The analysis of big data to predict future trends in sustainable and smart construction

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ABSTRACT

The idea of sustainable development will become increasingly important which has been globally evolved. Big data has been collected through a variety of sensors and channels worldwide, both structured and unstructured, is regarded as one of the most crucial instruments for developing policy and identifying the future trend of sustainable and smart buildings. As a result, it is essential to comprehend the global parallels and differences in sustainable and smart construction in order to learn about technological innovation. In order to analyze and predict trends in the sustainable and smart building industry, this study aims to identify the area of data in a qualitative fashion and extract it from big data.

Four civil engineering specialists and one data scientist were chosen for interviews for a study on civil construction that used the qualitative research methodology.

In this research, 12 environmental fields, 10 social fields, and 7 economic fields in the three aspects of sustainable construction, as well as 14 fields regarding the characteristics of smart buildings, have been identified through interviews.

The results indicate that a more in-depth content interpretation and analysis based on gathering data from each point of the world through collecting big data about types of construction, materials, construction waste, and demolition may improve predictions about future trends and strategies in sustainable and smart buildings.

Keywords: Big data, sustainable construction, smart building, civil engineering, construction industry

1. INTRODUCTION

The world in which we live is unquestionably turbulent, uncertain, and unclear (Mortati et al., 2023). Advances in technology, communication, and market dynamics are profoundly altering global perspectives of time, distance, and spatial limits (Chinowsky et al., 2000). As a result, researchers should anticipate future trends in order to discover better circumstances and achieve sustainable development. The advent of the big data era is impacting human existence, production, and scientific research (Chen et al., 2022). Researchers in 2016 mentioned creating petabytes of data per year (Bilal et al., 2016), however, in 2023 they quote this rate as zettabytes of data per year (Todman et al., 2023), demonstrating that fast-advancing technology leads to a continual rise in data (Bilal et al., 2016). The era of big data is here (Todman et al., 2023). According to Kandt and Batty (2021), as the availability of real-time data and processing capacity increases, so does the likelihood of discovering patterns.

Nowadays, big data plays a vital role in various fields (Rabhi et al., 2019). The application value of big data and building science as an emerging interdisciplinary discipline has been recognized by the construction industry (Kang et al., 2017; Garyaev and Garyaeva, 2019; Daissaoui et al., 2020; Kandt and Batty, 2021; Huseien and Shah, 2022; Chen et al., 2022; Munawar et al., 2022). Scholars should try more interdisciplinary cooperative research in subsequent research work to further promote the development of intersectional research between big data and construction science (Chen et al., 2022).

Big data technology has begun to be widely applied to the design, construction, decision-making, and management services within the construction industry, ushering in a new wave of technological innovation in this area. Therefore, a thorough examination of the use of big data technology in the construction sector is

extremely important practically (Chen et al., 2022). Big data has significantly advanced numerous fields and yet holds out hope for more advancements (Todman et al., 2023). Big data technology already demonstrates increased potential for application development in the current growth process of the construction industry (Chen et al., 2022). Emerging developments have increased the complexity of the environment at an unprecedented rate, and big data is being produced. In this situation, big data is inspiring. By processing this data, a wide range of projects and infrastructure in different forms will be built that will drive contemporary approaches to smart cities. Examining and processing big data can effectively improve planning in the construction of large projects in terms of accuracy, execution speed, and technology. In fact, technology itself can't automatically transform and improve the construction industry or social lives. But the usage of big data as an enabler could make smart construction possible (Chen et al., 2022). In the context of smart buildings, a huge amount of data is created every second and reaches critical sizes (Daissaoui et al., 2020).

The big data of the industry sector includes all data about mapping data, roads, bridges, administrative and residential buildings, commercial and healthcare buildings, water supply facilities, dams, and energy production, which is collected from different paths constantly generated by sensors. Each country in the world performs its construction operations in a different way based on geographical, social, and economic conditions. However, the geographical similarity of the world is one of the reasons for the necessity of collecting data and standards for the construction industry. Also, awareness of the newest technologies and construction materials is necessary to access high efficiency and innovation in construction. Therefore, the ways to consider and collect big data from sensors.

In order for policymakers in the construction sector to make the best choices, it is crucial that information be gathered in accordance with the features of big data and made accessible at the appropriate moment. According to Zhang et al. (2023), a large dataset is allegedly produced using a data source like social media and search engines. In this regard, various channels such as mobile phones, computers, locators, online stores, social networks such as Facebook, Instagram, X, threads, YouTube, and other networks, organizations implementing public and private construction projects, Research and development centers, companies active in construction fields collect and store various data in the form of sensors that interact with humans in a way as the Internet of Things, these data show how people live socially around the world such as their choices, way of life, address, phone, emails, location, business situation, politics, weather and climate changes, type of technology, type of buildings, construction materials used, military forces, they reflect immigration, drought, the condition of cars, the distribution of wealth, healthcare, food, education and research, the global economy, etc.

Nowadays, big data analytics is an essential tool for businesses of all sizes and in a wide range of industries (Abdullah et al., 2023). Governments worldwide developing development programs want data that will give them with long-term environmental conditions (Chen et al., 2022). They explained that big data analysis can help with concerns including sustainable construction patterns, lowering energy consumption, preventing waste of construction materials, and preparing for earthquakes and disasters. Companies that embrace the power of big data may gain previously unattainable insights about their businesses and the world around them (Abdullah et al., 2023). Future potential for building will arise from the identification of frameworks and algorithms in construction and from the analysis of these statistics (Chen et al., 2022). Superior intelligence and erudition are made possible by large data collections (Zhang et al., 2023).

Sensors continually generate big data. It is often difficult to handle and evaluate large amounts of data in order to extract useful information. To uncover important information, businesses in the construction industry need an efficient and safe infrastructure to handle big data (Karatas et al., 2022). Building information modeling standards and accompanying rules are being rapidly adopted at the national and local levels in many nations throughout the world (Shin et al., 2022). Companies sell useful data in raw form before or after analysis. Based on the diversity of construction fields, construction patterns and materials, and project systems and processes, this data can be utilized to forecast the future trend of the construction industry. The methods for controlling smart buildings vary (Rodrguez-Gracia et al., 2023). As a result, many data fields are involved in this problem.

Smart buildings are defined as those that integrate advanced communication and technological systems (such as automatic monitoring equipment), organize information resources in the most efficient manner, and provide at least a reasonable return on investment (Huseien and Shah, 2022; Rodrguez-Gracia et al., 2023). Such structures are eco-friendly, comfortable, efficient, and energy-efficient (Huseien and Shah, 2022).

This article points out the importance of using big data in order to predict trends and make policy in sustainable and smart building. The purpose of this research is to identify the field of data in a qualitative way and extract it from big data for trend analysis and forecasting in the sustainable and smart building industry.

The analysis of these fields and features as a database helps strategy makers in the construction industry detect patterns.

2. BIG DATA

The big data era's advent is changing how people think about and act in relation to production, daily life, and science (Chen et al., 2022). Big data has become increasingly common as a result of recent technological breakthroughs (Rabhi et al., 2019). Thanks to new technology, ecological data is being collected at an unprecedented rate, and for some people, it is natural to believe that big data is necessary to fully comprehend complex challenges (Todman et al., 2023). The vast array of human behaviors and natural phenomena that are digitally recorded is what drives the search for big data (Zhang et al., 2023). Big data as unstructured (not ordered and text-heavy) and multi-structured data (containing many data formats arising from interactions between humans and machines) (Abdullah et al., 2023; Zhang et al., 2023). In this regard, big data has typical characteristics such as high volume, high frequency of collection, and a complex mix of data types (Ridzuan and Zainon, 2022; Todman et al., 2023). The large volume of data collected from sensor networks feeds Big Data databases and opens up an in-depth analytical dimension to identify the needs of smart building operators based on models (Daissaoui et al., 2020). Big Data analytics is the process of drawing conclusions from unstructured data by looking at and analyzing its patterns and behavior using both qualitative and quantitative methods (Rabhi et al., 2019).

Big data can be defined by the huge volume of data generated in real-time from various digital sources like sensors, smartphones, social media, and others. These data can have many different types, such as videos, audio, images, text, and so on. Several researchers defined the data by its features, which are shown in Table (1) as below:

Table 1. The characteristics of big data

Characteristics	References
Volume	Bhathal and Singh (2019); Rabhi et al (2019); Dedic and Stanier (2017); Al-Sai et al (2019); Munawar et al (2022); Kang et al (2017); Bilal et al (2016); Karatas et al (2022); Ridzuan and Zainon (2022); Ferraris et al (2018); Belhadi et al (2020); Ghasemaghaei and Goran Calic (2020); Faroukhi et al (2020)
Velocity	Bhathal and Singh (2019); Rabhi et al (2019); Dedic and Stanier (2017); Al-Sai et al (2019); Munawar et al (2022); Kang et al (2017); Bilal et al (2016); Karatas et al (2022); Ridzuan and Zainon (2022); Ferraris et al (2018); Belhadi et al (2020); Ghasemaghaei and Goran Calic (2020); Faroukhi et al (2020)
Variety	Bhathal and Singh (2019); Rabhi et al (2019); Munawar et al (2022); Kang et al (2017); Bilal et al (2016); Karatas et al (2022); Ridzuan and Zainon (2022); Ferraris et al (2018); Belhadi et al (2020); Ghasemaghaei and Goran Calic (2020); Faroukhi et al (2020)
Veracity	Bhathal and Singh (2019); Rabhi et al (2019); Dedic and Stanier (2017); Munawar et al (2022); Kang et al (2017); Ridzuan and Zainon (2022); Ferraris et al (2018); Belhadi et al (2020); Faroukhi et al (2020)
Value	Rabhi et al (2019); Dedic and Stanier (2017); Munawar et al (2022); Ridzuan and Zainon (2022); Ferraris et al (2018); Belhadi et al (2020); Faroukhi et al (2020)
Variability	Rabhi et al (2019); Dedic and Stanier (2017); Munawar et al (2022); Belhadi et al (2020); Faroukhi et al (2020)
Validity	Rabhi et al (2019); Dedic and Stanier (2017); Munawar et al (2022)
Volatility	Rabhi et al (2019); Munawar et al (2022); Belhadi et al (2020)
Visualization	Rabhi et al (2019); Munawar et al (2022); Faroukhi et al (2020)
Vulnerability	Bhathal and Singh (2019); Munawar et al (2022); Faroukhi et al (2020)
Vagueness	Lewis and Martin (2015); Dedic and Stanier (2017)
Venue	Dedic and Stanier (2017)
Vocabulary	Dedic and Stanier (2017)

Big data consisting of construction patterns, how to build old and historical buildings, native and local, regional, and national in every country, modern and smart, along with the type of building materials used every day in the world through various sensors, is brought to light. This huge volume of data and its usability must be confirmed in terms of different dimensions. Thus, zettabytes of data are generated, shared, or stored. These data must have variety, veracity, value, and validity as characteristics of big data in order to be analyzed for prediction. The prediction of future construction models shown in Figure (1) is as follows:

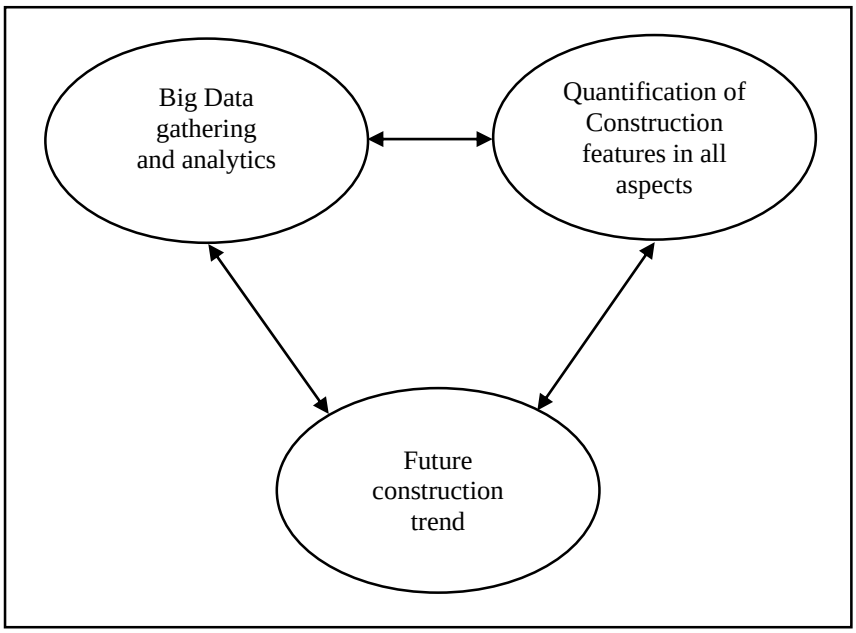

Fig. 1. The prediction of future construction model

3. METHOD

The purpose of this research is to identify the field of data in a qualitative way and extract it from big data for trend analysis and forecasting in sustainable and smart construction. Interviews are the most common method for gathering opinion and behavioral data, especially when a complex or highly sensitive topic is involved or when in-depth information is required (Li and Zhang, 2022). For comprehensive results, the research conducted an interview with three experts in the field of civil engineering with more than fifteen years of experience, and aside from that, one data scientist was contacted through email for an interview about big data. The interview was conducted to ask about the types of data needed to predict future trends in the construction industry. In addition, the research looked at big data as a stream and source of this data.

Two different categories of topics were covered in the interview: (1) sustainability in construction and (2) smart construction. The interview questions are limited to naming the information fields, and if there is a need to explain each field, the most suitable answers for introducing the information field have been provided by the experts.

4. RESULTS

According to the obtained results, the interviewees have pointed out different aspects where it is necessary to extract their data from the big data to be analyzed. Based on in-depth interviews with four experts, the results can be summarized into four categories. The first category refers to the economic, environmental, and social factors in sustainability and smart construction. The interviewees pointed out that even if these fields do not exist in big data, they should be taken into account by companies in order to collect their data in different countries and geographical locations. In this regard, the interviewees mentioned the diversity and accuracy of big data in order to ensure the accuracy of big data and its up-to-date. The list of interview results in the form

of required data, which should be extracted and analyzed from big data in order to predict future trends and determine construction strategies, is given in Figure (2).

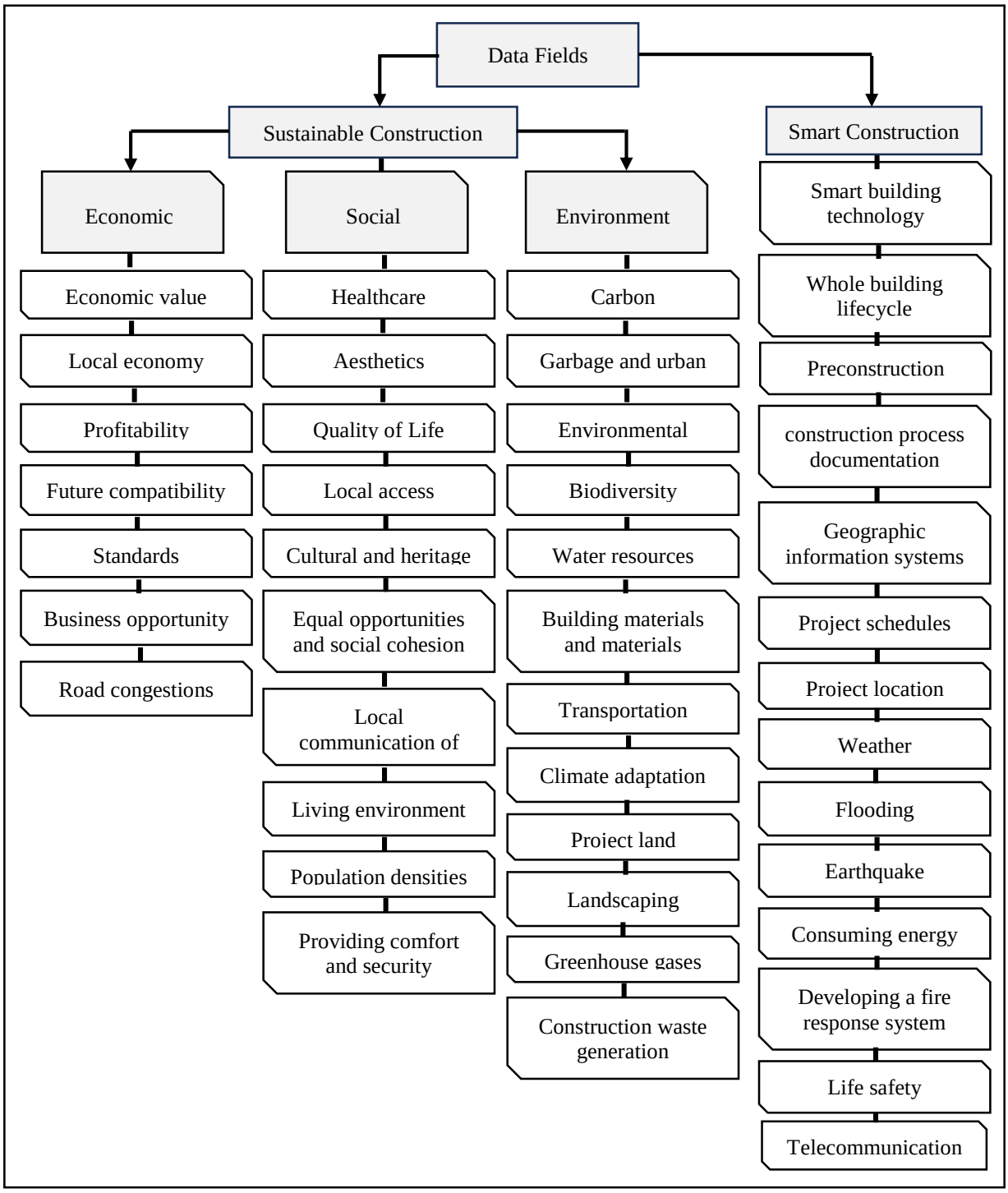

Fig 2. The results of the interview

5. CONCLUSION

This research deals with the identification of required fields and their extraction from big data for predicting and analyzing sustainable and smart building construction processes. The results indicate that a more in-depth content interpretation and analysis based on gathering data from each point of the world through collecting big data about types of construction, materials, construction waste, and demolition may improve predictions about future trends and strategies in sustainable and smart construction.

Sensor data, as an output of a device that detects and responds to some type of input from the physical environment, should be used to provide information about fields to an end user or as input to big data. These patterns of fields should adapt to detect any physical element of sustainable and smart construction.

A huge amount of data is produced and sent through sensors, which, if correct, can be used to predict trends and determine strategies for sustainable and smart buildings. Identifying the trend of the construction industry in every corner of the world through data collection, filtering, and analysis can inform policymakers to be aware of innovations, needs, and technologies.

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