ABSTRACT In the data-driven world, data is created in huge volume and then analyzed by several organizations to get benefit from them. Smart city is one of the examples to use big data to offer improved services for its resident and tourist. However, some countries face certain obstacles to analyze the big data integration for sustainability in smart city development. Therefore, the purpose of this research paper is to identify and analyze the significant barriers related to sustainable smart city development. To accomplish this objective, fourteen barriers of big data analytics are selected through the combined approach of literature review and expert input. After that, these barriers are evaluated using the best worst method for obtaining deeper insights. The result of this study reveals that the most significant barrier is ‘lack of technologies for BDA’, ‘lack of BDA framework’, ‘nature of big data’, and ‘low availability of analytics platforms for big data’. These barriers need to address on priority to develop a sustainable smart city. This study is helpful to the urban planner, government, and consultancy agencies to decide on the adoption of BDA for sustainable smart city development. Further, they can also optimize their resources in the best possible manner to achieve the sustainable development of the existing smart cities.

INDEX TERMS Decision making, sensors, big data, Internet of Things, data analysis, smart city, sustainable development, best worst method (BWM), big data analytics (BDA).

I. INTRODUCTION
Several countries are supporting the idea of smart cities to address the problems of ongoing urbanization, growing population density, and providing a higher quality of life for people and tourists [17], [18], [25], [39]. In the smart city, Information and Communication Technologies (ICT) applications and extensive usage of digital artifacts such as sensors, actuators, and mobiles are crucial ways of achieving smartness [55]. This extensive adoption and application of digital technologies in different city domains and day-to-day lives have enhanced human-to-human, human-to-things, and things-to-things interactions, resulting in huge amounts of data generation, commonly referred to as big data [34]. Big data is a mix of complex data characterized by large and rapidly growing sizes of datasets that go beyond the capabilities of traditional data storage and processing systems. Governments are starting to collect this big data to extract useful information [40]. This data assists governments in improving the living conditions and ensuring the sustainability of their residents as well as visitors [28]. It is also vital to reduce costs and streamline processes to improve citizens’ comfort and quality of life. As the result of reduced cost, it boosts performance in sectors like education, health care, transportation, security, and emergency services. With analyzing these big data, valuable insights, and associations among the several variables may be derived. This kind of analysis is called Big Data Analytics (BDA), which is considered one of the main empowering capabilities of smart cities development [20], [5]. This big data should be appropriately maintained and analyzed so that the citizens of the smart city can move forward towards sustainable development.

As smart cities have had a significant impact on several aspects of human life, including transportation, health, energy, security, and education. Therefore, big data for smart
cities has the potential to revolutionize every aspect of a country’s economy. However, the adoption of big data and its analysis requires the capabilities of BDA for handling and analyzing this large amount of data [21]. BDA is about the application of advanced analytics techniques to extract meaningful information from large volumes of data, allowing for data-driven decision-making [57], [58]. Sensors, IoT, cameras, scanners, metal detectors, and other technologies have all been utilized extensively in smart cities to collect data for BDA analysis [51]. The integration of the data collection devices and analytics creates several difficulties for the management of smart cities [41]. The effective analysis of data has the potential to improve city conditions and contribute to a more sustainable way of life for inhabitants and visitors. These BDA would allow the government to better manage their resources and prepare them for more effective decision-making.

Several governments throughout the world are supporting smart city programs integrated with BDA to achieve sustainable urban development. However, achieving the smart city’s unique capabilities with BDA has been hindered by several concerns including privacy and security, unstable political condition, and data complexity. Due to scarcity of resources and technical incompetency, these barriers are posing additional challenges for emerging economies to progress toward sustainable smart city development. These barriers are essential to understand for the development and management of smart cities in emerging economies to move towards sustainable urban development. Therefore, this study presented a framework for adopting BDA in smart cities development by emphasizing important barriers to overcome these barriers in developing countries. The primary objective of this research is provided as follows:

- Identification of the barriers of BDA adoption for sustainable smart city development.
- Prioritization of identified barriers using the empirical method.
- Recommend some solutions to overcome these barriers.

Through the accomplishment of the above objectives, this study contributed to the literature in smart city development and assist the urban city planner, government, and regulatory bodies to develop a sustainable smart city. The remaining paper is structured as: the present section is the introduction section that provides an overview of BDA and their scope for the sustainable smart city. The second section highlights the major studies related to sustainable smart city development and identifies the major barriers to BDA adoption. The adopted research methodology is mentioned in the third section. The fourth section presents data analysis and reports the result. In section five, the major findings of the study are discussed, and implications are reported in section six. Finally, in section seven we provide the conclusion, limitation, and future scope of research in the field.

II. LITERATURE REVIEW
This section deals with the role of the BDA in sustainable smart city development. Further, the major barriers to BDA adoption are identified with the appropriate references.

A. SUSTAINABLE SMART CITY AND BDA
Big data analytics has been used for several purposes in different domains such as smart grid operation, healthcare, smart manufacturing, sustainable supply chain, and smart city development. For instance, Munshi and Mohamed [64] describes a smart grid big data eco-system based on the state-of-the-art Lambda architecture and proposed a smart grid big data eco-system using the Hadoop Big Data Lake to store a variety of smart grid data, including smart meter, picture, and video data. In the context of the healthcare industry, Dash et al. [60] identify the various application of big data analytics. They also identified the various challenges related to big data analytics. A similar application of big data analytics could be also seen in Kumar et al. [62] and Bajic et al. [59] in the manufacturing sector. In addition, Kusi-Sarpong et al. [63] provide a framework for the risks that organizations could face while using big data analytics in sustainable supply chains, as well as strategies for overcoming them. Koppel and Chang [61] present a new Six Sigma framework by integrating human input and big data to find possibilities for continuous improvement initiatives in manufacturing. Some application of BDA is also seen in the context of smart city development such as Osman [39]. Therefore, big data analytics are used for various domains.

Several cities have begun to adopt a more comprehensive approach to transforming/developing smart cities employing digital technologies in the recent two decades [13]. Smart cities have shown to be more than merely a trend or buzzword. Countries are focusing on “All cities aspire to be smart and sustainable”. The term, ‘smart sustainable city’ is understood as a city that is supported by the extensive presence and prevalent use of cutting-edge ICT, which combined with many urban systems and domains and how they are interrelated and coordinated, enables the city to safely regulate the available resources, sustainably, and efficiently to improve the social and economic performances [10]. The sustainability of the smart city is very much essential for urban development in the long run. Therefore, countries are not only focusing on the smartness of the city but also tried to make them sustainable. The sustainability of smart cities is dependent on the use of ICT for data collecting from smart cities and these massive volumes of data (big data) are being utilized to improve the living standards of residents. This collected big data are required BDA capabilities for drawing useful insights. BDA refers that “…the capability to manage and analyze petabytes of data that enables the organization to deal with clusters of information that could have an impact on the business” [23]. This BDA brings sustainability in smart cities by utilizing the analytics’ outcome for a variety of applications, including home security, traffic control, resource allocation, healthcare,
education, and environmental protection. Several studies are conducted in the area of sustainable smart city development and some relevant are mentioned here. Silva et al. [48] argued that due to technological, economic, and regulatory constraints, the smart city idea is still emerging and not widely adopted throughout the world. Therefore, they also identified potential challenges and opportunities for smart cities. In this row, Khan et al. [29] identified and analyzed the interrelationships between the challenges of efficient big data utilization in the development of smart cities. Bibiri [10] organize the vast and complicated scientific field of sustainable cities by defining, condensing, and organizing the fundamental characteristics of a foundational framework for sustainable smart city development as a collection of future practices. Fugini et al. [17] studied and developed an innovative solution in the field of BDA for three companies working on smart cities. Khan et al. [29] studied the major challenges related to smart city development and proposed some solutions to overcome them. Kumar et al. [31] studied the selection of 100 Smart Cities Mission of India and evaluated city eligibility in a multidimensional fashion and design assessment criteria for the city selection process to accomplish the purpose of the smart city. Yadav et al. [53] proposed a structural framework to develop a sustainable smart city (SSC) in the Indian context. Khan et al. [27] determined and prioritized the obstacles to IoT adoption in smart cities for the emerging economies.

B. IDENTIFICATION OF BARRIERS OF BDA ADOPTIONS

The importance of big data in the development of smart cities cannot be underestimated. BDA has a wide range of applications in smart city domains, including planning [16], traffic control [26], transportation [11], criminal analysis [14], energy [40], and the environment [24]. These applications are possible with the effective adoption of the BDA in smart cities. However, the adoption of the BDA faces several barriers and we have identified these barriers using the germane literature review. The relevant literature is identified through the Scopus database. The rationale behind the selection of the Scopus is that it covers a range of high-quality academic journals of the science and management field. Further, we prepared a list of keywords as ‘big data’, ‘sustainable smart city’, ‘barrier’, and ‘BDA’ for the identification of articles. After that, these keywords are searched within the article title, abstract, keyword section of the search string in Scopus. These keywords are searched separately and combined with Boolean operator OR/AND for the identification of the relevant articles. Afterward, a comprehensive literature review is conducted on the listed papers to identify the initial barriers to BDA adoption for sustainable smart city development. With the support of expert’s judgment, these impediments are aggregated and verified. As a result, fourteen barriers to BDA adoption for sustainable smart city development have been finalized. To undertake the deep insights, these barriers are further classified into three major categories. Table 1 shows the finalized list of BDA adoption barriers and their categories with appropriate references.

III. RESEARCH METHODOLOGY

A two-phase framework is proposed to fulfill the defined objectives of the research. In the first phase the significant barriers of BDA adoption for sustainable smart city development using the literature survey. Further, these identified barriers are discussed with the expert panel for the finalization of the barriers through focused group discussion. There are several methods available for the finalisation such as focus group discussion, Delphi, and interview [66], [67] [68]. The idea behind choosing the focus group discussion over the other method such as an interview or Delphi technique is that it could provide the agreement or disagreement among the experts in real-time and develop the consensus in relatively less time [65]. An eight-member expert panel was formed that consist of five industry professionals, two academia, and one consultant. The experts’ selection is based on professional experiences and managerial positions. The experts

| TABLE 1. Barriers of BDA for smart city. |
|-----------------------------------------|
| Barriers Sub Barriers Code | Reference |
|-----------------------------------------|
| Urban Planning related Barriers (UP) | Population diversity | UP1 | Ahmad, Jeon & Yu, (2021); Bibiri & Krogstie, (2017) |
| Lack of BDA framework | UP2 | Manjunatha & Annappa, (2020); Osman, (2019) |
| Lack of citizens involvement | UP3 | Komninos et al. (2013); Rana et al., (2018) |
| Political instability | UP4 | Letsaifa, (2015); Rana et al., (2018) |
| Higher cost for IT | UP5 | Mokhtadir et al., (2018); Rana et al., (2018); Ablyazov, (2021) |
| Data security and privacy issues | D1 | Losavio, Chow, Kolay & James, (2018); Magare, Dugdhaonkar & Kondekar, (2020) |
| Data and informati on related barriers (DI) | Insufficient Information Sharing | D2 | Gil-Garcia, Pardo & De Taya, (2019); Anthony Jnr, (2020) |
| Unavailability of data security regulation | D3 | Huertas Celdran et al., (2019); Andoni et al. (2019) |
| Fear of cyber-attacks | D4 | Makhdoum et al., (2019); Chen, Wawrzynski & Lv, (2021) |
| Lack of technologies for BDA | TE1 | Yang, Wen, Aziz & Lahach, (2021); Khan et al., (2021) |
| Lack of storage and processing capabilities | TE2 | Zhang et al., (2021); Techolchev & Schieferdecker, (2021) |
| Low availability of analytics platforms for big data | TE3 | Ben Sta, (2017); Fiore et al., (2019); Shahat Osman & Elragal, (2021) |
| Technological Barriers (TE) | Lack of data collection devices | TE4 | Soyata, Habibzadeh, Ekenna, Nosbaum & Lozano, (2019); Khan et al., (2021) |
| Nature of big data | TE5 | Al Nuaimi et al., (2015); Yigitcanlar & Kamruzzaman, (2018) |
have a minimum fifteen-year experience and have great knowledge about analytics, big data, and smart city. Based on the expert’s comment, BDA adoption barriers are finalized for sustainable smart city development. The second phase deals with the prioritization of these barriers. A well-known MCDM method, Best Worst Method (BWM) is utilized for prioritization of the barriers for developing countries in particular. Collection of the data for the BWM method, a structured questionnaire was prepared. This questionnaire was distributed to the expert group, who were invited to submit it. One of the authors presented the BWM to the expert panel before completing the questionnaire, to provide them with an outline of the technique. After that, the questionnaire was filled, and the BWM is followed to obtain the results. Figure 1 depicts the research framework for the study.

A. BEST WORST METHOD (BWM)

Rezaei [43] proposed BWM that gain popularity day by day among the management researchers because of its benefits over the other MCDM method. The major advantage of BWM is that it requires fewer pairwise comparisons [28], [43]. Furthermore, this method successfully addresses the inconsistency resulting from pairwise comparisons. Because of these features, this method saves a substantial amount of time for experts by requiring fewer comparisons.

The BWM merely requires reference comparisons, implying that all criteria are compared to the best and worst criteria for experts by requiring fewer comparisons. The BWM method is illustrated as [43]:

**Step 1:** Literature review along with experts’ judgments are applied to identify the crucial barriers of BDA for the prioritization that could be in ‘n’ numbers.

**Step 2:** Finalization of the most important (C_B) and least important (C_W) barriers among all the identified barriers by the expert’s group.

**Step 3:** The expert group provides the preference of the C_B is over all the other barriers using a 9-point scale (1-9) and this reference comparison is denoted by the vector (A_B) as:

\[
A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})
\]

where, A_B the Best-to-Others (OB) vectors, a_Bj implies the preference of the C_B over C_j and a_{BB} = 1.

**Step 4:** The expert group evaluate the preference of the other barriers over the C_W using a 9-point scale (1-9) by expert feedback and the resultant vector (A_W) is presented as:

\[
A_W = (a_{W1}, a_{W2}, \ldots, a_{Wn})
\]

where, A_W is the Others-to-Worst (OW) vector, a_{Wj} refers the preference of the C_j over the C_W and a_{WW} = 1.

**Step 5:** Optimal weight for each barrier is defined as one in which each pair w_B/w_j and w_j/w_W should have w_B/w_j = a_{Bj} and w_j/w_W = a_{Wj}. To comply with these specifications for all j, maximum absolute differences minimized of the set {w_B/w_j − a_{Bj}, w_j/w_W − a_{Wj}}. This problem is mathematically characterized by following model:

\[
\begin{align*}
\min & \max \{ |w_B/w_j - a_{Bj}|, |w_j/w_W - a_{Wj}| \} \\
\text{Subject to:} & \sum_j w_j = 1 \quad w_j \geq 0; \quad \forall j
\end{align*}
\]

Model (1) can be transformed into following linear model:

\[
\begin{align*}
\min & \xi^L \\
\text{s.t.} & |w_B/w_j - a_{Bj}| \leq \xi^L; \quad \forall j \\
& |w_j/w_W - a_{Wj}| \leq \xi^L; \quad \forall j \\
& \sum_j w_j = 1 \quad w_j \geq 0; \quad \forall j
\end{align*}
\]

The optimal weights of each barrier \(w_1^*, w_2^*, \ldots, w_n^*\) and an optimal value of \(\xi^L\) obtained by solving the linear model (2). A Consistency ratio \(\hat{\xi}^L\) closer to 0 is required for better consistency [44].

IV. RESULT

The objectives of this study are fulfilled with the help of the proposed research methodology. Initially, an experts’ group is formed that consists of industry experts, academia, and consultant. This expert group finalized the barriers related to BDA adoption for sustainable smart city development. The expert panel provides feedback on the barriers which are initially identified from the comprehensive literature review. Through the literature review, eighteen barriers are initially identified. Among these barriers, fourteen are finalized for this study by the expert panel, and the same is shown in Table 1.
Further, the importance ranking of the BDA adoption barrier is evaluated using the BWM method. To implement the BWM method, a questionnaire is prepared for the collection of responses from the experts. Before responding, one of the authors describes to the expert group how to fill the questionnaire. The consensus response is composed and collected from the expert’s team. After getting the responses, the BWM is applied to rank the barriers.

The most severe (best) and least severe (worst) barriers are identified at the barrier and sub-barriers level. The expert group provides the preference of the best barrier over remaining barriers (BO) on a 1–9 points scale. Similarly, the preference of the best sub-barrier over the other sub-barrier is also evaluated. The preference of the best barrier over the barrier (BO) is shown in Table 2.

Similar to Table 2, the preference of the best sub-barrier over another sub-barrier is presented in Tables 3–5.

Further, the preference of the other barrier over the worst barrier (OW) is also evaluated using the 1–9 points scale. The OW vector for the main barrier and sub barrier is shown in Table 6 and Tables 7–9 respectively.

The comparison between all barriers and their sub-barriers is received from the experts’ panel. After getting the experts’ input, the BWM is applied to get the importance weights of barriers and sub barriers. Each barrier and sub barriers important weights are determined using equation 2. In this manner, the importance weight of the main barrier and the local weight of each sub barrier is determined. Based on the local weight, each sub-barriers are ranked locally as shown in Table 10. Using the weight of the main barrier and the local weight of each sub barrier, the global weight of each sub barrier is also calculated. As per the global weight, the global rank of each sub barrier is determined. The local weight, global weight, global rank, and consistency ratio are represented in Table 10.

### V. DISCUSSION

BDA has a significant effect on the planning and decision-making of smart city services such as transportation management, surveillance and public security, smart parking, weather prediction, and healthcare services. These functions are well supported by the BDA, and it makes significant to adopt BDA while developing a sustainable smart city.
However, the adoption of BDA faces many barriers and this study explores these barriers. The most significant barrier to BDA adoption is the urban planning-related barriers. This barrier needs to be addressed first to develop sustainable smart cities. The second main category of the barrier is the and technological barriers that could be reduced for analyzing the big data for sustainable development. The third category of the barrier is the privacy and information-related barriers, and these barriers are required to mitigate for enabling social sustainability in the smart city.

A. URBAN PLANNING RELATED BARRIERS
Among the urban planning-related barriers, the important order is ‘lack of BDA framework’ > ‘higher cost for IT infrastructure’ > ‘political instability’ > ‘lack of citizens involvement’ > ‘population diversity’. The highest significant barrier is the unavailability of a framework for BDA implementation. The framework is required to implement the BDA in smart city and there is a scarcity of frameworks for the smart city in the context of emerging economies. The government, private sector of city developers, and urban planners need to think about the development of BDA formwork for smart city development to maintain sustainability in the smart cities. The next barrier is the ‘higher cost for IT infrastructure’ that needs to address with help of public, private, and foreign investment. Most of the emerging economies face a challenge related to infrastructure development and the same is true for digital infrastructure. Therefore, the government and public policymaker need to invite the private player and foreign investor for the infrastructure development that supports the smart city objectives. In this row, the next barrier is the ‘political instability that hinders the investment in that state. If political instability is present in the country, then the realization of sustainable development of the smart city is quite hard. The government policies should towards a politically stable environment for the BDA adoption for sustainable smart city development. The next barrier is the ‘lack of citizens involvement’ that is very much required for the development of BDA-enabled smart cities. For the BDA, public data is collected, so their involvement has a huge impact on the BDA adoption. This involvement brings sustainability to the smart city in the long run. Further, population diversity is the next challenge for the BDA in the smart city. The public is the main stakeholder of the smart city, and their contribution is required for sustainable development.

B. TECHNOLOGICAL BARRIERS
The second most significant barrier is the technological barrier for sustainable smart city development. Among the technological barriers, the important order is ‘lack of technologies for BDA’ > ‘nature of big data’ > ‘low availability of analytics platforms for big data’ > ‘lack of storage and processing capabilities’ > ‘lack of data collection devices.’ The most significant barrier is the ‘lack of technologies for BDA’ that should be addressed on priority. BDA requires a huge variety of technologies for data capture, process, data storage, and analysis. These technologies are not adequately available in developing countries so that it appears as a barrier for BDA adoption. These barriers could be reduced through the deployment of digital technologies and creating awareness about these technologies so that citizens could participate in the smart city’s functioning. The next barrier is the ‘nature of big data’ that infer the diverse nature of the big data. This diverse nature is present because the data is collected from a different format. To cater to this barrier, horizontal and vertical platform scalability seems the logical solution. The next barrier is the ‘low availability of analytics platforms for big data’ that is the major concern of the urban developer. Emerging countries face less availability of the analytics platform. Thus, there is a need to develop analytics platforms for big data for sustainable smart city development. In this context, the next barriers are ‘lack of storage and processing capabilities that could be extended through technological advancement and capability development. The next barrier for the BDA is the ‘lack of data collection devices’ such as smart cameras, sensors, and other smart devices. These devices are required for the efficient and effective functioning of BDA. Before the BDA implementation, the urban planner needs to deploy a large amount of data capturing devices in the smart city.

C. PRIVACY AND INFORMATION RELATED BARRIERS
The privacy and information-related barriers are the next significant barrier. Among these barriers, the important order is ‘insufficient information sharing’ > ‘unavailability of data security regulation’ > ‘data security and privacy issue’ > ‘fear of cyberattacks’. The most significant barrier is the

### TABLE 10. Importance weights and rank of BDA adoption barrier.

| Barriers | Weights | Sub Barriers | Local Weight | Local Rank | \( \omega_p \) | Global Weight | Global Rank |
|----------|---------|--------------|--------------|------------|--------------|---------------|-------------|
| UP       | 0.5417  | UP1          | 0.0583       | 5          | 0.0316       | 11            |
|          |         | UP2          | 0.4250       | 1          | 0.2302       | 1             |
|          |         | UP3          | 0.1000       | 4          | 0.0542       | 7             |
|          |         | UP4          | 0.1667       | 3          | 0.0903       | 4             |
|          |         | UP5          | 0.2500       | 2          | 0.1354       | 2             |
|          |         | DI1          | 0.1724       | 3          | 0.0287       | 12            |
|          |         | DI2          | 0.4655       | 1          | 0.0776       | 5             |
|          |         | DI3          | 0.2586       | 2          | 0.0431       | 9             |
|          |         | DI4          | 0.1034       | 4          | 0.0172       | 14            |
|          |         | TE1          | 0.4158       | 1          | 0.1213       | 3             |
|          |         | TE2          | 0.1183       | 4          | 0.0345       | 10            |
|          |         | TE3          | 0.1577       | 3          | 0.0460       | 8             |
|          |         | TE4          | 0.0717       | 5          | 0.0209       | 13            |
|          |         | TE5          | 0.2366       | 2          | 0.0691       | 6             |
‘insufficient information sharing’ that needs to be addressed to realize the concept of the smart city. A smart city is seen as a collection of interconnected systems. This holistic perspective of a smart city necessitates information exchange across domains. Therefore, the information is shared across the domain with the help of well-defined protocols. To do so, public participation is required for the information sharing so that it could use for improving the quality of life in a smart city. The next barrier is the ‘unavailability of data security regulation’ that explicitly exists in developing and underdeveloped countries. Data security regulation is required for the processing of public data. Therefore, there is a need to develop a data security protocol for collecting, storing, and sharing public data for the welfare of their residents. The next barrier is the ‘data security and privacy issue’ that needs to address for achieving social and political stability. The collected data might include sensitive information of the residents, tourists, and the government. A failure in security or an information theft might lead to citizen profiling and constitute a security risk. Therefore, data security and privacy are required for sustainable smart city development. The next barrier is the ‘fear of cyberattacks’ that are addressed through the robust data security system. For the development of a smart city, big data is collected that includes financial, health, and medical records, including the detailed history which may reveal internal views of the people they represent. Any unauthorized use of such big data can create a serious threat to citizens’ privacy, protection, and safety.

VI. IMPLICATION OF THE RESEARCH
This study presents a list of fourteen barriers that affect the effective implementation of BDA in sustainable smart city development in developing nations. These barriers help the urban policymaker to make an informed decision regarding the adoption of BDA for smart city development. Further, they also make strategies and action plans to mitigate these barriers. This study further evaluates these barriers by prioritizing them. The prioritization of the barriers assists the policy planner, government, and consultant to mitigate the high-rank barriers on a priority basis. They could also use their resources more rationally to eradicate the barriers. It also advances the understanding of the researchers and professionals working in the area of smart cities to adopt the BDA and their relationship with sustainability. The findings allow academics to concentrate their efforts on the identified barriers, allowing them to contribute to the improvement of urban sustainability through the use of BDA. The study also suggests that the private and foreign investor is also invited for the infrastructure development for smart city realization. As the citizens are a major stakeholder of smart cities, their participation is much more required to make the successful transformation of existing cities into smart cities. These findings may be used by practitioners to identify common barriers in smart sustainable urban planning and development projects and their potential solutions. Moreover, this study lays the foundation for more in-depth research on smart, sustainable cities, particularly in developing countries.

VII. CONCLUSION, LIMITATION, AND FUTURE SCOPE
The notion of a smart city has developed as an application of digital technologies to provide improved services for their residents. Even though smart cities have become a buzzword in the current world, they nevertheless confront significant barriers to their development. To meet the objective of smart city, BDA plays a significant role and their application leads towards sustainability. This study focuses on the adoption of big data for the development of sustainable smart cities. Initially, fourteen significant barriers are identified through the literature review and expert’s feedback, and these barriers are categorized into three categories namely ‘urban planning related barriers’, ‘data and information related barriers’, and ‘technological barriers.’ Further, these barriers are prioritizing to support the urban planner for their decision-making related to the adoption of the BDA. The prioritization has been accomplished with the help of the BWM method. The finding of this study suggests that the most significant barrier is ‘lack of technologies for BDA’, ‘lack of BDA framework’, ‘nature of big data’, and ‘low availability of analytics platforms for big data’. These barriers are needed to address on a priority basis to develop a sustainable smart city.

In terms of limitation, this study is based on the literature review and there is a chance to overlook some significant barriers. Further, the finalization of the barrier is based on the judgment of the experts so that some barriers may be deleted due to the expert’s bias. Therefore, care should be taken while finalization the barriers. Further, the subjective input of the expert is also a limitation for this study that could be mitigated through fuzzy and grey theory. This study is conducted in a developing country, so if the same study is repeated in the developed or underdeveloped countries then some barriers may be deleted and added as per the requirement. There is a scope to conduct similar studies in developed or underdeveloped economies. Further, the identified barriers can be also prioritized or modeled with some popular methods such as AHP, ANP, DANP, and ISM in future studies.

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