smart cities

MDPI

Review

Role of Smart Cities in Optimizing Water-Energy-Food Nexus: Opportunities in Nagpur, India

Vibhas Sukhwani [1], Rajib Shaw [1,*], Sameer Deshkar [2], Bijon Kumer Mitra [3] and Wanglin Yan [1]

[1] Graduate School of Media and Governance, Keio University, 5322 Endo, Fujisawa, Kanagawa Prefecture 252-0882, Japan; vibhas@sfc.keio.ac.jp (V.S.); yan@sfc.keio.ac.jp (W.Y.)
[2] Department of Architecture and Planning, Visvesvaraya National Institute of Technology, South Ambazari Road, Nagpur, Maharashtra 440010, India; smdeshkar@arc.vnit.ac.in
[3] Institute for Global Environmental Strategies (IGES), 2108-11 Kamiyamaguchi, Hayama, Kanagawa Prefecture 240-0115, Japan; b-mitra@iges.or.jp
* Correspondence: shaw@sfc.keio.ac.jp; Tel.: +81-466-49-3641

Received: 22 September 2020; Accepted: 27 October 2020; Published: 29 October 2020

Abstract: The evolving concept of 'Smart Cities' (SC) is today gaining global momentum in scientific and policy arenas. With the rising potential for jobs and improved lifestyle, these fast-growing cities are witnessing an ever-increasing concentration of populations and economic activities. However, the core aspect of sustainability is often overshadowed in SC by the components of economic growth. In view of the rising water, energy, and food (collectively referred to as WEF) demands in cities and the interlinkages between WEF systems, this study aims to highlight the role of SC in enhancing WEF resource efficiency from a nexus perspective. To study the current trends of SC developments first, a specific case of proposed Nagpur smart city (India) is reviewed based on document analysis and preliminary discussions with local government officials. Thereafter, bibliometric analysis (based on Scopus data) is conducted to establish a comprehensive understanding of existing SC research in varying domains of interlinked WEF systems. While the proposed Nagpur smart city is observably focused on city-centric goals with a high emphasis on infrastructure development, this study underlines the need for environmental resource conservation at a transboundary level. The key opportunities for optimizing the WEF nexus in Nagpur are then highlighted in reference to the bibliometric analysis.

Keywords: smart cities; information and communication technology; water-energy-food nexus; integrated resource management; Nagpur; bibliometric analysis

1. Introduction

Cities around the world have today become a center of attraction for large populations. More than 55% of the global population (about 4.2 billion people) was already living in cities by 2018, and this proportion is expected to reach 68% by 2050 [1]. Concentrated in nearly 3% of the total land surface, cities worldwide generate a major proportion (around 80%) of global Gross Domestic Product 'GDP'. To secure more investments and boost job creation for rapid economic growth, the fast-growing cities continue to bring about notable development transformations. However, it is also important to underline that cities account for a significant share (60–80%) of greenhouse gas emissions, around 50% of global waste, and 75% of natural resource consumption [2–4]. The geographically expanding city boundaries, rapid urbanization trends and the growing resource demands, therefore present serious concerns for environmental sustainability. Apart from that, the fast-growing cities are also faced with a range of developmental challenges in terms of air and water pollution, waste generation, overstressed infrastructure services, etc. These issues are particularly severe in developing countries, due to factors like high population density, poverty, lack of basic infrastructure services, etc. [5].

With regards to the existing developmental challenges, the concept of 'Smart Cities' (SC) has today become a globally accepted solution to improve the quality of life in urban areas. Although the SC concept is not new, there is still no universally agreed definition for it. Of the numerous descriptions that have emerged so far from the academic, commercial and (inter) national organizations, the SC concept mainly refers to the utilization of Information and Communication Technology (ICT) features to enhance the provision of urban services in a fast and efficient manner. It is particularly linked with the adoption of leading-edge technologies like Artificial Intelligence (AI), Internet of Things (IoT), big data, robotics, etc. [6–8]. Recently, several policy schemes have been introduced around the world to materialize the idea of SC. For example, in 2014, the city-state of Singapore announced its 'Smart Nation' initiative to fully harness the potential of digital and smart technologies [9]. In 2015, the Government of India announced an ambitious 'Smart Cities Mission' (SCM) for the development of 100 SC across the country [10]. Until 2015, over 300 cities in China had been identified as pilot projects for SC development [11]. Earlier, several initiatives have also been taken by large private companies for enabling technology integration in cities, such as IBM's 'Smarter Cities' initiative launched in 2009 [12], and Cisco's 'Global Intelligent Urbanization initiative' launched in 2009 [13].

Noticeably, remarkable advancements have been made in scientific and policy arenas to smartly enhance the functioning of cities. However, the effective implementation of SC is still confronted with a number of challenges including the digital divide and lack of digital competencies [7]. Allam and Newman [6] underlined that the SC concept is still evolving, and the cultural values and historical profiles of a city are seldom taken into consideration for planning and development of SC. The core aspect of sustainability has also received limited attention in the wide array of contrasting views that have emerged about the multidimensional SC paradigm [2]. Although the environment dimension is encompassed in the SC frame, it often gets overshadowed by the components of economic growth [14]. The current and future livability of SC is therefore threatened by the rapid exploitation of natural resources, which is imperative for the overall well-being of the citizens as well as economic growth.

In the backdrop of already existing resource shortfalls [15], the global demands for the three essential resources of water, energy and food (collectively referred to as WEF) are projected to correspondingly increase by 55%, 80% and 60% by 2050 [16]. The rising WEF resource demands are likely to be centered in fast-growing urban areas due to the increasing concentration of populations. Herein, the expanding city boundaries and changing population dynamics have become a matter of serious concern for sustainable development, as cities largely meet their WEF demands from areas outside their physical boundaries [17]. The inextricable linkages between WEF sectors in the form of a 'nexus' further make it a complex challenge. Addressing the WEF nexus at regional level has therefore become central to achieving sustainable urban development, as it affects the extent to which the security of WEF resources can be simultaneously achieved [18,19].

In recent years, soaring research interests have been directed towards conceptualizing SC and enabling technology intergration for smart urban development [20]. While the scientific literature on SC research continues to be dominated by technology aspects, limited studies have focussed on enhancing the efficiency of WEF resources from an interconnected and nexus perspective. As the consumption of WEF resources is showing an increasing trend, a few conceptual approaches such as a smart urban metabolism have been discussed in recent studies [6,21]. However, the resource inputs in cities, intersectoral flows, stocks and outputs are still not methodically characterized [22]. The implications of these studies on urban governance have also not been systematically studied [23] and the operationalization of the WEF nexus remains to be a challenge at local level [24,25].

With an aim to bridge the existing science–policy gaps, it is imperative to first establish a precise understanding of current trends of SC implementation. To this end, this study reviews a specific case of a proposed Nagpur smart city in India, which has been at the forefront in terms of project implementation under the national government's SCM mission [26,27]. Cities selected under the SCM have so far witnessed substantial transformations in terms of physical and social infrastructure development. However, the strategic approach of SCM has also received wide criticism [28]. The mission's lack of focus on the environmental dimension and minimal consideration of disaster risks is also highlighted as a concern [29–31].

Thereafter, a bibliometric technique is adopted (with reference to Guo et al. [20]) to establish a comprehensive understanding of existing SC research in the domain of WEF systems, independently and conjointly. The parallel understanding of the Nagpur smart city case and the existing SC research trends is intended to identify the existing shortcomings as well as the potential opportunities (or directions) for enhancing WEF resource efficiency in Nagpur.

The three key objectives of this research are: (1) To study the action plan of the proposed Nagpur smart city in India and review its key focus areas; (2) To study the existing SC research in the domain of interlinked WEF systems; (3) To highlight the key opportunities for the proposed Nagpur smart city to optimize WEF nexus. Herein, the term 'optimize' refers to making the most effective use of WEF resources from an interlinked perspective. Although the article has an explanatory approach based on a literature review, the study results will contribute to advancing the theoretical understanding of SC and the WEF nexus concept. It is also hoped that this study will provide generalized lessons for integrating WEF components in the development agenda of 100 proposed SC in India, as they are still in the transformation phase.

The remaining part of the paper is structured as follows. Sections 2 and 3 provide a precise overview of the SC and WEF nexus concept by reviewing the state-of-the-art scientific literature. Before explaining the research methods adopted for this study, Section 4 also establishes the SCM context and introduces the case study area of Nagpur in India. Section 5 presents the study results, which consist of the case study analysis and literature analysis. Based on the research findings, Section 6 discusses the key opportunities to enhance WEF resource efficiency in Nagpur. Towards the end in Section 7, the authors summarize the key conclusions and outline the way forward.

2. Overview of the Smart Cities Concept

The historical development of the SC concept has previously been discussed in several studies [32–34]. It has been revealed that the 'smart city' term was primarily recognized during the late 1990s from the discussions on 'intelligent cities' and 'smart growth'. Thereafter, since the early 2000s, the application of the SC concept gained global currency as several technical institutes and large companies such as IBM, Cisco and Ericsson significantly invested for the integration of ICTs in cities. It should be noted that a variety of similar concepts like Digital Cities, Intelligent Cities, Virtual Cities, Hybrid Cities, and Ubiquitous Cities are also in practice, and the term SC is often interchangeably used with these terms [35,36].

Figure 1 highlights the year-wise proportion (until the year 2019) of research documents on the Scopus database (articles, conference papers, etc.) for these six varying concepts. Although the overall number of research documents has kept on increasing over the years (like 323 documents in the year 2000; 1699 in 2010; 12,148 in 2019), the figure mainly illustrates how the comparative usage of these terms in academic research has changed over the years. Apparently, the use of the SC term has today overshadowed all the other concepts in academic research and has universally been recognized as an umbrella term for enhancing livability, sustainability, and quality of life through ICT-based applications in urban areas.

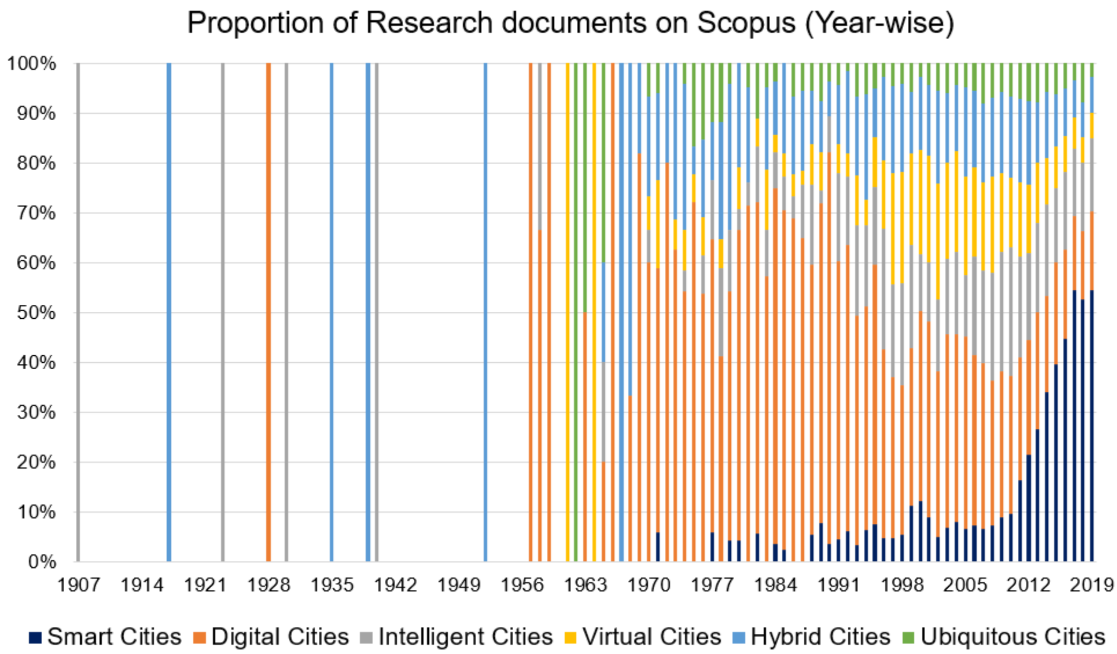

Figure 1. Highlighting the growing significance of Smart Cities research (Image source: Authors).

Thus far, numerous definitions of SC have been put forward by different quarters including academia, private companies, etc., with varying nomenclatures and context [2,6,33,37]. However, there is no standardized definition of SC yet and the concept is currently being applied with several different meanings [35,38]. While the definitions put forward by the corporate sector (like IBM and CISCO) are primarily based on ICT applications, the academic and research perspectives have emphasized more on the environmental sustainability aspect. Colding et al. [39] argued that an ideal smart city must essentially consider the sustainability aspects, like the wise use of natural resources.

Building on an extensive review of more than 100 definitions, the International Telecommunication Union (ITU), a specialized agency of the UN, established that,

> "A smart sustainable city is an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" [40].

While the term 'smart' itself enjoys many different descriptions in the literature, Allam and Newman [6] underlined that there is also a lack of a universal smart city framework or agreed dimensions of SC, as the current frameworks include an array of overlapping and non-overlapping themes. Against the persisting ambiguity in defining the precise features of SC, six key structuring dimensions are widely recognized: (1) Smart Economy, (2) Smart People, (3) Smart Environment, (4) Smart Living, (5) Smart Governance and (6) Smart Mobility [7,37,41,42]. Amongst these six components, Sanseverino et al. [41] explained that the Smart Environment dimension is particularly linked with the smart and sustainable urban environment with a wise management of natural resources. Here, the ICT features can be employed to improve the knowledge of environmental services such as water and energy, so as to change people's behaviors, reduce waste and improve the efficient use of resources [4,43].

Further, the content and nature of SC also vary in different countries. However, several pilot projects have already been implemented around the world. These projects are mainly categorized into two types, namely, Greenfield and Brownfield projects [44]. A third category of Purpose-driven SC is also specified by Chander and Mohan [45]. These three categories of SC are briefly explained below with examples:

- Greenfield projects (built from the start): Initiated in 2008, Masdar city in Abu Dhabi is a prominent example of a greenfield project. Envisioned to cover an area of 6 square kilometers (km^2) in the middle of a desert, the city aims to be the world's first sustainable 'smart city' with no carbon footprint [46].
- Purpose-driven SC (industrial city, science park, etc.): Initiated in 2002, the Songdo International Business District (South Korea) is one of the world's largest private development projects. Built from scratch on 600 hectares (6 km^2) of reclaimed land, it is conceptualized as the ultimate smart and sustainable city that integrates different dimensions of real estate, utilities, transportation, education, health and government [47].
- Brownfield projects (by retrofitting existing cities): In 2009, Amsterdam (The Netherlands) became one of the first European cities to launch a smart city program. To achieve a high quality of living, sustainable economic development and efficient use of natural resources, Amsterdam is actively partnering with business, authorities, research institutions and the people [48].

3. Growing Relevance of Water-Energy-Food Nexus Perspective

The water-energy-food nexus (WEF nexus) mainly refers to the tight interconnections between water, energy and food sectors [49]. Just as water is required for energy production and supply, energy is also required for the treatment and supply of water, and both energy and water are required for food production [50]. Against the competing needs to collectively meet the WEF resource demands of growing population, the WEF nexus perspective has now become a prerequisite to avoid any unintended impacts of policy decisions across different sectors [51]. The nexus perspective mainly emphasizes on the integrated governance of WEF resources while addressing their mutual interlinkages [23].

The history of nexus thinking can be traced back to 1983, when the United Nations University (UNU) launched the Food–Energy Nexus Programme. It was also subsequently discussed in various international and regional forums. However, the concept of the WEF nexus was officially recognized only after the Bonn Nexus Conference in 2011 [52,53]. Since then, the concept has gained significant momentum in academic research (refer to Figure 2) and policy sectors. The importance of WEF nexus thinking is also recognized through the Sustainable Development Goals, SDGs [54], as three of the 17 SDGs, namely, Goal 2 (No hunger), Goal 6 (Clean water and sanitation) and Goal 7 (Affordable and clean energy), specifically focus on security of WEF resources for human survival, economic growth and development. Further, Goal 10 (Reduced inequalities), Goal 11 (Sustainable cities and communities), Goal 12 (Responsible consumption and production), etc., emphasize the need for resource efficiency and strengthening urban–rural linkages to achieve sustainable development.

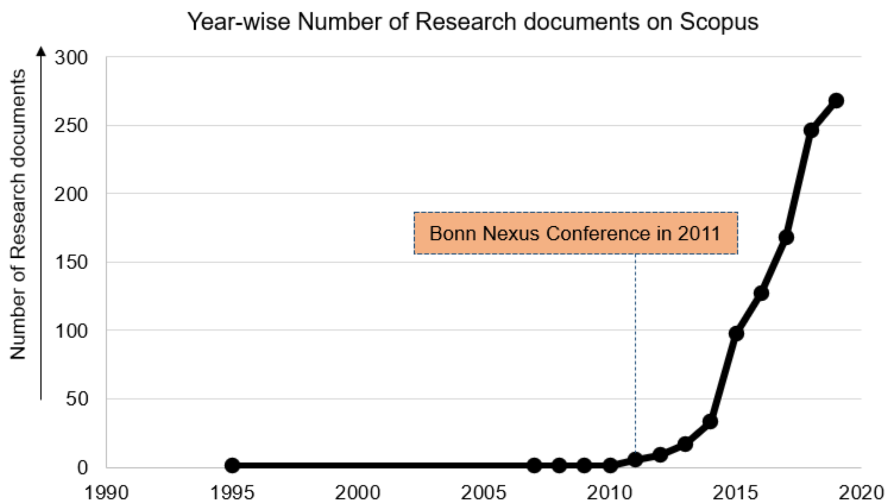

Figure 2. Highlighting the growing significance of water-energy-food (WEF) nexus research (Image source: Authors).

Post 2015, the concept of 'nexus' has become central to achieving sustainable development. Several attempts have been made to develop guiding frameworks for WEF nexus implementation and integrated governance [55,56]. A variety of interdisciplinary and transdisciplinary research methods have also been established for analyzing WEF systems in different contexts [57,58]. However, the policy-level applicability of these approaches at local level remains to be a critical challenge [24,59]. Even today, most of the policy decisions concerning the WEF sectors are made by independent institutions, across different sectors and administrative scales [60,61]. Mohtar and Daher [62] stressed that the science–policy gaps are widening as WEF research findings are not being incorporated in the development planning agendas.

Need for Water-Energy-Food Nexus Perspective in Cities

In the backdrop of growing WEF resource demands, cities are today being placed at the center of WEF nexus discussions [63,64]. Recent studies [65,66] have stressed that meeting WEF demands in cities has become the most critical challenge for achieving sustainable development. Being the net consumer of WEF resources, cities predominantly depend on non-urban areas outside their physical boundaries. However, at the same time, the expanding city boundaries and haphazard development activities in terms of land use change, wetland reductions, etc. are degrading the natural ecosystems [24]. Arthur et al. [67] underlined that the unprecedented increase in WEF demands is now outweighing the ecosystem thresholds and leading towards dire consequences.

To enhance the WEF resource security in cities, Schlör et al. [65] emphasized on considering both in-boundary as well as transboundary resource systems. Djehdian et al. [68] also highlighted the exposure of urban WEF systems to direct and indirect water scarcity concerns on a transboundary scale. These deliberations on WEF nexus implementation mainly reflect the ongoing transitions towards the long-anticipated goal of integrated resource management in consideration of spatial and temporal scales [64,69]. A range of other innovative solutions are also being put forward to address the complex nexus problems in terms of environmental monitoring, multi-stakeholder engagement, smart urban metabolism, technology integration in urban governance, etc.

4. Materials and Methods

4.1. Context of India's Smart Cities Mission

The Smart Cities Mission (SCM)—launched by the Government of India in 2015—is mainly an urban renewal and retrofitting program [10]. With an allocated funding of around 700 million United States Dollars (USD), the five-year program aims to drive economic growth and improve the quality of life by developing 100 SC across the country, which have been selected after a rigorous two-stage competition at the intra-state and inter-state levels. The implementation of SCM at city level is being done through the establishment of Special Purpose Vehicles (SPVs), which comprise the nominees of Central and State Government, and the Urban local bodies on its board. It is important to highlight that SCM is also complemented with several other urban development programs such as the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat Abhiyan (Clean India Mission) and Heritage City Development and Augmentation Yojana [5,29,32].

The SCM is being executed under two broad strategies of Area-Based Development (ABD) and pan-city initiatives. Under the ABD strategy, model areas are being developed within the selected cities, for either of the following development types namely, city improvement (retrofitting), city renewal (re-development), city extension (greenfield development), or a mixed strategy. Under the pan-city initiatives, ICT-based solutions such as electronic service delivery, traffic management systems, etc. are being applied to larger parts of a city for improved delivery of public services [70]. Both these strategic developments are expected to have rub-off effects on the city and surrounding areas.

For the selection process, the SCM Guidelines [70] had not prescribed a 'one-size-fits-all' model for SC. Rather, each of the potential city was required to formulate their own concept, vision, mission and plan for a Smart City (proposal), in consideration of local context, available resources and levels of ambition. It should be noted that the proposals were expected to contain ABD plans and pan-city initiatives, with high emphasis on infrastructure services and smart solutions.

4.2. About Nagpur City in India

Nagpur is one of the most prominent urban agglomerations in Central India (location highlighted in Figure 3). With a population of nearly 2.5 million spread over an area of 217.56 km^2, Nagpur is the third largest city in the state of Maharashtra. It is also an established medical and education hub [71–73]. Due to its strategic geographical location, robust connectivity profile and rich natural resource base, it is further projected to be one of the fastest growing cities in the world from 2019 to 2035 with an average annual GDP growth rate of 8.41% [74].

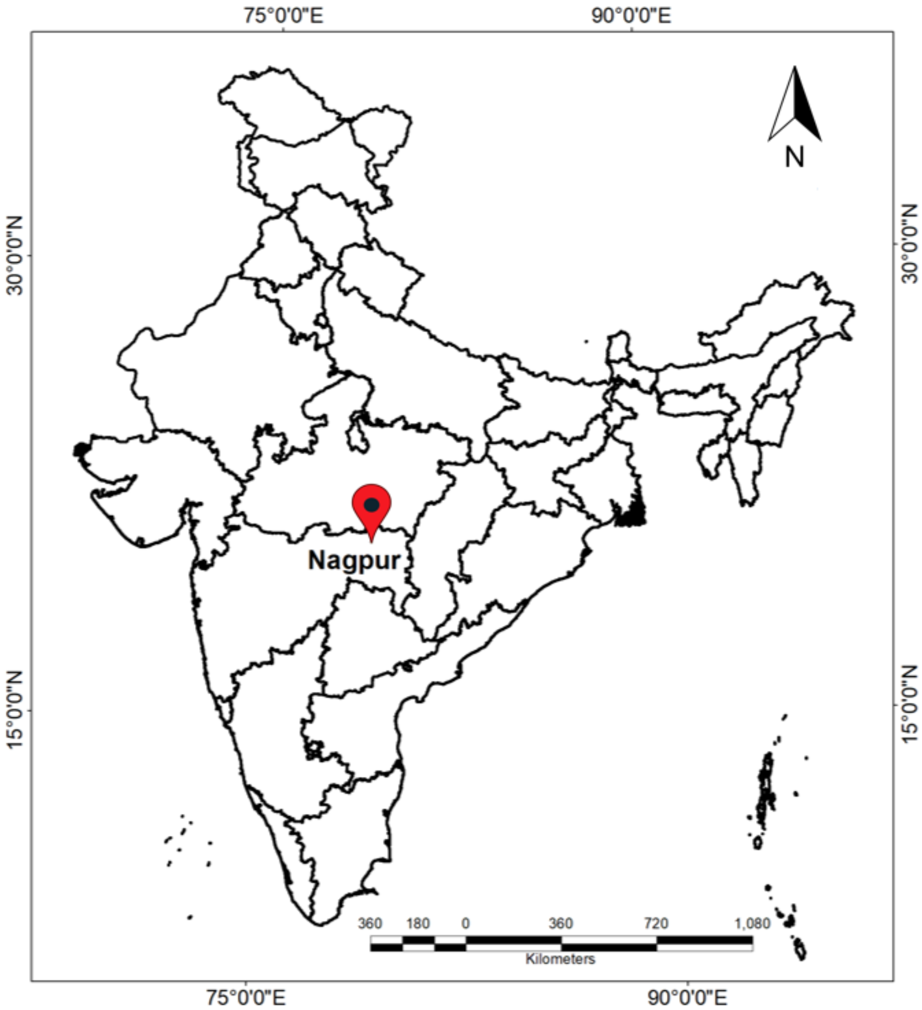

Figure 3. Location of Nagpur City in the Administrative Map of India (Image source: Authors).

Nagpur is also selected as one of the 100 proposed SC under the Government of India's SCM mission. The Nagpur smart city project aims to transform the city into the "most livable eco-friendly, edu-city that electronically connects people with the government to co-create an inclusive ecosystem." For the implementation of this project, 'The Nagpur Smart and Sustainable City Development Corporation Limited (NSSCDCL)' has been set up as a SPV. It is jointly owned by the Nagpur Municipal Corporation and the Government of Maharashtra. NSSCDCL as a lead agency is responsible for implementing the projects envisaged under the Smart City Proposal (SCP) of Nagpur, which is approved by the Government of India under SCM. The agency conducts a range of activities including planning, designing, executing, and operating the projects defined under Nagpur's SCP. It also acts as a platform to connect different stakeholders including governments, businesses and citizens for effective decision making and implementation of the project [75,76].

4.3. Research Methods

To bridge the existing science–policy gaps for enhancing WEF resource efficiency through SC development, this study conducts two types of analysis. For understanding the policy context of SC implementation and their links to WEF systems, a specific case of proposed Nagpur smart city is studied. Thereafter, literature analysis is conducted to study the existing SC research trends and identify new directions of SC research in the domain of WEF systems. The findings through both the case study analysis and literature analysis will pave the way for identifying key opportunities in Nagpur to enhance WEF resource efficiency through SC developments.

4.3.1. Case Study Analysis: Review of the Nagpur Smart City Action Plan

The action plan of the proposed Nagpur smart city is reviewed based on specific documents that include Nagpur's SCP [77], the proposed smart city vision [78], the types of projects proposed [79] and related annexures [80]. In addition to that, preliminary discussions were also held with the members of NSSCDCL (Nagpur smart city's SPV) and Nagpur Municipal Corporation who are responsible for implementing the projects listed in Nagpur's SCP. Based on the document analysis and interactions with local government officials, the authors reviewed the key focus areas of proposed Nagpur smart city and their significance for the local context. While doing so, the authors also highlight the key focus areas that are linked with environmental sustainability and WEF systems.

4.3.2. Literature Analysis: Review of Existing SC Research in the Domain of WEF Systems

To study the existing SC research in the areas of WEF systems, a methodical search was conducted in Elsevier's Scopus, the largest abstract and citation database of multidisciplinary literature (peer reviewed) and other high-quality web sources including books and conference proceedings [81].

For the literature analysis on Scopus, the authors applied search equations with a mix of keywords in the 'Article title, abstract and keywords' category. The document search was based on 'smart cities' as a fixed keyword, and the add-on keywords consisted of varying combinations of WEF systems, independently and conjointly. A total of eight search equations (as mentioned below) were run to cover the varying SC research domains in the areas of WEF systems:

1. 'Smart Cities' AND 'Water'
2. 'Smart Cities' AND 'Energy'
3. 'Smart Cities' AND 'Food'
4. 'Smart Cities' AND 'Water' AND 'Energy'
5. 'Smart Cities' AND 'Water' AND 'Food'
6. 'Smart Cities' AND 'Food' AND 'Energy'
7. 'Smart Cities' AND 'Water' AND 'Energy' AND 'Food'
8. 'Smart Cities' AND 'Water' AND 'Energy' AND 'Food' AND 'Nexus'

For each of these search equations, the following data were retrieved from Scopus database on 15 October 2020 and analyzed:

1. Number of research documents: Irrespective of the subject area, year of publication, document type or country of origin, the total number of research documents for each of the search equations are noted along with the document type (conference papers, articles, book chapters and others). This step is intended to establish a broader understanding of existing SC research in different directions, as the quantity of publications is an important indicator to study the development trends of scientific research.

2. Top 10 keywords: Keywords are nouns or phrases that reflect the core content of any publication. To have a parallel understanding of SC research trends in different directions, the top ten keywords for each of the search equations are noted and tabulated.
3. Bibliographic data (Keywords): From the 'Analyze search results' tab on Scopus, the author and index keywords for all publications (in each of the search equations) are exported as a CSV file. It should be noted that Scopus imposes download restrictions, as the downloaded files may not contain data for more than 2000 documents. Thus, for search equations with a larger number of documents, the data were downloaded in multiple batches. In reference to Guo et al. [20], these data are then used to carry out co-keyword (keywords co-occurrence) analysis in VOSviewer (Visualization of Similarities), a free software tool for bibliometric analysis [82]. Through VOSviewer, item density visualization maps are created for visualizing and exploring the research hotspots in different areas of SC research. For the keyword co-occurrence analysis in VOSviewer, the unit of analysis is set as 'All keywords', and the counting method is set as 'Full counting'. The co-occurrence threshold of the keywords is varyingly set, such that around 50 items can be brought into visualization for each of the search equation results.

5. Results

5.1. Review of Nagpur Smart City Action Plan

In accordance with SCM guidelines [70], the action plan of the proposed Nagpur smart city includes strategies for ABD and pan-city initiatives. These strategies are outlined by the city government in Nagpur's SCP [77], which was prepared based on a precise understanding of local context, geospatial growth and assessment of core infrastructure services etc. In addition to that, extensive stakeholder engagement (citizens, private sector etc.) was realized to frame the goals of the proposed Nagpur smart city through household surveys, focused group discussions, media campaigns, etc.

For the ABD strategy, a range of options were considered to identify an appropriate site for retrofitting, redevelopment, or greenfield development. Based on the self-assessment mapping of existing core infrastructure and quality of life indicators for different parts of city, retrofitting in 951 acres (3.85 km^2) of land in the Pardi-Bharatwada-Punapur (PBP) areas was finalized. Herein, moret than 50% of the population residing in PBP areas (≈65,000 citizens; ≈15,000 households) did not have access to basic infrastructure. The ABD developments in PBP areas using Town Planning Scheme are intended to regularize and mainstream these vulnerable areas, for achieving the vision of inclusive Nagpur [83]. In consideration to the essential features defined by SCM guidelines, the ABD plan has put great emphasis on physical and social infrastructure development.

For the pan-city initiatives, the city government received a range of suggestions through citizen engagement like for cleanliness, employment, smart mobility, safety, etc. In consideration of the aspirations of local citizens for a 'clean city', a customized ICT-based Smart Swachh City Solution to streamline the city's garbage management was adopted. This solution comprises of technology components like GPS enabled collection vehicles, RFID (radio-frequency identification) tagged bins, CCTV (Closed Circuit Television) surveillance, etc. Furthermore, for enhancing safety, Nagpur City Community Network (NCCN—dark cable optical fiber and backbone infrastructure), and a Unified Operations Command and Control Center (UOCCC) is being developed to operationalize ICT based solutions, including that for waste collection and management.

To implement the defined strategies, the Nagpur SCP has enlisted 30 Projects, of which 27 projects are focused on ABD and only three are related to pan-city solutions. Here, it is important to highlight that bulk of SCM funds for Nagpur (>85%) are being used for executing the ABD plan [79].

Strategic Focus of Nagpur Smart City Action Plan

For enhancing the quality of life in Nagpur, the Nagpur SCP defines 4 key Transformation Agendas and 12 Focus Areas (FAs) (summarized in Table 1). Each of these FAs have further defined Goals (32 in total), which are precisely explained in the Nagpur Smart City Annexure [80].

In reference to Nagpur's SCP and preliminary discussions with the local government officials, the twelve FAs of Nagpur smart city and their significance are as discussed below:

1. Inclusive Living
The Nagpur smart city aims to provide an ambitious 24 × 7 (24 h a day, 7 days a week) water supply to the entire city of Nagpur. The previous experience of local authorities with implementation of a pilot 24 × 7 water supply scheme [84] through Public-Private-Partnership model is being leveraged to scale up the approach at city level. While achieving this, it also advocates for mitigation measures such as stormwater drainage, sewerage system, etc. In convergence with other projects aimed at improving urban basic infrastructures such as AMRUT, the Nagpur SCP also envisages to improve water use efficiency through smart metering and real-time water quality monitoring. Utilizing the government-owned land resources, the Nagpur SCP also proposes a 100-acre green field development. In order to bring conformity with such development and promote the principle of inclusivity, it also considers slum upgradation and regularization of haphazard developments along the city fringes that are inconsistent with the development plan.
2. Poly-Centric City
For supporting the work and leisure culture of Nagpur, the SCP highlights the creation of sub-clusters of economic and recreational activities at selected key locations. This component also builds on the convergence of the Nag Riverfront Development project being developed under the National River Conservation Project and the Metro Rail project. It calls for restructuring of land use to strike a balance between economic and recreational facilities.
3. Safe and Walkable Streets
The safety of pedestrians and universal accessibility (children, elderly, etc.) have been prioritized for better mobility in Nagpur city. A blueprint for building a smart road network in the ABD area is prepared based on stakeholder discussions and by adopting the TenderSURE (Specifications for Urban Road Execution) concept [85]. In reference to relevant design standards and guidelines, inclusive, walkable and complete streets are proposed to be developed in the ABD area.
4. Economic Vitality
The Nagpur SCP focuses on creating infrastructures for enabling skill development, realizing real estate potentials in city fringe areas, and capitalizing on the existing health infrastructure for creating more job opportunities. By projecting Nagpur as an affordable and sustainable investment destination, the proposal also aims to attract high value adding industries and services.
5. Transit-Oriented Development
Following up with the success stories of Transit-Oriented Development (TOD) approach across global cities, the Nagpur SCP contemplates its application to generate more vibrancy in the land-use planning and real estate sector. Some major transformations in the land use and land management are postulated along the Metro routes considering the application of the TOD concept.
6. Connect Places and Move People
To create multi-modal mobility options, the Nagpur SCP envisions creation of walkable and bicycle-friendly promenades around water bodies. To encourage people to shift to public transportation, the Nagpur SCP emphasizes on creating multiple and affordable mobility options. Further, dedicated cycle tracks and public bike sharing systems are also proposed to be developed.

Table 1. Key features of Nagpur Smart City Action Plan (Source: Nagpur SCP [77]).

Transformation Agendas	Focus Areas	Key Goals
Smart Living	1. Inclusive Living ** 2. Poly-Centric City * 3. Safe and Walkable Streets 4. Economic Vitality	(i) Create basic infrastructure of water supply, sewerage system, storm water drainage and electricity, all with '24 × 7' availability (ii) Create 'hubs' of education, health, logistics, etc. for building economic avenues
Smart Mobility	5. Transit-Oriented Development 6. Connect Places and Move People * 7. Urban Regeneration with walk-to-work	(i) Create multi-modal mobility options for enabling smooth flow of people (ii) Develop strategic nodes along the metro corridors (iii) Revitalize old-city areas with improved walkability
Smart Environment	8. Carbon Neutral and Sustainable Habitat ** 9. Swatch Nagpur ** 10. Urban Greens *	(i) Promote energy efficiency in building and transportation sectors, and enhance the use of non-conventional energy (ii) Rejuvenate rivers, promote rainwater harvesting and urban forestry
Smart Governance	11. Digital, Efficient and Transparent Governance ** 12. Revive Nagpur's image as the regional economic center and boost job creation	(i) Explore alternate means of service delivery for improving efficiency and transparency by leveraging various ICT platforms

* FAs related to environmental sustainability; ** FAs specifically related to WEF systems.

7. Urban Regeneration with walk-to-work
   The Nagpur SCP promotes the walk-to-work principle by creating self-sufficient neighborhoods. This approach is more suitable for the old city areas, which are observed to be having mixed land use, dense urban forms, and increasing vehicular population.
8. Carbon Neutral and Sustainable Habitat
   The Nagpur SCP has put up ambitious plans to reduce conventional energy demand and carbon emissions at the city as well as neighborhood levels. It plans to introduce 'green buses' and replace all streetlights with LED (light-emitting diodes)-based lights. At neighborhood level, it promotes bio methanation plants and rooftop solar energy systems. Further, to create a clean and green ecosystem, the SCP encourages green buildings, energy efficiency, rainwater harvesting, etc.
9. Swatch Nagpur
   In convergence with the ongoing nationwide program for getting rid of open defecation [86], the Nagpur SCP plans to build toilets for every household level, particularly in slums and city-periphery areas. It also aims to enhance wastewater treatment, solid waste collection and re-engineering solid and liquid waste management by adopting newer technologies.
10. Urban Greens
    Nagpur is recognized as one of the greenest cities in India [76], but these green patches exist mainly over the institutional campuses, in lake catchments and pristine hill forests, which have restricted access to the citizens. In view of that, the Nagpur's SCP aims to create more inclusive, accessible, and attractive open spaces through landscape designs and increasing the green cover in the city. It also proposes to establish an urban forest in one of the lake catchment areas.
11. Digital, Efficient and Transparent governance
    In Nagpur's SCP, a citywide ICT backbone called NCCN is proposed to be established. The UOCCC connected with CCTV cameras at critical junctions across the city has already been established, which has strengthened the traffic management and social safety monitoring (Unpublished Impact Assessment Study by VNIT, Nagpur, 2019). The Supervisory Control and Data Acquisition (SCADA) system and quality sensors are also proposed in Nagpur's SCP to improve the monitoring of water supply and sewerage systems.
12. Revive Nagpur's image as the regional economic center and boost job creation
    To bring economic vibrancy and improve the viability of various SC initiatives, the Nagpur's SCP aims to develop a strategic roadmap. Through multi-stakeholder and innovation partnerships with education and research institutions, it also aims to create a framework for promoting incubation centers, start-ups, and youth entrepreneurship centers. A shift in policy environment is also considered for encouraging trading and allied investments to foster economic growth.

5.2. Existing SC Research in the Domain of WEF Systems

Figure 4 highlights the number and types of SC-related research documents (in Scopus) in the domain of WEF systems (independently and conjointly), until 15 October 2020. It can be seen that a significant amount of research has so far been conducted on smart solutions related to energy and water, much more as compared to food systems. The interconnected areas of water and energy have also concurrently been addressed by a considerable number of SC-related studies, more as compared to other combinations of interlinked WEF systems. Noticeably, the integrated components of WEF systems and WEF nexus seem to have gained far less attention in SC research. This finding is also in line with Liang et al. [22], who pointed that most of the previous studies have analyzed WEF systems independently or examined two of the three WEF systems at a time within the defined boundaries. Further, a substantial proportion of these research documents are seen to be conference papers, through which it is apparent that all the interlinked areas of SC and WEF systems are widely been discussed and explored.

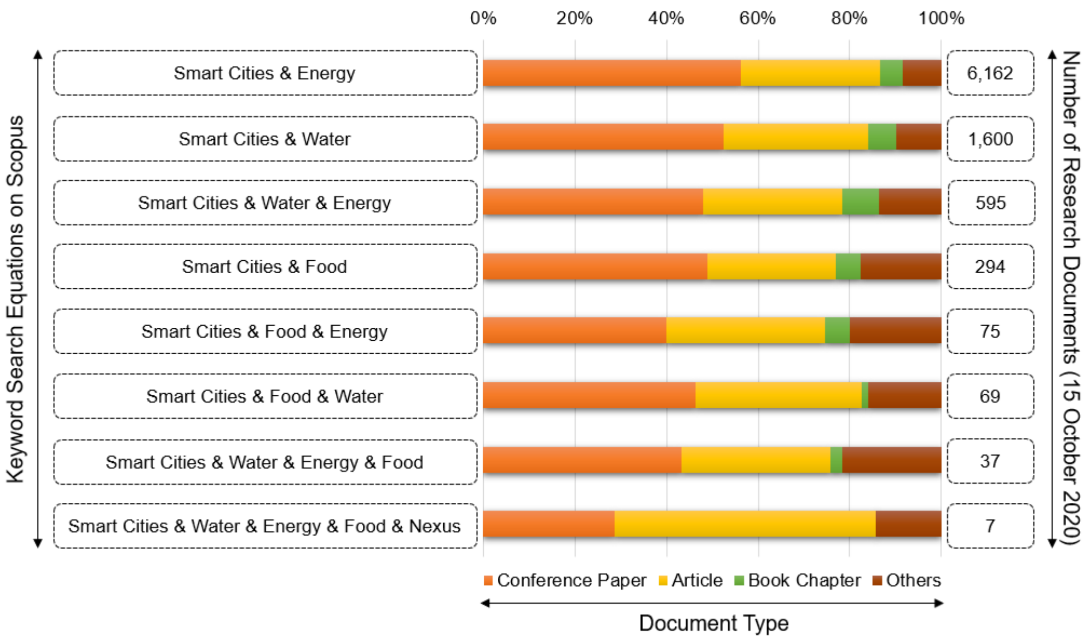

Figure 4. Number and types of research documents for Smart Cities research in various domains of WEF systems (Image source: Authors).

Figure 5 highlights the top 10 keywords for each of the eight search equations run to study the SC research trends in different domains of WEF systems. Not so remarkably, the terms of 'smart city' and 'smart cities' have been used widely in these defined set of documents. The wide usage of sustainability aspects as keywords is also predictable in all research domains, as WEF systems are connected to the natural environment. However, at the same time, this figure is quite revealing in several ways. The positioning of IoT and sustainability aspects in these top 10 keyword trends is an important indicator for interpreting the extent of technology integration and environmental consideration in these different research domains. For the independent WEF systems, it can be seen that IoT aspects are more commonly being used as a keyword, as compared to sustainable development. At the same time, sustainability aspects are seen to have more commonly been used for interlinked WEF systems.

Figure 6 presents the keyword density visualization maps for document results of all eight search equations. In these maps, each point has a distinct color that indicates the density of items (keywords) at that point. These colors by default range from red to green to blue. The higher the number of items (keywords) is in proximity to a point, and the higher the weights of their neighboring items are, the closer the color of that point is to red. Likewise, the smaller the number of keywords is in proximity to a point, and the lower the weights of their neighboring items are, the closer the color of that point is to blue. Apart from the color density, two key factors of 'size' and 'distance' are important to interpret these maps. The size of the labels (keywords) is directly related to their weight (frequency of occurrence), and the distance between two keywords demonstrates their relative strength and topic similarity. The shorter the distance between two labels, the stronger their relationship is in terms of co-occurrences [82].

As apparent from Figure 6, the keyword 'smart city' is seen to have the highest strength in all eight density visualization maps, which is very predictable as SC itself was a fixed part of the search equations. However, these maps help in further visualizing the relative strengths of other keywords to SC. As, for example, in Figure 6a, the keywords of energy utilization and conservation, IoT, smart grid and sustainable development, etc. have a larger label size and their reddish color density indicates their higher co-occurrence with SC in research documents. In terms of the distance between these labels, it can be stated that energy utilization and conservation are more commonly used in the SC research, as compared to IoT, sustainable development and smart grids. Likewise, the other maps shown in Figure 6 can also be interpreted.

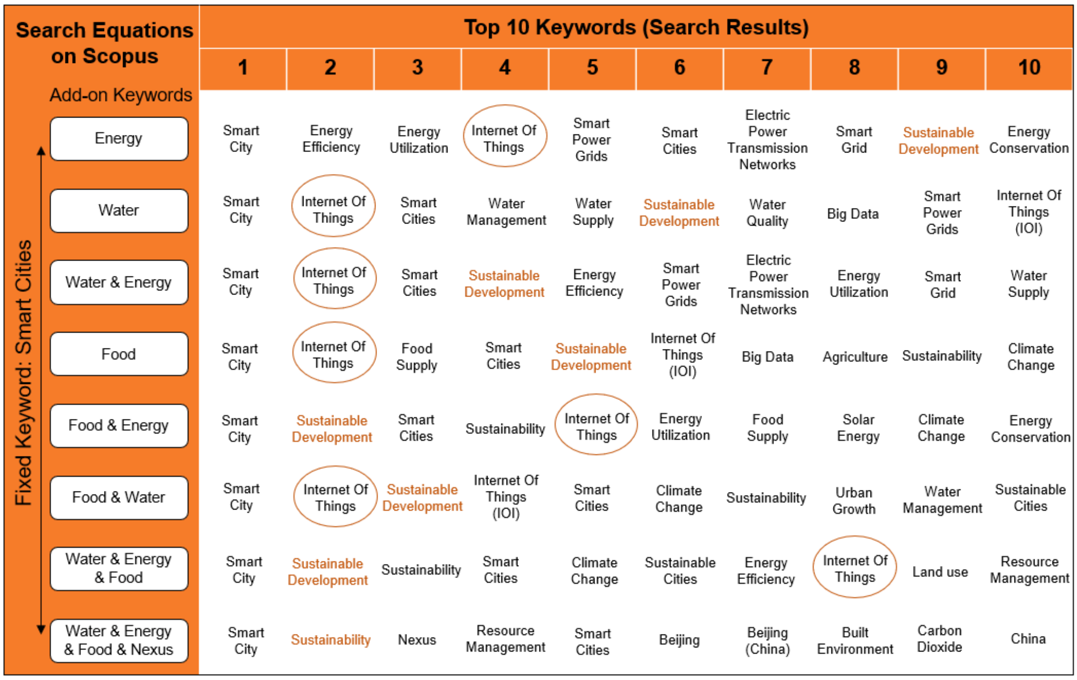

Figure 5. Top 10 keywords for SC research in various domains of WEF systems (Image source: Authors).

In reference to Figures 4–6, the following sub-sections provide an overview of the current SC research literature in the domain of WEF systems (independently and conjointly).

5.2.1. Smart Cities and Water

Cities around the world are today faced with diverse water-related issues such as water scarcity, degrading water quality, ageing infrastructure, water losses, etc. In line with that, the range of sub-clusters in Figure 6b indicates the diverse SC-related sub-fields, wherein advanced technologies such as IoT sensors and big data are being employed for diverse purposes such as enhancing water distribution systems, water quality monitoring, leakage detection, water efficiency, waste water management, etc. (e.g., [87–91]). Through automated metering and smart power grids, cities are also trying to optimize the water and energy consumption for different purposes while reducing water losses. Smart meters linked through smartphone apps are now allowing residents to check their water consumption in real time and reduce costs, while facilitating automated billing and payment (e.g., [92]).

5.2.2. Smart Cities and Energy

Energy efficiency, utilization and conservation are widely recognized as key focus areas of SC developments globally [93], which is also apparent through the keyword trends in their research domain (refer to Figure 5). Linked with advanced technologies such as IoT sensors, a range of smart solutions related to intelligent buildings, renewable energy generation, energy storage, electric vehicles, smart appliances, smart lighting, etc. are now being employed to enhance the functioning of urban areas (e.g., [94–98]). Herein, smart power grids are gaining increasing recognition (also seen from Figure 6a), as they allow for two-way communication of data (between energy generators and consumers) and real-time data collection concerning the supply and demand [44]. By maintaining an optimal supply of electricity, smart grids also help to reduce transmission losses [99]. For effective functioning, smart grids also rely on a range of smart technologies such as smart meters. Through sensor-based data collection, smart electricity meters help to automate, monitor and optimize the energy consumption for domestic, commercial and industrial purposes in real time [100].

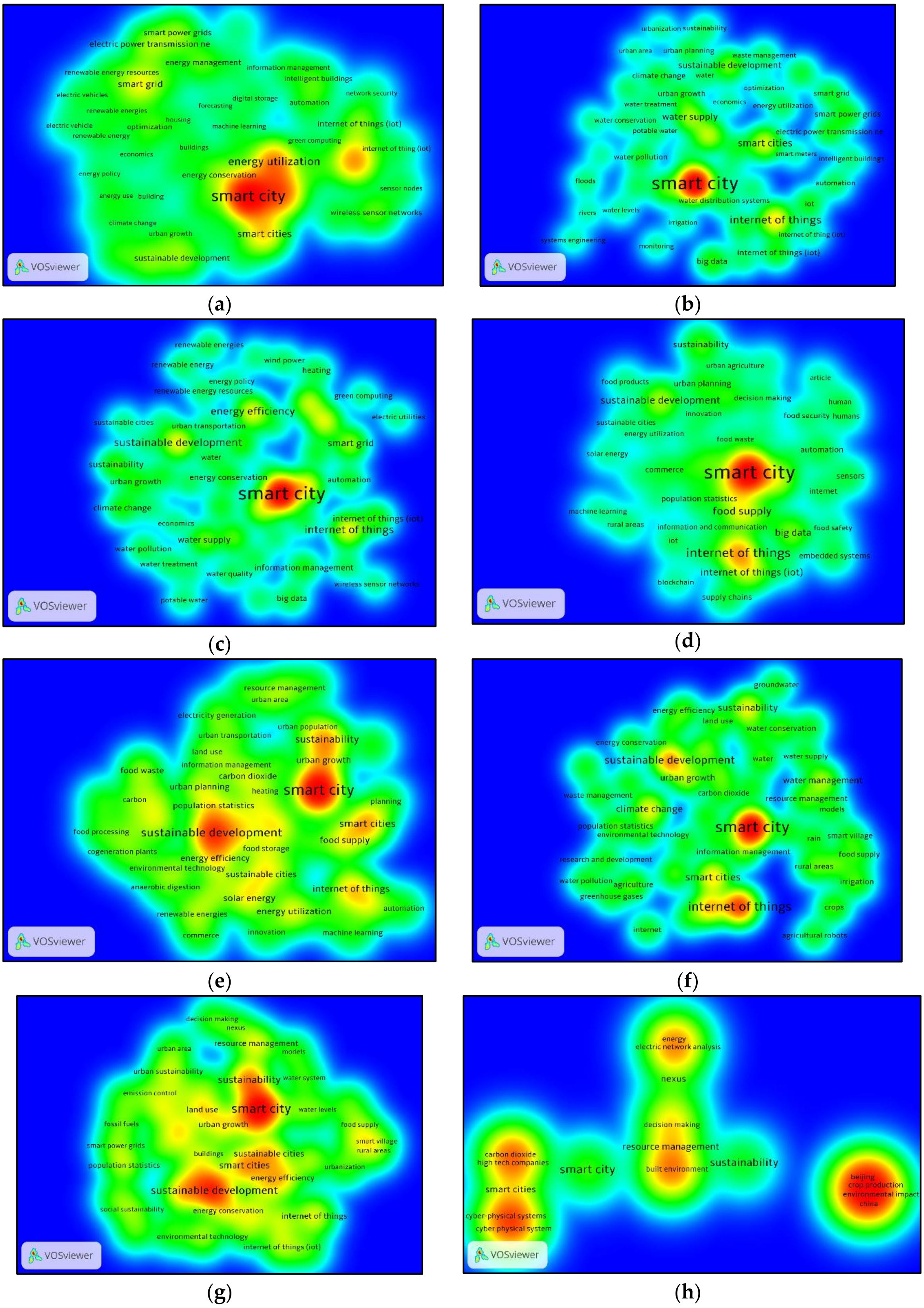

Figure 6. Density visualizations maps (based on co-keyword occurrences) for SC research in various domains of WEF systems, namely: (**a**) Smart Cities and Energy; (**b**) Smart Cities and Water; (**c**) Smart Cities and Water and Energy; (**d**) Smart Cities and Food; (**e**) Smart Cities and Food and Energy; (**f**) Smart Cities and Food and Water; (**g**) Smart Cities and WEF; (**h**) Smart Cities and WEF nexus (Image source: Authors).

5.2.3. Smart Cities and Food

To enhance food supply and management, cities are gradually adopting smart solutions such as IoT, big data, blockchain, etc. (refer to Figures 5 and 6d). Great emphasis is being put on encouraging urban agriculture, enhancing food safety and minimizing food waste. Noticeably, the keywords of rural areas, supply chains, etc. have also been recognized in SC literature on food systems (refer to Figure 6d). From smart farming to enhancing food supply-chain performance, ICT applications are increasingly demonstrating extreme potential to revolutionize food systems [101–103]. The governance of food systems in SC has also emerged as a key theme of the 2015 Milan World Expo [104]. Due to the wide range of actors involved in food systems, governance and multi-stakeholder engagement are increasingly being highlighted as the key focus areas of smart food systems [105,106].

5.2.4. Smart Cities and Interlinked Water-Energy-Food Systems

Except for the domain of water-energy nexus (Figure 6c), very few SC-related studies have focused on WEF systems from an interconnected perspective (refer to Figure 4). The existing studies for other nexus combinations such as the food-energy nexus (Figure 6e) and the food–water nexus (Figure 6f) are particularly linked with climate change and sustainable development. It should be noted that very few studies have addressed the three interlinked WEF systems combined, and the potential of SC in this regard is yet to be fully explored. Mekonnen et al. [25] highlighted that technology innovation and quantification of nexus relationships are two critical solutions in the context of SC. While the majority of the existing research is focused on conceptualizing WEF nexus and modelling approaches (refer to Figure 6g,h), some innovative solutions, such as the Roof Mosaic approach [107,108], have also been developed, that seek to enhance self-sufficiency in cities by using unused rooftops for food production, renewable energy and rainwater harvesting.

6. Discussion

Referring to Section 5.1, the proposed Nagpur smart city builds on four key structuring aspects of Smart Living, Smart Mobility, Smart Environment and Smart Governance. To make Nagpur city sustainable, inclusive and livable, great emphasis is being put on enhancing urban services like water and electricity supply, solid waste management, urban regeneration, improved mobility, digital governance, etc. However, most of these developments are stated to be a part of ABD in PBP areas (which cover <2% of city area), and only a few pan-city initiatives (e.g., waste management) are being applied to larger parts of the city. This finding is also in agreement with van den Bosch [28], who highlighted similar prospects for all proposed SC under the SCM mission. The predominant focus on ABD plans as compared to pan-city initiatives possibly reflects the content and nature of proposed SC in India, which again varies in different countries (as also explained in Section 2).

In regard to urban sustainability, Nagpur's SCP [77] has emphasized on development of open spaces, biodiversity parks, reducing carbon emissions, reducing energy demand, and water losses, etc. However, the importance of environmental resource conservation for the future relevance of SC developments has not been recognized. For example, to provide continued water supply to the city residents, the Nagpur smart city may not by itself achieve these objectives, as the city meets their water demands from areas outside their physical boundaries. Nagpur's SCP has, however, emphasized on improved water use efficiency within city boundaries through smart metering and water quality monitoring. However, the key water source areas of Nagpur city are situated outside the city boundaries [109]. This is the reason why despite the widespread advances under SCM, Nagpur city has witnessed severe water stress situations in the recent years [71]. Particularly in 2019, the water supply in Nagpur city had to be restricted to alternate days due to declining water levels in reservoirs [110–112]. At the same time, the drying water sources outside the city boundaries are also having an impact on regional food (agriculture) [113] and energy systems (thermal power stations), as drinking water demands in city areas are prioritized by law. Herein, the study underlines the core need for SC to think beyond ICT application within city boundaries. It is important to realize that resource management through ICT application in cities needs to go hand in hand with environment resource conservation at transboundary level. In consideration of the rising concerns of WEF resource security in the wider Nagpur region, WEF nexus thinking has become imperative for the SC developments in Nagpur.

In consideration of the defined FAs of the proposed Nagpur smart city (Section 5.1) and the identified SC research directions in the domain of WEF systems (Section 5.2), the authors discuss four key opportunities for optimizing the WEF nexus in the following sub-sections. These opportunities are specifically linked to the context of Nagpur but some generalized lessons can also be derived for other SC being developed under the SCM mission.

6.1. Smart Water Systems—An Entry Point to Optimizing the Water-Energy-Food Nexus

While the stock of freshwater resources is finite, there are competing water needs to meet the growing demands for varying purposes including the urban domestic needs, food and energy production. Meeting the water supply demands of Nagpur city without causing any cross-sectoral and transboundary implications has also become a challenge, as the city is already witnessing direct water stress. In this context, the Nagpur SCP [77] has already proposed solutions like smart metering and water quality monitoring at city level. However, to enhance the WEF resource efficiency at the transboundary scale, there is also a need to plan for improved water management at regional level.

Presently, Nagpur city receives water from three key surface water sources, namely, Gorewada lake, Kanhan river and Pench dam. Pench dam—a multipurpose project—located 45 km North of Nagpur city, presently caters to more than 70% of the city's water demands [73]. According to the Draft Sanitation Plan report prepared by NMC in 2011 [72], more than 50% of water supplied to Nagpur city is being lost in transmission and distribution networks. Considering the importance of limited water resources for urban domestic needs, as well as for other purposes like food and energy production, Nagpur smart city needs to incorporate plans to improve water use efficiency at the regional level. The effective use of cutting-edge technologies for water leakage detection, wastewater reuse and treatment, smart irrigation, etc. (also discussed in Section 5.2.1) from both an in-boundary as well as transboundary perspective can positively contribute to optimizing the WEF nexus.

6.2. Improved Understanding of Food Systems at Regional Level

The proposed Nagpur smart city has to an extent focused on enhancing the supply and efficiency of water and energy resources (refer to Section 5.1). However, the importance of food systems has not been recognized in Nagpur's SCP, regardless of the fact that cities are net consumers of food products. The importance of food systems was also recognized during the enforced COVID-19 lockdown in Nagpur, wherein the urban–rural food supply chains were reportedly disrupted [114]. While the source of water and energy in Nagpur are more or less known [109], the food products in the city come from several different places from across the region. In that context, enhancing food supply and management through smart solutions can serve for integrated management of water and energy resources, as agriculture is the overall largest user of water resources and it also requires energy (a generalized overview is shown in Figure 7).

As such, there is a need to employ ICT applications for tracing the flow of food products from agricultural producers outside the city boundaries to consumers in the city, and accordingly, work towards enhancing the efficiency of the WEF nexus at different stages of food production, supply and consumption. From a WEF nexus perspective, Sukhwani and Shaw [109] explained the flow of freshwater and wastewater resources between urban and rural areas in Nagpur Metropolitan Area (NMA). Likewise, if the overall input, intersectoral flows, stock and outputs of food production could be specifically defined, the ICT features of SC can be employed to collect, monitor and analyze the data for facilitating informed decision making. It can also offer insights into the energy usage, waste generation, etc. trends at household level, and open up opportunities for improving the resource efficiency and management from a metabolism perspective.

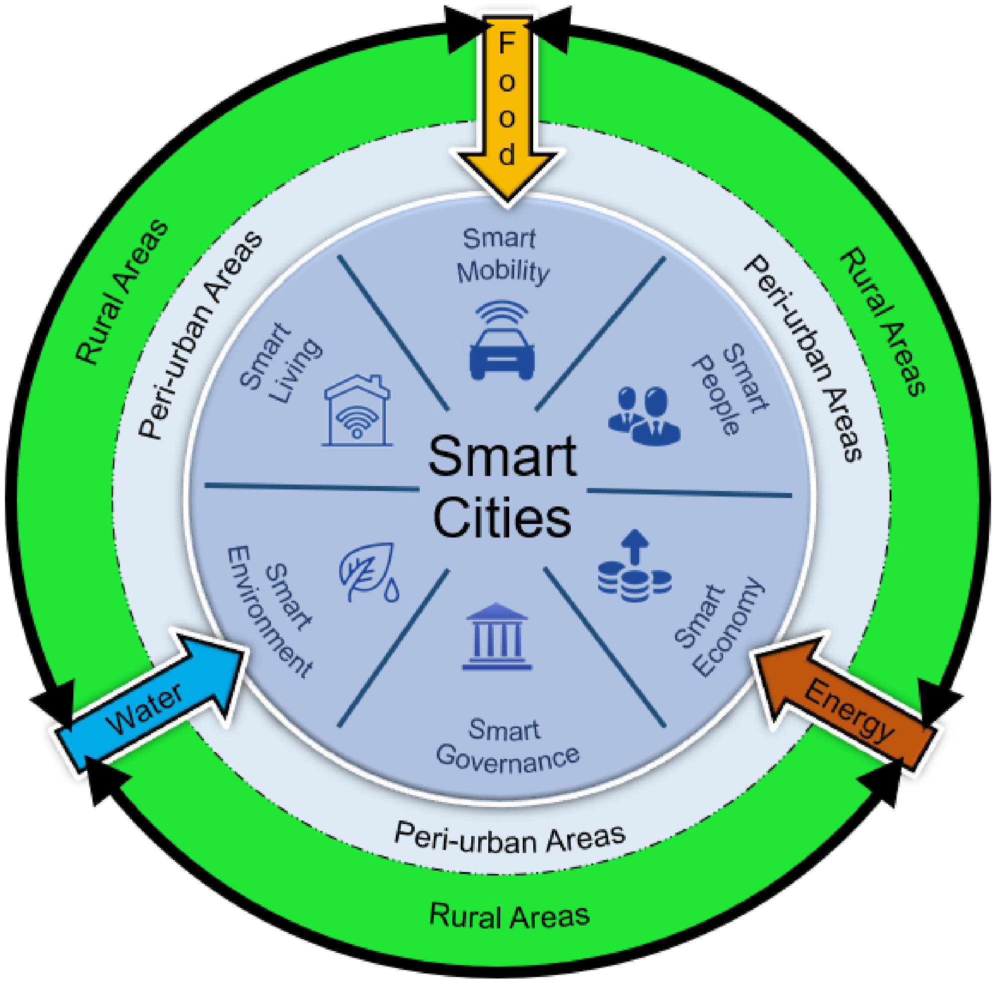

Figure 7. Schematic framework for integrating a WEF nexus perspective in Smart Cities planning (Image source: Authors).

Food systems are highly complicated due to their informal management, wide range of stakeholders and varied source areas. In consideration of the limited funds and institutional capacities, the study suggests that the potential of citizen science needs to be realized for bridging the knowledge gaps in WEF systems. While Nagpur SCP [77] has already emphasized on community engagement through digital technologies (e.g., for waste management), the scope of these initiatives can further be widened to understand food systems. From understanding community perception (as for food preferences) to enhancing food supply-chain performance, specific elements could be incorporated in the Nagpur smart city project for generating grounded evidence and working towards WEF nexus optimization through data-led governance in SC. New directions in utilizing ICT applications for food supply and management in Nagpur can also be derived from the existing SC research trends, which are discussed in Section 5.2.3.

6.3. Enabling Multi-Stakeholder Engagement for Transboundary Cooperation

From the WEF source areas to consumers, a wide range of actors are included at different administrative scales. In NMA also, the flow of WEF resources is separately governed and managed by different agencies at various territorial levels [73,109]. In consideration of the overlapping spatial scales of the natural systems (e.g., river basins), it is important for the Nagpur smart city to leverage the interlinkages between WEF sectors and promote policy coherence at transboundary scales. While no general consensus exists so far on optimal decision making, there is an opportunity for SC developments to stimulate participatory decision making through the 'Smart Governance' component. The keywords of 'decision making' and 'resource management' have also been recognized in the existing SC research trends on WEF interlinked systems, as seen from the density visualization maps in Figure 6g,h. Since the proposed Nagpur smart city is still in the transformation phase, resource sustainability and multi-stakeholder involvement can play a central role in creating adaptive and resilient cities [4].

Although the dynamic nature of stakeholders (including governments, industry, academia and communities) across different sectors and scales has for long been a decision-making challenge [115], the notion of multi-stakeholder engagement has recently gained increasing attention for bridging the science–policy gaps. Several best practices have emerged around the world for engaging local stakeholders to enable integrated resource management. In this context, the idea of 'Urban Living Labs' (ULLs) has recently gained wide recognition in different parts of the world. ULLs are often interchangeably used as an approach, a project, or a specific space. Nonetheless, they facilitate multi-stakeholder engagement to collectively derive sustainability solutions for cities. By involving citizens in development planning, ULLs help to enhance the livability and inclusiveness in cities [116–118]. For the case of Nagpur, establishment of a stakeholder platform similar to ULLs will not only provide a platform for bringing together a range of stakeholders, but it will also enhance knowledge co-creation for addressing WEF nexus issues that are specific to local context.

6.4. Coordinated Development of Nagpur Smart City and the Adjacent Wadoda 'Rurban' Cluster

The importance of strengthening urban–rural linkages is increasingly being recognized for achieving sustainable urban development, as the cities largely meet their WEF resource demands from areas outside their physical boundaries. The existing SC research trends in the domain of WEF systems have also identified rural areas as an important component for integrated resource management (also reflected in Figure 6d,f,g). The proposed Nagpur smart city should therefore take into consideration the possibilities of strengthening urban–rural linkages at regional level.

In this regard, it is important to point out that in parallel to the SCM mission, the Government of India also launched the 'Shyama Prasad Mukherji Rurban Mission' (SPMRM) in 2016 with the aim to develop 300 Rurban Clusters (a group of geographically contiguous smart villages) across the country [119]. Wadoda cluster (comprising of 31 villages) in Nagpur district has been selected as one of the Rurban clusters under SPMRM, which aims to preserve the dominant agrarian culture and enhance basic services such as water supply, sanitation, road drainage and solid waste management [120]. As shown in Figure 8, Nagpur city and Wadoda cluster are situated adjacently. However, they are being separately developed under two different national missions which are totally disconnected. Sukhwani and Shaw [109] also discussed the focus areas of Wadoda cluster in reference to the Nagpur smart city plan and emphasized the need for collective action for integrated resource management at the transboundary scale.

Both these nationwide programs of SCM and SPMRM are expected to build ideal models of smart cities and smart villages that could be replicated for future developments around the country. Therefore, the coordinated development of Nagpur smart city and Wadoda cluster could serve as an example for strengthening urban–rural linkages not only at regional level but also at national level. The importance of urban–rural linkages and partnerships has also been highlighted in global policy frameworks such as the SDGs [54] and The New Urban Agenda [121].

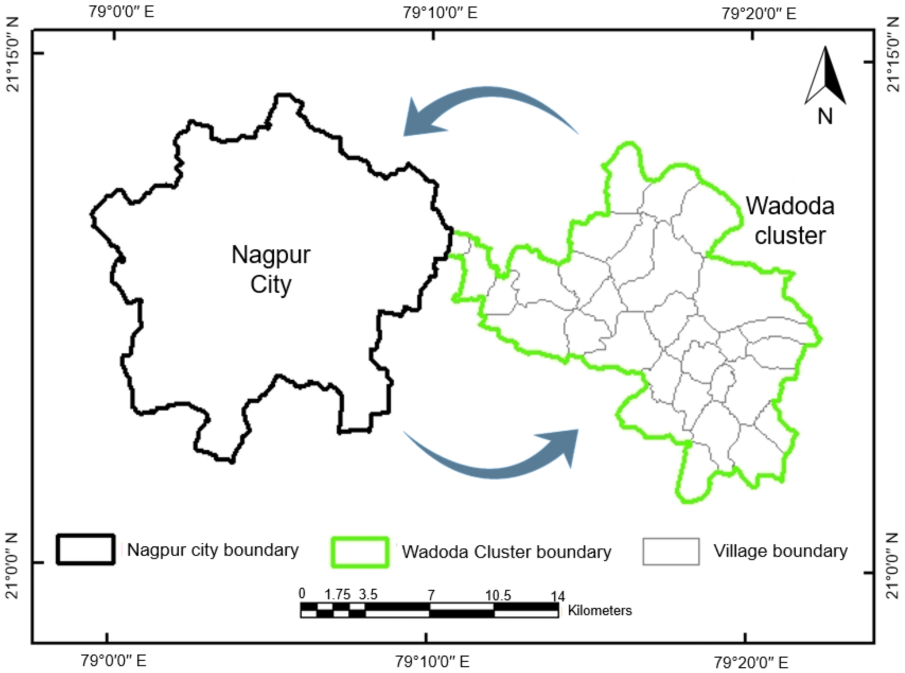

Figure 8. Location map of Nagpur city and Wadoda Rurban cluster (Image source: Authors).

7. Conclusions

This study discussed the two evolving concepts of SC and the WEF nexus, alongside their overlapping focus areas. Against the rising WEF resource demands and the core need for environmental sustainability, the ongoing SC developments need to have a clear understanding of direct and indirect nexus-based concerns. Although technology advancements and infrastructure development are core to SC projects, the study underlined a genuine need for safeguarding the future WEF resource security of fast-growing cities. For the SC developments to remain relevant in the long term, the decision makers need to essentially consider the aspects of environmental resource conservation at regional level. As the world is already experiencing significant WEF resource shortfalls, the ICT-based smart solutions can serve for improved data collection and analytics for enabling effective use of natural resources. The increasing penetration of ICT applications through SC developments also provide a genuine opportunity to the city governments for creating insights on resource consumption patterns and take informed decisions to optimize WEF nexus.

Through the case of the proposed Nagpur smart city in India, it is noted that the SCM mission in India puts high emphasis on physical and social infrastructure development within city boundaries, in terms of waste management, energy efficiency, mobility solutions, traffic management, etc. However, there is limited scope for consideration of environmental sustainability aspects and natural resource management beyond the city boundaries. The notion of optimizing the WEF nexus at the transboundary scale therefore needs to be mainstreamed for enhancing WEF resource efficiency in proposed SC in India. The increasing concentration of populations and economic activities in these cities also provides a range of opportunities for optimizing the in-boundary (e.g., reduced water losses, consumption patterns) and transboundary linkages (e.g., wastewater reuse) between WEF sectors.

Through the bibliometric analysis on keywords, the existing SC research trends in various domains of WEF systems were highlighted. The density evaluation maps prepared through the VOSviewer tool helped to vividly draw on the various directions (areas/sub-areas) for enhancing WEF resource efficiency in SC. This analysis can also serve as a valuable future reference for researchers and practitioners in the field of SC and WEF systems.

To this point, the key objectives defined in the beginning of this study have been achieved, but the readers should note the following limitations of this research. Firstly, this research is largely based on a conceptual and interpretative approach. Secondly, the study is only based on the review of the proposed Nagpur SC plan and the opportunities for optimizing the WEF nexus are bound to vary in different contexts. Thirdly, the bibliometric assessment was only focused on the co-keyword analysis (for data derived from Scopus) through density evaluation maps. In that regard, there is scope for further exploring other types of analysis (such as the strength of links), and by combining the bibliographic data from other databases (e.g., PubMed and Web of Science). A recommended direction for further research would be to overcome these study limitations, as well as to work towards bridging the existing science–policy gaps.

Author Contributions: Conceptualization, investigation, visualization, methodology, writing—review and editing, all authors; software, formal analysis, writing—original draft preparation, V.S.; validation, resources, supervision, project administration, funding acquisition, R.S., S.D., B.K.M., and W.Y. All authors have substantially contributed to the development of this paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the Japan Society for the Promotion of Science (JSPS) and the Indian Council of Social Science Research (ICSSR) under the India-Japan Bilateral Research Project. Publication of the research was made possible with funding from Keio University.

Acknowledgments: The first author (V.S.) is thankful to the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan for the provided scholarship.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. UN DESA. *World Urbanization Prospects: The 2018 Revision*; United Nations, Department of Economic and Social Affairs (UN DESA): New York, NY, USA, 2019. Available online: https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf (accessed on 28 August 2020).
2. Schipper, R.P.J.R.; Silvius, A.J.G. Characteristics of Smart Sustainable City Development: Implications for Project Management. *Smart Cities* **2018**, *1*, 75–97. [CrossRef]
3. United Nations Environment Programme (UNEP). *Cities and Buildings*; UNEP-DTIE Sustainable Consumption and Production Branch: Paris, France, 2013.
4. Fernández, C.G.; Peek, D. Smart and Sustainable? Positioning Adaptation to Climate Change in the European Smart City. *Smart Cities* **2020**, *3*, 511–526. [CrossRef]
5. Gupta, K.; Hall, R.P. Understanding the What, Why, and How of Becoming a Smart City: Experiences from Kakinada and Kanpur. *Smart Cities* **2020**, *3*, 232–247. [CrossRef]
6. Allam, Z.; Newman, P. Redefining the Smart City: Culture, Metabolism and Governance. *Smart Cities* **2018**, *1*, 4–25. [CrossRef]
7. Baltac, V. Smart Cities—A View of Societal Aspects. *Smart Cities* **2019**, *2*, 538–548. [CrossRef]
8. Sharifi, A. A typology of smart city assessment tools and indicator sets. *Sustain. Cities Soc.* **2020**, *53*, 1936. [CrossRef]
9. Smart Nation Singapore, Transforming Singapore through Technology. Available online: https://www.smartnation.gov.sg/ (accessed on 19 August 2020).
10. Smart Cities Mission, Ministry of Housing and Urban Affairs, Government of India. Available online: http://smartcities.gov.in/content/ (accessed on 19 August 2020).
11. Wan, B.; Ma, R.; Zhou, W.; Zhang, G. Smart City Development in China: One City One Policy. *ZTE Commun.* **2015**, *13*, 40–44. [CrossRef]
12. Smarter Cities: New Cognitive Approaches to Long-Standing Challenges, IBM. 2009. Available online: https://www.ibm.com/smarterplanet/us/en/smarter_cities/solutions/human_solutions/ (accessed on 19 August 2020).
13. Komninos, N. Cisco Intelligent Urbanisation. Intelligent Cities/Smart Cities, URENIO Research Unit. 2009. Available online: https://www.urenio.org/2009/03/13/cisco-intelligent-urbanisation/ (accessed on 19 August 2020).
14. Joss, S.; Sengers, F.; Schraven, D.; Caprotti, F.; Dayot, Y. The Smart City as Global Discourse: Storylines and Critical Junctures across 27 Cities. *J. Urban Technol.* **2019**, *26*, 3–34. [CrossRef]

15. Stephan, R.M.; Mohtar, R.H.; Daher, B.; Irujo, A.E.; Hillers, A.; Ganter, J.C.; Karlberg, L.; Martin, L.; Nairizi, S.; Rodriguez, D.J.; et al. Water-energy-food nexus: A platform for implementing the Sustainable Development Goals. *Water Int.* **2018**, *43*, 472–479. [CrossRef]
16. IRENA. *Renewable Energy in the Water, Energy & Food Nexus*; International Renewable Energy Agency (IRENA): Abu Dhabi, UAE, 2015. Available online: https://www.irena.org/publications/2015/Jan/Renewable-Energy-in-the-Water-Energy--Food-Nexus (accessed on 6 September 2020).
17. Heard, B.R.; Miller, S.A.; Liang, S.; Xu, M. Emerging challenges and opportunities for the food–energy–water nexus in urban systems. *Curr. Opin. Chem. Eng.* **2017**, *17*, 48–53. [CrossRef]
18. Weitz, N.; Nilsson, M.; Huber-Lee, A.; Davis, M.; Hoff, H. *Cross-Sectoral Integration in the Sustainable Development Goals: A Nexus Approach*; Discussion Brief; Stockholm Environment Institute (SEI): Stockholm, Sweden, 2014. Available online: https://www.sei.org/publications/cross-sectoral-integration-in-the-sustainable-development-goals-a-nexus-approach/ (accessed on 19 August 2020).
19. Biggs, E.M.; Bruce, E.; Boruff, B.; Duncan, J.M.A.; Horsley, J.; Pauli, N.; McNeill, K.; Neef, A.; Ogtrop, F.V.; Curnow, J.; et al. Sustainable development and the water-energy-food nexus: A perspective on livelihoods. *Environ. Sci. Policy* **2015**, *54*, 389–397. [CrossRef]
20. Guo, Y.-M.; Huang, Z.-L.; Guo, J.; Li, H.; Guo, X.-R.; Nkeli, M.J. Bibliometric Analysis on Smart Cities Research. *Sustainability* **2019**, *11*, 3606. [CrossRef]
21. Kennedy, C.; Cuddihy, J.; Engel-Yan, J. The changing metabolism of cities. *J. Ind. Ecol.* **2007**, *11*, 43–59. [CrossRef]
22. Liang, S.; Qu, S.; Zhao, Q.; Zhang, X.; Daigger, G.T.; Newell, J.P.; Miller, S.A.; Johnson, J.X.; Love, N.G.; Zhang, L.; et al. Quantifying the Urban Food–Energy–Water Nexus: The Case of the Detroit Metropolitan Area. *Environ. Sci. Technol.* **2019**, *53*, 779–788. [CrossRef] [PubMed]
23. Artioli, F.; Acuto, M.; McArthur, J. The water-energy-food nexus: An integration agenda and implications for urban governance. *Polit Geogr.* **2017**, *61*, 215–223. [CrossRef]
24. Sukhwani, V.; Shaw, R.; Mitra, B.K.; Yan, W. Optimizing Food-Energy-Water (FEW) nexus to foster collective resilience in urban-rural systems. *Prog. Disaster Sci.* **2019**, *1*, 100005. [CrossRef]
25. Mekonnen, Y.; Sarwat, A.; Bhansali, S. Food, Energy and Water (FEW) Nexus Modeling Framework. Proceedings of the Future Technologies Conference (FTC), San Francisco, CA, USA, 24–25 October 2019; Arai, K., Bhatia, R., Kapoor, S., Eds.; Springer: Cham, Switzerland, 2020; pp. 346–364. [CrossRef]
26. Mundhada, T. Smart City Project, Nagpur again Clinched Top Position. The Live Nagpur. Available online: https://thelivenagpur.com/2020/03/05/smart-city-projectnagpur-again-clinched-top-position/ (accessed on 6 September 2020).
27. Elets News Network. MoHUA Ranks Nagpur Smart City 1st in Maharashtra, 2nd in India. Available online: https://smartcity.eletsonline.com/mohua-ranks-nagpur-smart-city-1st-in-maharashtra-2nd-in-india/ (accessed on 6 September 2020).
28. van den Bosch, H. India's 100 Smart Cities Mission Is flawed. Smart City Hub. 2017. Available online: https://smartcityhub.com/governance-economy/indias-100-smart-cities-mission-is-flawed/ (accessed on 19 August 2020).
29. Randhawa, A.; Kumar, A. Exploring sustainability of smart development initiatives in India. *Int. J. Sustain. Built Environ.* **2017**, *6*, 701–710. [CrossRef]
30. Jogesh, A.; Rajasekar, U.; Chakraborty, S. Climate Disconnect in India's Smart Cities Mission. 2017. Available online: https://www.preventionweb.net/news/view/55356 (accessed on 19 August 2020).
31. SEEDS; CRED. *Decoding the Monsoon Floods in Bangladesh, India, Myanmar and Nepal*; The Socio Economic & Educational Development Society (SEEDS) and the Centre for Research on the Epidemiology of Disasters (CRED): New Delhi, India, 2018. Available online: https://www.seedsindia.org/wp-content/uploads/2018/01/Decoding-the-monsoon-floods-report180118v-min.pdf (accessed on 19 August 2020).
32. Hoelscher, K. The evolution of the smart cities agenda in India. *Int. Area Stud. Rev.* **2016**, *19*, 28–44. [CrossRef]
33. Mora, L.; Bolici, R.; Deakin, M. The First Two Decades of Smart-City Research: A Bibliometric Analysis. *J. Urban Technol.* **2017**, *24*, 3–27. [CrossRef]
34. Arafah, Y.; Winarso, H. Redefining smart city concept with resilience approach. *IOP Conf. Ser. Earth Environ. Sci.* **2017**, *70*, 12065. [CrossRef]

35. Meijer, A.; Bolívar, M.P.R. Governing the Smart City: Scaling-Up the Search for Socio-Techno Synergy. In Proceedings of the 2013 EGPA Annual Conference, Edinburgh, UK, 11–13 September 2013. Available online: https://www.scss.tcd.ie/disciplines/information_systems/egpa/docs/2013/BolivarMeijer.pdf (accessed on 18 August 2020).
36. Moir, E.; Moonen, T.; Clark, G. What Are Future Cities? Origins, Meanings and Uses; Compiled by the Business of Cities for the Foresight Future of Cities Project and the Future Cities Catapult: 2014. Available online: https://www.gov.uk/government/publications/future-cities-origins-meanings-and-uses (accessed on 19 August 2020).
37. Papa, R.; Galderisi, A.; Majello, M.C.V.; Saretta, E. Smart and Resilient Cities. A Systemic Approach for Developing Cross-sectoral Strategies in the Face of Climate Change. *TEMA J. Land Use Mobil. Environ.* **2015**, *8*, 19–49. [CrossRef]
38. Baron, M. Do We Need Smart Cities for Resilience. *J. Econ. Manag.* **2012**, *10*, 32–46.
39. Colding, J.; Wallhagen, M.; Sörqvist, P.; Marcus, L.; Hillman, K.; Samuelsson, K.; Barthel, S. Applying a Systems Perspective on the Notion of the Smart City. *Smart Cities* **2020**, *3*, 420–429. [CrossRef]
40. ITU. *Smart Sustainable Cities: An Analysis of Definitions, Focus Group Technical Report*; The International Telecommunication Union (ITU): Geneva, Switzerland, 2015. Available online: https://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx (accessed on 19 August 2020).
41. Sanseverino, E.R.; Sanseverino, R.R.; Anello, E. A Cross-Reading Approach to Smart City: A European Perspective of Chinese Smart Cities. *Smart Cities* **2018**, *1*, 26–52. [CrossRef]
42. Giffinger, R.; Fertner, C.; Kramar, H.; Kalasek, R.; Pichler-Milanovic, N.; Meijers, E. *Smart Cities—Ranking of European Medium-Sized Cities-Smart Cities—Final Report*; Vienna University of Technology: Vienna, Austria, 2007. Available online: http://www.smart-cities.eu/download/smart_cities_final_report.pdf (accessed on 19 August 2020).
43. Aletà, N.B.; Alonso, C.; Ruiz, R.M.A. Smart Mobility and Smart Environment in the Spanish cities. *Transp. Res. Procedia* **2017**, *24*, 163–170. [CrossRef]
44. Hayat, P. Smart Cities: A Global Perspective. *India Q. J. Int. Aff.* **2016**, *72*, 177–191. [CrossRef]
45. Chander, S.; Mohan, M. Smart Cities with Smarter Options in the Indian Context. In Proceedings of the 63rd National Town and Country Planners Congress, Chennai, India, 9–11 January 2015; pp. 292–303.
46. Masdar City—The City. Available online: https://masdar.ae/en/masdar-city/the-city (accessed on 19 August 2020).
47. Songdo International Business District in Incheon, South Korea. Available online: https://www.wsp.com/en-KR/projects/songdo-international-business-district-in-incheon-south-korea (accessed on 19 August 2020).
48. Amsterdam Smart City. Available online: https://amsterdamsmartcity.com/ (accessed on 18 August 2020).
49. Gerholdt, J.; Pandya, S.; Barrera, L. *Resources: The Energy–Water–Food Nexus*; Conservation International's Business & Sustainability Council: Arlington, VA, USA, 2013. Available online: http://docplayer.net/7565829-Conservation-international-s-business-sustainability-council-resources.html (accessed on 19 August 2020).
50. Mohtar, R.H.; Daher, B. Water, Energy, and Food: The Ultimate Nexus. In *Encyclopedia of Agricultural, Food, and Biological Engineering*, 2nd ed.; Heldman, D., Moraru, C., Eds.; CRC Press: Boca Raton, FL, USA, 2012. [CrossRef]
51. Hoff, H. *Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus*; Stockholm Environment Institute: Stockholm, Sweden, 2011. Available online: https://www.sei.org/publications/understanding-the-nexus/ (accessed on 19 August 2020).
52. Endo, A.; Tsurita, I.; Burnett, K.; Orencio, P.M. A review of the current state of research on the water, energy, and food nexus. *J. Hydrol. Reg. Stud.* **2017**, *11*, 20–30. [CrossRef]
53. Mitra, B.K.; Shaw, R.; Yan, W.; Takeda, T. Water-Energy-Food Nexus: A Provision to Tackle Urban Drought. In *Urban Drought: Emerging Water Challenges in Asia*; Ray, B., Shaw, R., Eds.; Springer: Singapore, 2019; pp. 69–86. [CrossRef]
54. Sustainable Development Goals (SDGs), United Nations Development Programme (UNDP). Available online: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html (accessed on 19 August 2020).
55. Bizikova, L.; Roy, D.; Swanson, D.; Venema, H.D.; McCandless, M. *The Water-Energy-Food Security Nexus: Towards a Practical Planning and Decision-Support Framework for Landscape Investment and Risk Management*; The International Institute for Sustainable Development (IISD): Winnipeg, MB, Canada, 2013. Available online: https://www.iisd.org/sites/default/files/publications/wef_nexus_2013.pdf (accessed on 18 August 2020).

56. Jones, K.; Magliocca, N.R.; Hondula, K. *White Paper: An Overview of Conceptual Frameworks, Analytical Approaches and Research Questions in the Food-Energy-Water Nexus*; National Socio-Environmental Synthesis Center (SESYNC), University of Maryland: Annapolis, MD, USA, 2017. [CrossRef]
57. Endo, A.; Burnett, K.; Orencio, P.M.; Kumazawa, T.; Wada, C.A.; Ishii, A.; Tsurita, I.; Taniguchi, M. Methods of the Water-Energy-Food Nexus. *Water* **2015**, *7*, 5806–5830. [CrossRef]
58. Ramaswami, A.; Boyer, D.; Nagpure, A.S.; Fang, A.; Bogra, S.; Bakshi, B.; Cohen, E.; Rao-Ghorpade, A. An urban systems framework to assess the trans-boundary food-energy-water nexus: Implementation in Delhi, India. *Environ. Res. Lett.* **2017**, *12*, 025008. [CrossRef]
59. Romero-Lankao, P.; McPhearson, T.; Davidson, D.J. The food-energy-water nexus and urban complexity. *Nat. Clim. Chang.* **2017**, *7*, 233–235. [CrossRef]
60. Pittock, J.; Hussey, K.; McGlennon, S. Australian Climate, Energy and Water Policies: Conflicts and synergies. *Aust. Geogr.* **2013**, *44*, 3–22. [CrossRef]
61. Leck, H.; Conway, D.; Bradshaw, M.; Rees, J. Tracing the Water-Energy-Food Nexus: Description, Theory and Practice. *Geogr. Compass* **2015**, *9*, 445–460. [CrossRef]
62. Mohtar, R.H.; Daher, B. Water-Energy-Food Nexus Framework for facilitating multi-stakeholder dialogue. *Water Int.* **2016**, *41*, 655–661. [CrossRef]
63. Gondhalekar, D.; Ramsauer, T. Nexus City: Operationalizing the urban Water-Energy-Food Nexus for climate change adaptation in Munich, Germany. *Urban Clim.* **2017**, *19*, 28–40. [CrossRef]
64. Zhang, P.; Zhang, L.; Chang, Y.; Xu, M.; Hao, Y.; Liang, S.; Liu, G.; Yang, Z.; Wang, C. Food-energy-water (FEW) nexus for urban sustainability: A comprehensive review. *Resour. Conserv. Recycl.* **2019**, *142*, 215–224. [CrossRef]
65. Schlör, H.; Venghaus, S.; Hake, J. The FEW-Nexus city index—Measuring urban resilience. *Appl. Energy* **2018**, *210*, 382–392. [CrossRef]
66. Wang, S.; Yang, K.; Yuan, D.; Yu, K.; Su, Y. Temporal-spatial changes about the landscape pattern of water system and their relationship with food and energy in a mega city in China. *Ecol. Model.* **2019**, *401*, 75–84. [CrossRef]
67. Arthur, M.; Liu, G.; Hao, Y.; Zhang, L.; Liang, S.; Asamoah, E.F.; Lombardi, G.V. Urban food-energy-water nexus indicators: A review. *Resour. Conserv. Recycl.* **2019**, *151*, 104481. [CrossRef]
68. Djehdian, L.A.; Chini, C.M.; Marston, L.; Konar, M.; Stillwell, A.S. Exposure of urban food–energy–water (FEW) systems to water scarcity. *Sustain. Cities Soc.* **2019**, *50*, 101621. [CrossRef]
69. Gragg, R.S.; Anandhi, A.; Jiru, M.; Usher, K.M. A Conceptualization of the Urban Food-Energy-Water Nexus Sustainability Paradigm: Modeling from Theory to Practice. *Front. Environ. Sci.* **2018**, *6*, 1–14. [CrossRef]
70. India Smart Cities Mission. *Smart Cities: Mission Statement & Guidelines*; Ministry of Urban Development, Government of India: New Delhi, India, 2015. Available online: http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf (accessed on 19 August 2020).
71. Deshkar, S. Resilience Perspective for Planning Urban Water Infrastructures: A Case of Nagpur City. In *Urban Drought: Emerging Water Challenges in Asia*; Ray, B., Shaw, R., Eds.; Springer: Singapore, 2019; pp. 131–154. [CrossRef]
72. NMC. *Draft City Sanitation Plan Report*; Nagpur Municipal Corporation (NMC): Nagpur, India, 2011. Available online: https://docplayer.net/62042234-City-sanitation-plan.html (accessed on 19 August 2020).
73. NIT. *Nagpur Metropolitan Area Development Plan: 2012-32, Draft Development Plan Report*; Nagpur Improvement Trust (NIT): Nagpur, India, 2015. Available online: http://www.nitnagpur.org/pdf/Metro_Region_DP.pdf (accessed on 19 August 2020).
74. Holt, R. *Global Cities: Which Cities Will Be Leading the Global Economy in 2035?* Oxford Economics: Oxford, UK, 2018. Available online: https://workplaceinsight.net/wp-content/uploads/2018/12/Global-Cities-Dec-2018.pdf (accessed on 19 August 2020).
75. Nagpur Smart and Sustainable City Development Corporation Limited. Available online: https://nsscdcl.org/index.jsp (accessed on 30 March 2020).
76. Innovation Centre Denmark. *Smart City Nagpur, Fact Finding Mission Report on Nagpur*; Royal Danish Embassy: New Delhi, India; The East Asiatic Company Foundation: Copenhagen, Denmark, 2016. Available online: https://asia-house.dk/wp-content/uploads/2016/06/Nagpur-FFM-report-by-ICDK.pdf (accessed on 19 August 2020).

77. Nagpur Smart City Proposal. *The Smart City Challenge Stage 2: Smart City Proposal Nagpur*; Ministry of Urban Development, Government of India: New Delhi, India, 2016. Available online: https://smartnet.niua.org/sites/default/files/resources/Nagpur_SCP.pdf (accessed on 19 August 2020).
78. India's Heart Nagpur, Smart City Nagpur, CRISIL. Available online: https://www.unescap.org/sites/default/files/IDM_Smart_City_Concept_Nagpur%20.pdf (accessed on 19 August 2020).
79. Nagpur Projects. List of Projects as per Smart City Proposal: Nagpur. Available online: https://smartnet.niua.org/sites/default/files/resources/Nagpur_projects.pdf (accessed on 19 August 2020).
80. Nagpur Smart City Annexure. Available online: https://smartnet.niua.org/sites/default/files/resources/nagpur_annexure.pdf (accessed on 19 August 2020).
81. Baas, J.; Schotten, M.; Plume, A.; Côté, G.; Karimi, R. Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quant. Sci. Stud.* **2020**, *1*, 377–386. [CrossRef]
82. Van Eck, N.J.; Waltman, L. VOSviewer Manual, Manual for VOSviewer Version 1.6.6. 2017. Available online: https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.6.pdf (accessed on 19 August 2020).
83. Nagpur Improvement Trust (NIT); Nagpur Municipal Corporation (NMC). *Town Planning Schemes Pardi, Punapur, Bharatwada, Bhandewadi No. 1, Nagpur*; Nagpur Improvement Trust (NIT)): Nagpur, India; Nagpur Municipal Corporation (NMC): Nagpur, India, 2018.
84. The World Bank. Nagpur, 24x7 Water Supply Project. Available online: https://ppi.worldbank.org/en/snapshots/project/nagpur-24x7-water-supply-project-7289 (accessed on 7 September 2020).
85. TenderSURE. "Project-Tendersure". Nagpur Smart and Sustainable City Development Corporation Ltd. Available online: https://nsscdcl.org/Tendersure.jsp (accessed on 30 March 2020).
86. Swachh Bharat Mission Urban, Ministry of Housing and Urban Affairs, Government of India. Available online: http://swachhbharaturban.gov.in/ (accessed on 7 September 2020).
87. Rojek, I.; Studzinski, J. Detection and Localization of Water Leaks in Water Nets Supported by an ICT System with Artificial Intelligence Methods as a Way Forward for Smart Cities. *Sustainability* **2019**, *11*, 518. [CrossRef]
88. Vakula, D.; Kolli, Y.K. Waste Water Management for Smart Cities. In Proceedings of the 2017 International Conference on Intelligent Sustainable Systems (ICISS), Palladam, India, 7–8 December 2017. [CrossRef]
89. Chen, Y.; Han, D. Water quality monitoring in smart city: A pilot project. *Automat. Constr.* **2018**, *89*, 307–316. [CrossRef]
90. Canales-Ide, F.; Zubelzu, S.; Rodriguez-Sinobas, L. Irrigation systems in smart cities coping with water scarcity: The case of Valdebebas, Madrid (Spain). *J. Environ. Manag.* **2019**, *247*, 187–195. [CrossRef]
91. Mohanasundaram, S.V.; Joyce, A.; Naresh, K.S.; Gokulkrishnan, G.; Kale, A.; Dwarakanath, T.; Haribabu, P. Smart water distribution network solution for smart cities: Indian scenario. In Proceedings of the 2018 Global Internet of Things Summit (GIoTS), Bilbao, Spain, 4–7 June 2018. [CrossRef]
92. Suresh, M.; Muthukumar, U.; Chandapillai, J. A novel smart water-meter based on IoT and smartphone app for city distribution management. In Proceedings of the 2017 IEEE Region 10 Symposium (TENSYMP), Cochin, India, 14–16 July 2017. [CrossRef]
93. O'Dwyer, E.; Pan, I.; Acha, S.; Shah, N. Smart energy systems for sustainable smart cities: Current developments, trends and future directions. *Appl. Energy* **2019**, *237*, 581–597. [CrossRef]
94. Castro, M.; Jara, A.J.; Skarmeta, A.F.G. Smart Lighting Solutions for Smart Cities. In Proceedings of the 27th International Conference on Advanced Information Networking and Applications Workshops, Barcelona, Spain, 25–28 March 2013; pp. 1374–1379. [CrossRef]
95. Paffumi, E.; Gennaro, M.D.; Martini, G. Innovative Technologies for Smart Cities: Towards Customer Driven Infrastructure Design for Large Scale Deployment of Electric Vehicles and Vehicle-to-Grid Applications. *Transp. Res. Procedia* **2016**, *14*, 4505–4514. [CrossRef]
96. Mathisen, O.V.; Sørbye, M.E.; Rao, M.; Tamm, G.; Stantchev, V. Chapter 16: Smart energy in smart cities: Insights from the smart meter rollout in the United Kingdom. In *Smart Cities: Issues and Challenges: Mapping Political, Social and Economic Risks and Threats*; Visvizi, A., Lytras, M.D., Eds.; Elsevier: Amsterdam, The Netherlands, 2019; pp. 283–307. [CrossRef]
97. Ma, Y.; Li, B. Hybridized Intelligent Home Renewable Energy Management System for Smart Grids. *Sustainability* **2020**, *12*, 2117. [CrossRef]
98. Stepaniuk, V.; Pillai, J.R.; Bak-Jensen, B.; Padmanaban, S. Estimation of Energy Activity and Flexibility Range in Smart Active Residential Building. *Smart Cities* **2019**, *2*, 471–495. [CrossRef]

99. Chhaya, L.; Sharma, P.; Kumar, A.; Bhagwatikar, G. IoT-Based Implementation of Field Area Network Using Smart Grid Communication Infrastructure. *Smart Cities* **2018**, *1*, 176–189. [CrossRef]
100. Chandrasekaran, A.R.; Aravind, E.; Ramya Sundaram, B.; Vasudevan, S.K. Smart Meter Based on Real Time Pricing. *Procedia Technol.* **2015**, *21*, 120–124. [CrossRef]
101. de Amorim, W.S.; Deggau, A.B.; do Livramento Gonçalvesa, G.; da Silva Neiva, S.; Prasath, A.R.; de Andrade Guerraa, J.B.S.O. Urban challenges and opportunities to promote sustainable food security through smart cities and the 4th industrial revolution. *Land Use Policy* **2019**, *87*, 104065. [CrossRef]
102. Zhang, Q.; Huang, T.; Zhu, Y.; Qiu, M. A Case Study of Sensor Data Collection and Analysis in Smart City: Provenance in Smart Food Supply Chain. *Int. J. Distrib. Sens. Netw.* **2013**, *382132*, 1–12. [CrossRef]
103. Heitlinger, S.; Bryan-Kinns, N.; Comber, R. Connected seeds and sensors: Co-designing internet of things for sustainable smart cities with urban food-growing communities. In Proceedings of the 15th Participatory Design Conference, Genk, Belgium, 20–24 August 2018. [CrossRef]
104. Deakin, M.; Diamantini, D.; Borrelli, N. The governance of a smart city food system: The 2015 Milan World Expo. *City Cult. Soc.* **2019**, *16*, 5–11. [CrossRef]
105. Maye, D. 'Smart food city': Conceptual relations between smart city planning, urban food systems and innovation theory. *City Cult. Soc.* **2019**, *16*, 18–24. [CrossRef]
106. Boossabong, P. Governing Bangkok's city food system: Engaging multi-stakeholders for smart, sustainable and inclusive growth. *City Cult. Soc.* **2019**, *16*, 52–59. [CrossRef]
107. Toboso-Chavero, S.; Nadal, A.; Petit-Boix, A.; Pons, O.; Villalba, G.; Gabarrell, X.; Josa, A.; Rieradevall, J. Towards Productive Cities: Environmental Assessment of the Food-Energy-Water Nexus of the Urban Roof Mosaic. *J. Ind. Ecol.* **2018**, *23*, 767–780. [CrossRef] [PubMed]
108. Salvador, D.S.; Toboso-Chavero, S.; Nadal, A.; Gabarrell, X.; Rieradevall, J.; da Silva, R.S. Potential of technology parks to implement Roof Mosaic in Brazil. *J. Clean. Prod.* **2019**, *235*, 166–177. [CrossRef]
109. Sukhwani, V.; Shaw, R. A Water-Energy-Food Nexus-Based Conceptual Approach for Developing Smart Urban-Rural Linkages in Nagpur Metropolitan Area, India. *J. Integr. Disaster Risk Manag.* **2020**, *10*, 1–22. [CrossRef]
110. Nation Next Newsroom. Water Crisis in Nagpur: Citizens May Get Water on Alternate Days for Four Months. Available online: https://nationnext.com/water-crisis-in-nagpur-citizens-may-get-water-on-alternate-days-for-four-months/ (accessed on 2 September 2020).
111. No Water Supply in Nagpur on Friday, Sunday Due to Water Crisis. Available online: https://www.business-standard.com/multimedia/video-gallery/general/no-water-supply-in-nagpur-on-friday-sunday-due-to-water-crisis-87664.htm (accessed on 2 September 2020).
112. Nagpur: Water Cuts Imposed for 3 Days Due to Less Rainfall. Available online: https://www.indiatoday.in/india/story/nagpur-water-cuts-imposed-for-3-days-due-to-less-rainfall-1571125-2019-07-19 (accessed on 2 September 2020).
113. Anparthi, A. No Water for Irrigation This Year in Pench Reservoirs. Available online: https://timesofindia.indiatimes.com/city/nagpur/no-water-for-irrigation-this-year-in-pench-reservoirs/articleshow/66217042.cms (accessed on 2 September 2020).
114. Sukhwani, V.; Deshkar, S.; Shaw, R. COVID-19 Lockdown, Food Systems and Urban–Rural Partnership: Case of Nagpur, India. *Int. J. Environ. Res. Public Health* **2020**, *17*, 5710. [CrossRef]
115. Hoang, G.T.T.; Dupont, L.; Camargo, M. Application of Decision-Making Methods in Smart City Projects: A Systematic Literature Review. *Smart Cities* **2019**, *2*, 433–452. [CrossRef]
116. Bulkeley, H.; Coenen, L.; Frantzeskaki, N.; Hartmann, C.; Kronsell, A.; Mai, L.; Marvin, S.; McCormick, K.; van Steenbergen, F.; Palgan, Y.V. Urban living labs: Governing urban sustainability transitions. *Curr. Opin. Environ. Sustain.* **2016**, *22*, 13–17. [CrossRef]
117. Yan, W.; Roggema, R. Developing a Design-Led Approach for the Food-Energy-Water Nexus in Cities. *Urban Plan.* **2019**, *4*, 123–138. [CrossRef]
118. von Wirth, T.; Fuenfschilling, L.; Frantzeskaki, N.; Coenen, L. Impacts of urban living labs on sustainability transitions: Mechanisms and strategies for systemic change through experimentation. *Eur. Plan. Stud.* **2019**, *27*, 229–257. [CrossRef]
119. Shyama Prasad Mukherji Rurban Mission, Ministry of Rural Development, Government of India. Available online: http://rurban.gov.in/ (accessed on 19 August 2020).

120. Wadoda ICAP. *Integrated Cluster Action Plan, Wadoda Cluster*; National Rurban Mission; Ministry of Rural Development, Government of India: New Delhi, India, 2017. Available online: https://rdd.maharashtra.gov.in/sites/default/files/Wadoda_ICAP_Report_Final.pdf (accessed on 19 August 2020).
121. Implementing the New Urban Agenda by Strengthening Urban-Rural Linkages-Leave No One and No Space Behind. United Nations Human Settlements Programme (UN-Habitat). Available online: https://unhabitat.org/implementing-the-new-urban-agenda-by-strengthening-urban-rural-linkages (accessed on 19 August 2020).

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.