Big Data Analytics as a Solution to Track Carbon Emission in Smart Cities: A Systematic Literature Review

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Abstract. The rise of big data and smart cities has expanded from time to time. The smart cities concept also connected with big data as the key factor. The big data analytics have a chance for a starting point to reduce carbon emissions that contribute as part of climate change. Big data analytics refers generally to any huge amounts of data that may be gathered, saved, retrieved, integrated, selected, pre-processed, converted, analyzed, and interpreted in order to learn something new or extract relevant knowledge. Big data analytics, in the context of smart sustainable cities, refers to a collection of sophisticated and specialized software applications and database systems operated by devices with extremely high processing power, that can transform a significant amount of urban data into knowledge, for well-informed decision-making and enhanced insights in relation to various urban domains, such as transportation, mobility, traffic, environment, energy, land use, planning, and design. Big data analytics have potential to be used as a solution for smart and sustainable cities. The importance to every city in country to have a precision data about carbon emission is to evaluate result and make a better decision to reduce carbon emission. This research finds the integration of different and varied systems in a smart city environment is a practical challenge for emergency management. Smart cities in the next generation must be focused on this integration which provides valuable data to support emergency detection, warning and mitigation.

Keywords: Big data · carbon emission · climate change · smart cities · systematic literature review

1 Introduction

The rise of big data and smart cities has expanded from time to time. The smart cities concept also connected with big data as the key factor. Sinergy between smart cities and big data could be used to make the cities smarter, by the example is the abilities of city to track and measure carbon emission. Big data analytics can be used to track carbon emissions by collecting and analyzing large amounts of data related to a company

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or organization's energy use [1]. This data can be used to identify areas where carbon emissions can be reduced and to develop strategies for reducing emissions. For example, data on a company's energy use can be analyzed to identify opportunities for energy efficiency improvements, such as upgrading equipment or implementing energy-saving measures. The data can also be used to monitor the effectiveness of these measures and to make any necessary adjustments. By using big data analytics, companies and organizations can gain valuable insights into their carbon emissions and take action to reduce them. Big data analytics involves using advanced analytical and statistical techniques to extract insights and knowledge from large datasets. This can include techniques such as machine learning, natural language processing, and data mining. By analyzing large amounts of data, organizations can gain valuable insights into their operations and make data-driven decisions that can improve their performance and productivity. The big data analytics have a chance for the starting point to reduce carbon emissions that contribute as part of climate change.

Moreover, big data analytics can play a key role in the development and management of smart cities. A smart city is an urban area that uses technology and data to improve the quality of life for its residents. By collecting and analyzing large amounts of data, cities can gain valuable insights into their operations and identify opportunities for improvement. For example, data on traffic patterns can be used to optimize the flow of vehicles and reduce congestion. Data on energy use can be used to improve the efficiency of the city's power grid and reduce carbon emissions. And data on public health can be used to identify and address potential health issues in the community. By using big data analytics, cities can become more efficient, sustainable, and liveable for their residents. This paper aimed to discuss and analyze how big data analytics could be a smart solution to track carbon emissions in smart cities through systematic literature review.

Big data is something that being a key successful factor for smart cities development. Based on De Mauro [2] big data is an information asset that has such a huge volumes, velocity, and variety that its processing into value requires specialized technology and analytical techniques. The power of big data could be use for advancing human activities, one of them is through smart cities enablement. This data can be collected from a variety of sources, such as energy usage data from buildings and infrastructure, transportation data from vehicles and public transit systems, and waste management data from garbage and recycling systems. By analyzing this data, cities can gain valuable insights into their carbon emissions and identify opportunities for reduction. For example, data on energy usage can be used to identify buildings and infrastructure that are using excessive amounts of energy, and measures can be taken to improve their energy efficiency. Data on transportation can be used to identify ways to reduce vehicle emissions, such as by promoting the use of electric vehicles or implementing carpooling programs. And data on waste management can be used to identify ways to reduce the amount of waste being generated, such as by increasing recycling and composting. By using big data analytics, cities can develop effective strategies for reducing their carbon emissions and achieving their sustainability goals.

In other hand, Climate change has been a concerning issue over the past decades and being one of priorities of sustainable development goals by United Nation to cooperate and achieve low-carbon economy. Among all environmental pollution, mainly CO2 emissions, has been treated as a concerning problem in present sustainable business. Based on Bolea [3] the nations with the highest rates of emissions growth are Luxembourg, China, and India. These three nations also contribute to the majority of the world's current CO2 emissions. The raise of these CO2 emission is because the contribute of domestic production and increasing trade within the world. Due to the intensity of their trade, countries in Central and Eastern Europe and Asia have greater rates of emissions growth. For instance, Estonia and Denmark fit into this category. Meanwhile, US and the Mediterranean European countries experienced the lowest CO2 emission growth rates. During the crisis, global economic activity slowed, which may have led to a decrease in CO2 emissions in some countries. However, the specific impact on CO2 emissions varied among countries and regions. For example, some countries may have experienced a decrease in emissions due to a shift away from energy-intensive industries, while others may have seen an increase in emissions due to a greater reliance on fossil fuels as a cheaper source of energy.

In terms of the contributions of domestic demand and trade to CO2 emissions, it is possible that these may have also changed significantly after the financial crisis. For example, if a country's domestic demand for goods and services decreased, this could lead to a reduction in the emissions associated with producing and transporting those goods. On the other hand, if a country's reliance on imports increased, this could lead to an increase in emissions due to the transportation of goods from other countries.

The findings point to a global pattern of emissions growth that is being accompanied by an ongoing trend of divergence. The temporal reduction in emissions recorded in some economies during the course of the global economic crisis was only due to the economy's contraction during the early years of the financial crisis and not to an improvement in the conditions of production (technological improvement that reduces unit emissions). However, when sectoral and regional features of countries are taken into account, these general and worldwide outcomes can be more accurately described. First, industry-block analysis shows that countries specialize in particular economic structures, which influences how emissions evolve. In industries that use more technology, there is a greater difference between direct emissions and embedded emissions. Thus, it appears that the overall trend in emissions is toward greater country-to-country disparities in CO2 emissions, which also implies some specialization of countries' production, with global values being significantly influenced by the rise in domestic demand of countries. The importance to every cities in country to have a precision data about carbon emission is to evaluate result and make a better decision to reduce carbon emission.

2 Methods

A thorough literature review was performed as the research methodology for this investigation (SLR). A technique for systematically synthesizing, assessing, and identifying [4]. The studies included in this systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Metanalyses) recommendations. The PRISM guideline is strongly advised for literature review research since it helps readers comprehend how articles are chosen for study [5]. The use of PRISM standards can also prevent publication bias (PB) towards the papers and journals that will be under investigation. Publication bias might manifest as difficulty in the systematic article search

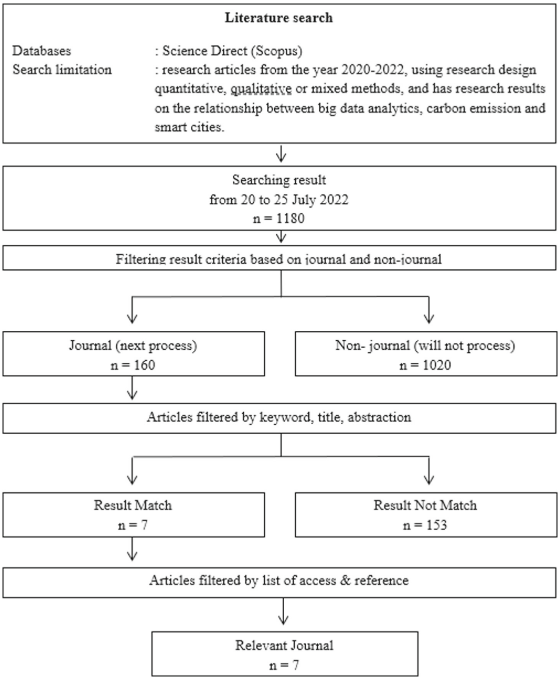

Fig. 1. Literature research

process in discovering published or unpublished scientific papers. This study used data sources from the Scopus database to conduct a systematic review of the literature. ("smart cities") AND ("big data") AND ("emission") were the search terms used to go through the literature. The chosen articles are those with a range of publications in 2020–2022, with individual participants—not organizations or institutions—with a range of educational and occupational backgrounds, as well as age and gender—across a range of age groups.

The publications in the journal under review used a quantitative, qualitative, or mixed-method research design as their research methodology. Scientific journal article search methodology is shown in Fig. 1 utilizing PRISM principles. The first step is to use a database from Scopus to identify scientific journal articles. The second stage, screening, is done in two parts and involves filtering the different kinds of articles that are discovered in the form of journals or non-journals, as well as the possibility of duplicate journal search results. The PRISM method's eligibility phase is the third. The journal papers that have been screened will now be arranged according to keywords, titles, abstracts, and access from each journal. The last stage, the articles that will be used as references must first be filtered.

3 Result and Discussion

The integration of different and varied systems in a smart city environment is a practical challenge for emergency management. In the last decade, most smart cities have been developed as independent and self- contained services with a well-defined set of objectives and data inputs. In this particular condition, several big cities around the world have taken initiative steps that are developed and applied as services that make it easier for their residents, but the integration is still in the development stage (early phase). Smart cities in the next generation must be focused on this integration which provides valuable data to support emergency detection, warning and mitigation [6]. Several opportunities for the evolution of emergency management systems can be found by the smart city systems being developed. The following are Smart healthcare, intelligent transportation, smart security, and smart environment monitoring.

Big data analytics is a powerful tool that can be used to extract valuable insights and knowledge from large datasets. In the context of smart cities, big data analytics can be used to collect and analyze data on a wide range of urban issues, such as traffic patterns, energy use, public health, and carbon emissions. By analyzing this data, cities can identify areas for improvement and develop data-driven strategies for addressing these issues. One way that big data analytics can be used to support the development of smart cities is by collecting and analyzing data on traffic patterns. By analyzing data on the flow of vehicles and pedestrians in a city, planners and policymakers can identify ways to reduce congestion and improve the efficiency of the transportation system. For example, data on traffic patterns can be used to identify bottlenecks and other areas where congestion is a problem, and strategies can be developed to address these issues. This could include implementing traffic management measures, such as variable speed limits or traffic signals, or investing in public transit infrastructure to reduce the number of vehicles on the road.

Another way that big data analytics can support the development of smart cities is by collecting and analyzing data on energy use. By analyzing data on the energy consumption of buildings and infrastructure, cities can identify opportunities for energy conservation and efficiency improvements. For example, data on energy use can be used to identify buildings and infrastructure that are using excessive amounts of energy, and measures can be taken to improve their energy efficiency [7]. This could include upgrading equipment or implementing energy-saving measures, such as better insulation or energy-efficient lighting. By reducing their energy consumption, cities can not only save money, but also reduce their carbon emissions and contribute to a more sustainable future.

Other potential integration between two or more smart city systems will need to handle some integration issues and call for common interfaces. Some works have already addressed the development of smart cities systems that adhere to established standards because integration issues are pertinent in other contexts for smart cities. In actuality, methodologies, evaluation labs, and supporting tools are emerging to address this issue, and validation of future proposed systems will continue to be a crucial design issue. All things considered, we think that this will be a significant development trend for emergency management systems. It has emerged as a fascinating and morally admirable subject category as an analytical result, but it is still essentially a theoretical and conceptual creation [8, 9]. Instead, we shouldn't presume that a person can immediately "green" himself with only one set of incentives, knowledge, or technology. It needs to be viewed in light of the challenges associated with renunciation ecological privileges and livelihoods in general, as well as the fact that environmentally friendly production or consumption may not be undertaken for its own sake but as part of regular daily concerns such as cleanliness, comfort, and convenience.

According to the findings, it seems that some tech traditions believe that creating a green subject isn't even necessary for decoupling to occur because the change that needs to be made is built into the technology and is pre-programmed to be morally and socially responsible for us without our knowledge [10]. Here, an ethnographic approach could challenge the presumption that technical advancement and digital technologies work (neutrally or not) as agents of change or as enablers of the creation of standardized "climate conscious individuals." They could, but such subject construction also changes when the same general information is met by various, nonidentical, and geographically particular reactions.

It is important to consider the complex interactions between economic activity, energy markets, and CO2 emissions in order to understand how they may have been affected by the financial crisis and other events [11]. The relationship between economic activity, energy markets, and CO2 emissions is complex and multifaceted. Economic activity, such as manufacturing, transportation, and the use of electricity, often involves the consumption of energy, which is typically provided by burning fossil fuels such as coal, oil, and natural gas [12]. These fossil fuels release CO2 into the atmosphere when they are burned, contributing to climate change.

The energy markets, which determine the supply and demand for different forms of energy, can also have a significant impact on CO2 emissions. For example, if the price of fossil fuels is high, this may encourage the use of alternative energy sources, such as renewable energy, which typically have lower emissions. On the other hand, if the price of fossil fuels is low, this may lead to an increase in their use and therefore an increase in CO2 emissions.

In addition to the direct relationship between economic activity and energy markets, there are also indirect relationships that can affect CO2 emissions. For example, economic policies and regulations, such as taxes on carbon emissions or subsidies for renewable energy, can influence the choices made by consumers and businesses about the energy sources they use. Changes in these policies or regulations can therefore have a significant impact on CO2 emissions.

It's critical that the recognize that stereotypes about technological adoption are often tied to particular cultural concerns and ideals (such as those related to climate change, digitization, scientific knowledge, and value improvements and optimizations), and that we shouldn't generalize them to encompass other types of subjects or people [12]. An analysis with anthropological inspiration can help highlight how the changes that are thought to be possible with technological solutions need to be problematized and viewed in light of what is initially interpreted as change, whether it is about shifting subjectivities, reflexivity, forms of agency, responsibility distributions, or even change at all.

There are certain things that IT cannot alter but understanding how we perceive change in both people and technology is a good place to start. The main components of emergency management systems are detection, alerting, and mitigation. However, other significant research areas are equally pertinent and should be taken into account when creating smarter, more effective solutions for existing and upcoming catastrophes. These areas can include networking, security, energy efficiency, availability, and other related areas.

4 Conclusion

In summary, understanding the complex interactions between economic activity, energy markets, and CO2 emissions is important for developing effective strategies to reduce emissions and address climate change. Big data analytics can be a useful tool for tracking carbon emissions in smart cities and helping policy makers develop strategies to reduce emissions [13]. Smart cities are urban areas that use advanced technologies, such as sensors, data analytics, and the Internet of Things (IoT), to improve the efficiency, sustainability, and livability of the city.

One way that big data analytics can be used to track carbon emissions in smart cities is by collecting and analyzing data from a variety of sources, including sensors, smart meters, and other IoT devices. This data can be used to identify patterns and trends in energy usage and emissions, allowing policy makers to identify opportunities for reducing emissions and improving energy efficiency [14]. Big data analytics can also be used to develop models and simulations that can help policy makers understand the impacts of different policy options on carbon emissions. For example, a simulation could be used to predict the effect of different transportation policies on emissions from vehicles in a city.

In addition to tracking and modeling emissions, big data analytics can also be used to develop and implement strategies for reducing emissions in smart cities. For example, data analytics can be used to identify and prioritize actions that are most likely to have the greatest impact on emissions reduction, and to monitor the effectiveness of these actions over time.

Overall, big data analytics can be a valuable tool for policy makers seeking to reduce carbon emissions in smart cities, by providing insights and helping to identify and implement effective strategies.

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