

Systematic & Synthesized Critical Literature of Big Data, Business Intelligence-Analytics & Smart Cities to the Current Era

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Abstract

Present digital world with the concept of Smart cities are producing enormous amount of data over the period of time at different sectors of life. It is becoming difficult to track information and produce knowledge out of it without using emerging information management technologies. Big Data Analytics is a must to make use of data generated by IoT. In the present paper, A systematic and synthesizing critical literature have been discussed on the concept and relationship of Big Data, Data Analytics and smart cities and imperatives of the same. This study primarily contributes in providing the rationale of Big Data, Business Intelligence & Data Analytics in smart cities. The study discusses the valuable information to the Big Data practitioners by clarifying the process of effective management of Big Data through Business Intelligence and Analytics processes in smart cities. Study further provides the directions to the future research.

Keywords: Big data; BI and analytics; Smart cities.



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1. Introduction

Nowadays, in this digital world, massive amounts of data are generated daily from different sources, and generating data rate is still growing exponentially for many reasons. For instance, public social media is creating vast quantities of data regarding its users' activities and their personal information on YouTube, Facebook, Twitter and other platforms. Also, retailers are building huge databases to track their customers' activities and other organizations in financial, health and logistic sector are doing the same (Elgendy and Elragal, 2014).

Organizations are storing these data in order to extract valuable information and knowledge from them which will help business leaders in understanding individuals' demands and take appropriate decisions. According to (Acharjya and Ahmed, 2016), the concept of big data refers to "the collection of large and complex data sets which are difficult to be processes using traditional database management tools or data processing applications". These datasets of big data are different from traditional ones because of the following characteristics which are illustrated in the 4Vs index:

Volume: this attribute concerns about the enormous quantities of data generated or the number of records, files, tables or transactions performed. Data volumes were measured before by Terabyte (TB) but in 2011 it exceeds ZB and further on.

Variety: this attribute refers to the different types or formats of data captured as a result of collecting them from different sources. Various types of data are stored such as structured, unstructured and semi-structured when documents, pictures, audio, video, XML and other data types are combined together. This attribute is affecting the first one and vice versa. When the volume of data increased, the opportunity of having more various types will be increased and when organizations are having various types of data, it could be result in higher rates of volume.

Velocity: this attribute concerns about the speed or frequency of generating data. It is difficult to deal with big data using the traditional technologies because they are not qualified enough to handle the required data processing rates, so cloud computing is used instead of them.

Value or Veracity: this attribute concerns about the quality of big data, as bad, good or undefined due to the data incompleteness or inconsistency (Mukherjee and Shaw, 2016).

As it was mentioned before, these characteristics made big data unique and cannot be stored, managed, processed or analyzed using traditional database management systems because of their limited abilities. This was the force deriving concerned people to develop advanced techniques and scalable architectures to perform different processes on big data. Businesses and organizations do not want to store data only, but they want to get benefited from it by processing and analyzing these data in order to elicit valuable knowledge, identify patterns and

relationships. So, Big Data Analytics can be identified as the process of using and applying advanced analysis techniques on big data sets or big data. Researchers and decision makers are paying attention to big data analytics because of the valuable information extracted from different sources such as healthcare, manufacturing, telecom, banking, retail and others. According to [Alam et al. \(2014\)](#), the importance of Big Data lies in its ability to achieve the following advantages which are:

Reduce Cost: the cost of storing a specific amount of big data sets using Hadoop framework is 800 times less than storing the same amount using traditional relational databases.

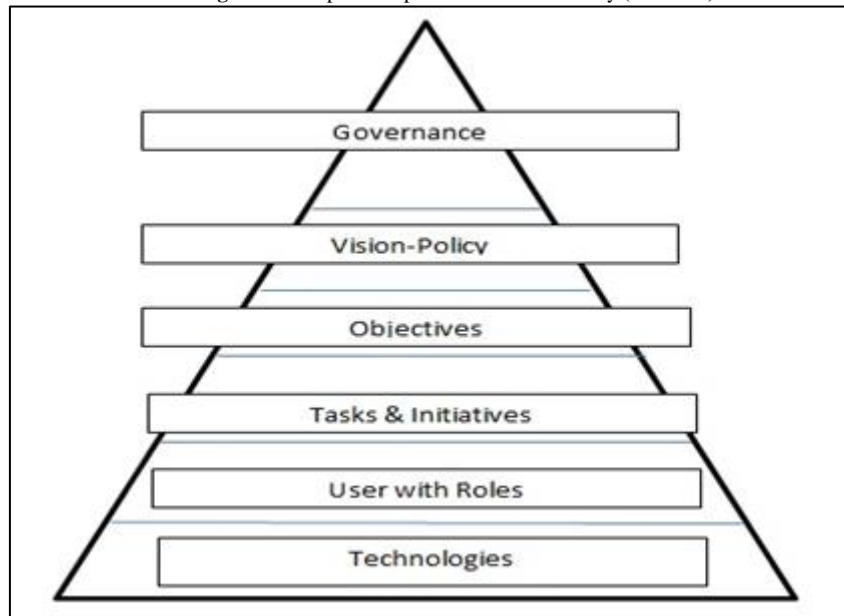
Reduce Time: data sets pricing which needs hours to be calculated using traditional methods, now they can be calculated in minutes using Macy's merchandise pricing optimization application.

Improve business decisions: the main benefit of BDA is to analyze data sets and extract valuable knowledge regarding market demands, customers' behaviors in order to help organizations to make better decisions on what they should do in the future, what promotions and products should be offered to customers, etc.

Develop new attractive products: LinkedIn is one example of social media platforms which adopts the idea of big data when it starts providing unique features for users such as jobs we may be interested in or people to whom we may know.

Smart city projects have been evolved around the world for the latest years. There are some factors driving local governments towards the use of technologies to support quality living in urban areas and providing better services to the public, and these factors are: the continuous growth of population in the cities and the complexity of city management. Smart cities are intended to relate high technology to green environment and well-being of citizens. However, the concept of smart cities is still not clear-cut as many different smart cities all over the world were established with distinct characteristics. Therefore, we can say that a systemic theoretical study about smart cities is still lacking ([Dameri, 2013](#)). A bottom-up development path is suggested by researcher of a smart city based on six different aspects as below:

Fig: Bottom-Up Development Path of Smart city (Research)



[Dameri \(2013\)](#) suggests that smart city is best defined as “a geographical area, in which high technologies such as Information and Communication Technologies-ICTs, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development”. A believe that the recent history of smart cities is based on two parts, namely: the urban future and knowledge & innovation economy. However, smart cities concept was evolved since the past 20 years as future vision of urban areas which were designed using the art of technology and the production system. Those visions were and still are representing a significant part of the planning and development of urban areas. Therefore, most of the strategies to establish smart cities are far from instant achievement rather they indicate a strategic line to achieve a long-run goal which makes the future vision about it, an important driver for the establishment of smart city ([Angelidou, 2015](#)).

Cities are called smart if they function intelligently through a synthesized and integrated data, improve the way of living in cities efficiently, fairly and qualitatively. The concept of smart cities is based on the impression that ICT is fundamental to its operation regardless of the various names that are given to describe it; Intelligent, virtual, digital or future cities. ([Batty, 2012](#)). Designing a smart city requires investments to be made in human and social capital, traditional means of transport and advanced ICT communication infrastructure which enrich the commercial development and upgrade the standard of living with intelligent management of natural resources that is supported by the government. ([Caragliu, 2011](#))

The common concept of smart entrepreneurial city serves the rich, successful, innovative businessmen through providing the business portals and services, in addition to the availability of luxury facilities and services besides the global business transport connections, in a way that it disregards the welfare needs of its ordinary residents. The contribution of people is obviously required to build a smart progressive city rather than simply adopting a sophisticated information technology infrastructure or creating a self-promotional website to be referred to as a smart city. The growing number of people who live in those cities takes more than just electrical connections, electronic orders, smart offices, and luxurious facilities. The smart city tag is used to cover the nature of some of the underlying fluctuations in cities. It takes a great risk associated with technology, transfer of power, challenging the variations and redefining what they mean by smart itself to create real smart cities. (Hollands, 2008)

It is common in our daily contemporary life to rely the most on automated services and without any second thoughts we all know that we have a persistent desire to automate every possible process or service which may result in a revolution in economics, politics, and community. Smart systems which are involved in new applications and services would obviously require enormous amounts of smart things connected. The total number of devices in such a network, called Internet of Things (IoT), will reach to 50 billion by 2020 based on the analysts' predictions. The best way to connect huge numbers of devices is by wireless means. Therefore, international organizations such as IEEE have adopted their technologies towards the emerging market of IoT, but they found out that WiFi, for instance, is designed originally for limited areas. As a result, TGah was formed as 11ah task group by IEEE 802 to extend the applicability area of networks to allow thousands of devices to work indoor and outdoor at the same area. However, TGah has done many activities and faced several challenges as well. TGah innovates many mechanisms which totally transformed the core functionality of smart systems for the WiFi vendors which are very useful in the implementation of smart cities. (Khorov *et al.*, 2015)

There are various conceptual dimensions composing smart cities such as technological, human, and institutional components. When a city is labelled as "smart", it is associated with several pioneering and transformative changes supported by new technologies. However, social factors also significantly influential on the creation of smart cities. Thus, a socio-technical view on smart cities is required which involves a comprehensive understanding of the complications and interrelations within social and technical factors of a city's services and physical infrastructure to initiate a smart city. (Nam, 2011). Cities are (re)built in the 21st century based on the requirements of corporations, officials and average citizens. However, the smart city model is still controversial and under criticism as it is designed and proposed by large technology corporations and as it has been applied in real cities such as Louisville and Philadelphia. There are some alternative options proposed through new types of data-influenced governance. However, analysis has been conducted on the actually existing cities where these policies are being employed that it provides a mutual understanding on both the potentials and risks associated with the smart city model. (Sheltona, 2015).

The concept of "smart cities" was explored as innovation-driven environments that represent a perfect platform for testing and validating future internet-enabled services through an advanced ICT infrastructure which is one of the key factors of the welfare of cities. Other factors of the welfare of cities are important as well such as: the infrastructure for education and innovation, the business and governments networks, citizens and their businesses to accelerate innovation and enhance the quality of services. Thus, the living labs concept came up as an influential view of the possibility of organizing user-driven open innovation ecosystems. It also represents open business form of partnership between citizens, enterprises and local governments. The living lab concept is also referred to as a means of shaping innovation programs and projects and conducting innovation experiments. (Saqib *et al.*, 2018a; Schaffers, 2011).

Nowadays with the rapid growth of digital world, Business Intelligence (BI) has become the essence in most developed organizations. Many people think that BI term was found in the 21st century due the current technological growth, whereas Business Intelligence was found in 1890s. However, the term was developed over years along with the information age and technological advancement.

Defining Business Intelligence has become challenging as it is considered to be an umbrella that covers several topics. According to Zamani *et al.* (2017) Business Intelligence can be defined as the combination of processes and different technologies being used for intelligence data processing; gathering, storing and analyzing data into a format that helps users mostly decision makers to take proper decision based on obtained results. It also was defined as a computer-based system that integrates database, architectures, various tools, processes, best practices and application for analytical purpose that support decision making within the organization. (Ali *et al.*, 2017; Saqib *et al.*, 2018b)

Business intelligence is being used in almost every sector; health, government military and others. The architecture of Business Intelligence consists of five stages as shown in figure 1. First stage is gathering raw data from various sources. Secondly, data will be under extraction, transfer and loading process (ETL). ETL application will quote data from diversity of sources, arrange and purify them into meaningful context. The third stage is storing arranged, structured and integrated data in Data warehousing (DW). Next stage the data are being analyzed by using different analysis engine such as; online analytical process (OLAP), Data mining engine and machine learning. Such analysis engine provides quick data analysis and access. Final stage, the data is being available and visualize for end user in reports and other format. (Hani *et al.*, 2016).

According to Jennex (2017), the main function of Business Intelligence is to transform data into information, information into knowledge, and eventually into intelligence. Data can be defined as; raw and unprocessed facts, information are processed or meaning full data. Then, knowledge is sensible information that containing some meanings and being understood. Whereas, intelligence is a collection of integrated and analyzed business information that support decision making.

From the concept of Business Intelligence Tools and Technologies, Business Analytics (BA) was derived. Some researchers claim that there is a significant difference between BI and BA but this is challenging as business analytics is considered to fall under the umbrella of business intelligence (BI). According to [Lim et al. \(2013\)](#) Business analytics can be defined as a subset of BI that deals with statistical and operational analysis of data for the purpose of preparing predictive model. The main difference between BI and BA is that BA is used for predicting future decisions while BI is more about improving current activities.

From this view an advanced technology has been developed which is Business Intelligence and Analytics (BI&A). According to [Dupin-Bryant and Olsen \(2014\)](#) BIA refers to the development of best practices, technologies, methodologies and applications in order to critically analyze business data in manner that helps organization in understanding its business and market hence make better decision.

Figure-BI Scope (Anony, 2018)



BI&A support advanced analysis as it provides solution and improvement for the current statues as well as providing forecasting for future improvement. It enhances and improving business operation, efficiency, products and customer relationships. BI&A analytical tools can be classified into three broad topics; Big Data Analytics, Text Analytics and Network Analytics. Big Data analytics functions based on advanced technology such as; Hadoop which supports the presentation of graphs, relationships, information flows, customer and products patterns. Secondly, text analytics which support Information Retrieval Systems (IR), Advanced QA Systems and other advanced technologies to enhance search logs analytics. Lastly, Network Analytics which supports records integration. Such integration will enhance business performance for example; it helps in discovering new insight about customers, competitors then leveraging finding to improve or develop services or products. ([Lim et al., 2013](#))

Nowadays most of companies are moving into implementing Business Intelligence and Analytics due to its importance in improving business performance and productivity. Yet some companies find difficulties due to the lack of understanding their business requirements. ([Hani et al., 2016](#))

According to [Malladi \(2013\)](#) the benefits of BI&A is derived from the benefits of both BI and BA. First of all, BI&A supports real-time performance management which helps to manage huge amount of data, analyze it and present it in several templates which enhances business collaboration. In addition to that, BI&A facilitates decision making by analyzing large amount of data. It also supports accurate and high speed reporting. Moreover, BI&A gives comprehensive details about customer behaviors through analyzing sales figures, feedback and others in order to improve business. It also helps the organization to identify new opportunities by analyzing past and current data and drawing perception.

Apart from adopting BI&A in organizations, nowadays most governments are turning to smart cities. What about adopting BIA in smart cities? This can be called as setting smart into smart. The government is full of requirement that should be fulfilled. This cannot be possible with the traditional technology. Business Intelligence and Analytics tools can support such development and support enormous benefits to smart cities. First of all, BI&A helps government to ensure control over all processes and make them integrated. It also helps in making informed decision and solutions by having integrated records that helps in sharing results. Moreover, make data visualized in advanced dashboards, maps and other technology which will lead to advanced KPI. By implementing BI&A the used visibility of real-time data, structures, information publishing and other activities will build trust and transparency among public. In addition to that the reuse of data and transparency will enhance innovations by citizens. ([Selvakanmani, 2015](#)).

Smart city concept is quite new as it was first emerged since the past two decades; however, it has been rapidly spreading worldwide in the recent few years. Smart cities are now widely spread all over the world; cities are transforming into smarter urban areas where they use high technology to deal with essential issues related to urban

life like traffic, pollution, poverty. Moreover, there is a lack of studies that have discussed thoroughly the real meaning of smart cities and their connection to technology components and strategic economy. Here it comes the importance of highlighting the significant concept of smart cities and their relation and implications to big data and business intelligence through a technology orientation manner.

There are fewer studies that are made to emphasize on the importance of smart cities and none of them focused on the relation between them, big data and business intelligence. This paper examines the technology oriented side of smart cities by linking the effect of big data on both smart cities and its impact on business intelligence.

1.1. Relationship Between Big Data and Smart Cities

In this digital world, where huge amounts of digital information are generated daily, researchers and governments are trying to get benefited from this information in a way which improves human life – style and reduce the effect of different issues faced.

Internet to things (IoT) is one of the emerging concepts which illustrate that “network of physical objects or (things) supported with sensors, software and network connectivity to allow these things (objects) to gather and exchange data (Sinha *et al.*, 2013). So, in (IoT) world each object will be connected to a network, controlled remotely, sending and receiving data resulting in more efficiency, accuracy and achieving more economic benefits.

Smart city is one of the (IoT) applications, its definition varies from country to country and from city to city but simply it can be identified as a developed urban area which is digitalized and created in order to solve different problems of continuous urbanization and to improve citizens’ life.

As it was mentioned before and since big data concerns about collecting information from different sources, smart cities will be meeting this requirement by generating digital data from networks, devices, cars and sensors embedded to smart building and exchange it through the Internet. Also, smart cities need the ability of big data analytics in understanding, predicting and creating patterns for different aspects. The following points illustrate how BDA can help researchers to design smart cities in the following areas:

Transportation Management: As we are seeing rapid increase in world population and urbanization, it becomes necessary to apply advanced technologies to reduce traffic congestion with the help of BDA to achieve the following:

- Monitor traffic performance and understanding its patterns over time.
- Improving road maintenance by analyzing data generated from sensors and video cameras on the roads.
- Decrease accidents by analyzing data generated from smart cars & transportation on the roads which identifies the traffic situation and inform others about the best route to avoid accidents.
- Smart Governance: the analytics of big data sets plays an important role in making governments smarter by helping them establish wise and satisfactory policies to be implemented in different sectors. Furthermore, it will help in reducing the number of people searching for jobs by analyzing data of different educational institutes (Hashem *et al.*, 2016).
- Smart grid: which is considered as one of the most important aspects will be improved by applying BDA. Using smart meters and readers will facilitate managing power supply, estimating the future needs and detecting any energy theft by monitoring consumption patterns to know if anything went wrong. Also, it can be used to manage the smart lights which will be switched on when someone enters the home and it will be switched off when he went outside by the help of the embedded sensors (Susmitha and Jayaprada, 2017).
- Biomedical industry: big data captured from different sources in hospitals and healthcare sector such as magnetic resonance imaging, echocardiography and others could be analyzed to understand individuals’ health situation, disease etiology and genetic variation. This will help patients to have more beneficial control on them and expenses in healthcare sector will be reduced.

1.2. Importance of Big Data Analytics

Big data has no value unless they are effectively processed and analyzed to gain useful information. Different communities from health and governments to e-commerce and sports organization are analyzing big data which are generated from web, social media, mobiles and sensors-enabled machines in order to gain complete understanding about their services provided, products, competitors, customers behavior and activities. This will result in increasing sales, improving work efficiency, offer better customer service and lower costs.

Big data analytics have had important impact on various aspects and fields. The following are some examples on Big Data Applications:

- Social media platforms analyze their contents to understand customers’ behavior and their ideas and thoughts about specific products or services.
- Information technology logs contents in IT departments are analyzed to enhance IT troubleshooting and security breach detection, so employees can understand which problems occur often and their solutions without spending long time and wasting effort (Why Is BIG Data Important? A Navint Partners White Paper 2012).
- Analyzing data generated from smartphones and GPS applications to allow the advertisers target new customers when they are close to a restaurant or store. This will help them to increase revenues and gain better reputation.

- In the field of history and geography, historical information is analyzed to map different patterns to understand climate changes may occur, predict them before and extract actionable insights and solutions to reduce their serious effects on humanity.

1.3. Business Intelligence and Analytics

The rapid development of business intelligence and analytics has attracted researchers' attention. The reason organizations are no more depending on traditional technologies as the data is growing enormously. This massive amount of data requires advanced analytical techniques in order to turn it into valuable information that helps organizational growth. BI&A is the contemporary methodology to extract the value from this enormous amount of data, drives strategic decision making, predict future and leverage opportunities.

Implementing BI&A has become essential in most organizations. BI&A has proven effective support in decision making. In addition to that data and IT infrastructure is obviously influenced by the good usage of BI&A practices. Nowadays Business Intelligence and Analytics has taken a vital part in most organizations and sectors due to its value and benefits. BI&A helps the organizations to gain better vision to its own data hence improves fact-based decision making. Also such methodologies and data analysis helps to maintain competitive advantage as well as resolving technical and quality issues which will enhance the performance and productivity of organizations. (Lautenbach *et al.*, 2017). According to Abai *et al.* (2015) BI&A also helps in building an integrated framework which will support in accelerating organizational performance.

Several factors and technological advancements have shaped the past and present of BI&A directions. With the rapid development of technology, the use of traditional analytical techniques isn't sufficient. The future direction of business intelligence and analytics will expand to cover diversity fields. According to Chen *et al.* (2012) the success opportunities associated with data analysis techniques has generated future interest in Business Intelligence and Analytics. In addition to that BI&A contains various practices and methodologies that can be applicable to various sectors; healthcare, security, market intelligence, e-government and others. According to Mohammed and Westbury (2015) BI&A is contributing to the future development systems. By mapping all facts, BI&A in the near future is becoming a vital technology in developing cities by supporting real-time information which will turn countries into smart cities.

1.4. Implications & Future Research Direction

This study focuses on the importance of smart cities as technology oriented and relates that to the role and contribution of big data and business intelligence but it does not consider other strategic orientations. Future studies will apply to consider strategic- orientations such as economy orientation or tourism orientation. Also, the effect of the three components of technology orientation needs to be further examined on different stages of innovation.

The study also does not discuss how the technological innovation is carried out when establishing a smart city. Further research in this case may emphasize more on the making process at the technical level and all the relevant implications.

As it was mentioned before, Big Data is one of the emerging technologies in IT field which affects different communities nowadays. This effect will increase in the next years and the following are some predictions:

- Around 70% of big organizations purchased external data from other organizations in order to analyze them and get benefited. This number will increase to reach around 100% of big organizations that will do the same in 2019.
- The number of Decision Management Platforms will increase at a CAGR 60% after the next year because companies trends toward consistency decision making are increasing (Mukherjee and Shaw, 2016) .
- The analytics of rich data such as images, audio and video will be increasing 3 times more and they will become as the key driver for Big Data Analytics investment.

Machine learning tools which are used for data processing can be improved to overcome their limitations and make them more intelligent and able to handle inconsistency and uncertainty of data (Acharjya and Kauser, 2016).

2. Conclusion

As the world is moving towards urbanization, the competition is growing as well and Technology is playing the winning role. The paper concludes that a smart city depends absolutely on the use of emerging technologies in urban areas and it is must relating them to green environment and well-being of citizens. Smart cities concept is created to make life easier and faster in a contemporary world that rely on high-tech services and products. Several definitions of smart cities concept depending on the quality and quantity of research done on that subject; most of them are correct; however, further research needs to be accomplished to get a more comprehensive and common idea that focuses on detailed sides and implications of smart cities. Regarding the boundaries, scope and development of smart city, it is must to have an evaluation tool of smart city, that can be used to assess the effectiveness of public policies as well as private initiatives regarding the same.

Finally, by linking all applications; e-government, healthcare, military, security and others, and by highlighting the importance of BI&A practices, it is expected that BI&A will have an effective contribution to turn cities and countries into smart.

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