diagram is at Figure 5b. Climate change and life cycle ruled. Climate change experts underlined the necessity to explore its implications in many sectors. Horton et al. reported climate change in New York City stakeholder adaptation planning. Their study showed huge increases in coastal floods, severe heat events, and other extreme events, suggesting long-term adaptation planning. Karamouz et al. explored how climate change influences urban floods and their consequences on society and infrastructure, underlining the need to integrate climate change in urban water studies and improve drainage. Qi and Chang studied municipal water demand forecasts and the economy-water demand link. Broto and Bulkeley's climate change experiments were “purposive interventions that seek to reconfigure urban sociotechnical systems to achieve low-carbon and resilient cities”. The first studied climate change experiment maintenance and the second global city climate change experiments. Ferguson et al. improves urban water systems' sustainability and resilience. Green spaces attenuate and adapt to climate change, according to Demuzere et al.

Venkatesh and Brattebo study Oslo water supply pipes' 16-year environmental life cycle performance by measuring annual resource utilization, emissions, and LCA effect potentials. Their study shows that the Oslo water pipeline system most impacts global warming and abiotic depletion.

Cost optimization, energy efficiency, and sustainability are important priorities. The mathematical and political ramifications of cities' trans-boundary infrastructure supply chain GHG footprints were investigated by Chavez and Ramaswami. GHG footprints from production and consumption outside cities and infrastructure supply networks were evaluated. Aylett utilized Solarize Portland to demonstrate the value of organized civil society in renewable energy promotion in a qualitative case study.

Punkkinen et al. evaluated pneumatic and conventional door-to-door waste systems' rubbish collection environmental sustainability under the life-cycle cluster. The studies revealed that stationary pneumatic rubbish collection would increase urban infrastructure air emissions but minimize waste collecting area emissions owing to reduced mobility. Air pollutants were affected by trash collection system component manufacturing. Loijos et al. used LCA to study pavements' environmental impact. Cement manufacturing contributed most pavement GHG emissions in the first year of a 40-year study, whereas traffic intensity and cement production parameters impacted results most. LCA research recommended reducing end-of-life and embodied use phase emissions. The urban infrastructure cluster released most 2010–2015. SUI relevance was suggested by high centrality, but low density allowed further investigation to establish the theme area. The most referenced study was Chen et al.'s on municipal solid waste management in China, the world's biggest producer. Mahalingam improved Indian cities. Mahalingam investigated public-private partnerships and Misra urban drainage in the urbanizing Ganga basin. Misra said climate change may need water conservation and pollution education. Historic municipal planning-infrastructure links were investigated by Neuman and Smith. Hayhoe et al. evaluated the economic implications of climate change on energy use and municipal infrastructure in Chicago and found that lowering emissions may lower economic costs at various levels. Wu used lagged input and output variables to compare Chinese cities' urban infrastructure and economic development. Coutinho-Rodrigues et al. developed urban infrastructure planning decision support. Horton et al. examined how NYC planners integrate climate change into adaptation strategies. Karamouz et al. examined climate change's impact on Tehran's urban drainage. We used an algorithm to identify management solutions for varied climate change-induced rainfall patterns. El-Diraby and Osman

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revealed SUI informatics ontology. E-cities were networks of actors, processes, and goods like bridges, traffic lights, choices, and information. Masson et al. investigated using geographic and ecological elements to drive urban expansion in Paris.

In 2010-2015, cities were less dense and central than in 1984-2009, decreasing SUI thematic influence. Chen as al. researched Chinese municipal solid waste management, while Peng et al. explored Beijing's Chinese migrant workers' healthcare seeking and hurdles. Broto and Bulkeley examined city climate change experiments. Hodson et al. advised critical investigation of resource flows and SUI linking cities, urban infrastructure, ecosystem services, and natural resources using material flow and transition analysis. Demuzere et al. investigated green urban infrastructure in different cities, climates, and social contexts, weighing many benefits. It emphasized green spaces' climate change prevention.

Low centrality and average density characterized the vulnerability cluster. The new, unconnected notion was significant from 2010–2015. Kalyanapu et al. proposed resilient urban infrastructure mitigation and adaptation alternatives for likely maximum floods downstream of the American River. They evaluated dam vulnerability in extreme rainfall floods. After significant storms destroyed port facilities, coastal tourism infrastructure, and urban infrastructure in the French Gulf of Lyon, de la Torre et al. evaluated coastal vulnerability. They devised a monitoring system and wave-forecasting model to identify coastal hazards and develop mitigation strategies. Szmytkiewicz and Marcinkowsky increased beach fill effectiveness with submerged breakwaters to lessen coastal vulnerabilities in Gdynia's Gulf of Gdansk. Tscheikner-Gratl et al. investigated if changing the urban water network's susceptible locations will reduce floods.

From 2010 to 2015, the storm-water cluster remained in the top left quadrant of the strategic picture as a relatively isolated and well-known SUI concern. Davis et al. led the cluster with 72% citations. They examined bio retention measures to limit impermeable surface rainfall runoff.

Figure 6 concludes with the SUI strategy diagram's 2010–2015 new and current topics and their links. Figure 6 circles indicate keyword-containing articles. Line thickness between subjects reflects link strength. Colors distinguish clusters.

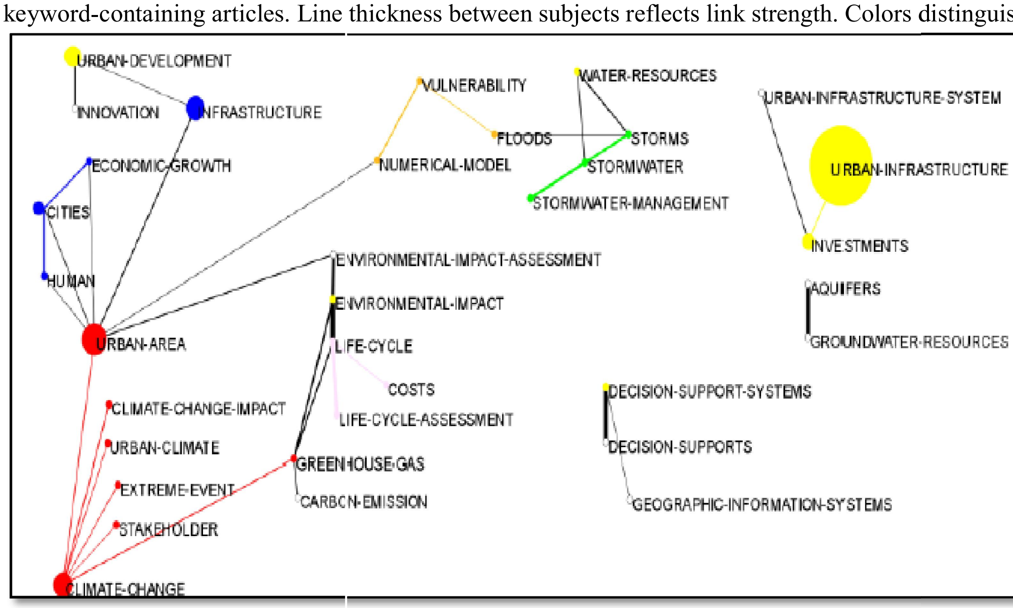

Figure 6 – Thematic clusters relationships: 2010-2015 Note: shows only arcs with weight over 0.4.

Infrastructure investments and systems dominate the urban infrastructure cluster. The group included decision support and GIS. The remaining categories in Figure 6 form a web of connected subjects explored together. Key topics include stakeholders, extreme events, urban climate, climate change impact, greenhouse gas, and urban area. People, economic growth, and infrastructure connect cities. Greenhouse gas and environmental impact evaluation affect life cycle, costs, and climate change. Storm water management, storms, water resources, and floods connect. A vulnerability cluster near storm water with floods and numerical models represents flood threats and coastal vulnerability.

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III. DISCUSSIONS AND CONCLUSION

The author used a rigorous and reproducible SLR technique to choose 995 SUI publications. Since 1999, articles have exploded in this new subject. Multidisciplinary urban infrastructure study is shown by the literature review's multiple topic fields and academic periodicals. It covers social science, engineering, mid-20th-century “urbanism” and today's urban amenities, infrastructure, and communication network. The 2010-2015 articles use 88% of earlier language, indicating consistency in a developing yet dynamic research subject.

Early urbanism and social-technical theory saw urban infrastructure as a source of power, economic expansion, and engineering utilities. SUI publications focus on social and environmental sciences. Most cited writers examine urban infrastructure concerns from economic, social, and technical perspectives. For RQ1, “What are the SUI prevailing themes?” This study discusses 1984–2009 storm-water, developing country urban infrastructure, cities, investments, urban area, and environmental effect. From 2010 to 2015, SUI examined storm-water, life cycle, climate change, urban infrastructure, cities, and vulnerability.

There are numerous ways to build and develop sustainable urban infrastructure to meet sustainability issues. Literature recommends improving climate change, investments, decision-making, technology, waste disposal, storm water, rainfall runoff, urban drainage, collaboration, life cycle, and vulnerability.

Answering RQ2—“How did sustainable urban infrastructure themes evolve?”—urban infrastructure study shifted from housing and city segregation to a systemic perspective of contemporary and new facilities and utilities, including urban metabolism and vulnerabilities, e-cities, and communication networks. SUI manages utilities, housing, transportation, renewable resources, electronic equipment, and communication networks that connect a complex urban population. This new, expanded urban infrastructure paradigm should be examined alongside physical and socio-technical infrastructure.

Strategic diagram topics aid study planning. In 1984–2009, developing nations, cities, and investments prevailed; in 2010–2015, life cycle and climate change. 1984–2009 urban infrastructure studies may focus on environment and urban area. Urban infrastructure research in 2010–2015 included municipal solid waste management, public-private partnerships for infrastructure development, rainfall management, and drainage in urbanized developing countries. City planning, energy consumption, climate change's economic impact, urban infrastructure's impact on economic development, best practices in rainfall and drainage management, e-city, and urban planning ecology are 2010–2015 research priorities. Disaster mitigation, urban service maintenance and sustainability (water systems, waste management, renewable energy, energy consumption, drainage basins sentinel projects, urban soil sealing), metabolism analysis, climate change forecasts, vulnerability assessment and resilient cities, and e-city communications are promising SUI research topics

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