# Chapter 4
# Big Data Analytics as an Enabler in Smart Governance for the Future Smart Cities

**Parag Kulkarni and K. B. Akhilesh**

**Abstract** Smart city is a buzzword in many discussions and debates and is being seen as a model for the development of future cities and a way forward for urbanization. To find the dimensions on which the performance of the smart city is assessed, various well-accepted models were identified. Smart governance being one of the dimensions, its various aspects as to how smart governance can translate to good governance is analyzed. The power of big data analytics is being leveraged by the businesses and corporates to improve their decision making by gaining insights on their business problems along with improving efficiency and delivering customer satisfaction. As the big data analytics is showing promise with its present applications, it is acting as a motivation to diversify the domains in which it can be applied. Smart Governance is required for creating successful smart cities, and big data analytics can play a major role in solving diverse day-to-day problems that a modern urban city faces.

## 4.1 Introduction

The use of word 'smart' before any entity makes a person pause and give a thought, as to why this word is being prefixed with the existing nomenclature of the entity. What are the new additions to the already existing features of that entity which are being upgraded that entitles it to be prefixed with the word 'smart.' These days we read or hear many entities prefixed 'smart' such as smartphones, smart cities, smartwatch and smart homes. The further discussion will be focused on smart cities.

Cities being economic and social centers contribute to 70% of global gross domestic product. From time and again these cities have to face many challenges due to rapid urbanization, environmental issues, along with ever increasing demand on the

P. Kulkarni (✉)
KPMG India, Gurgaon, India
e-mail: parag2803@gmail.com

K. B. Akhilesh
Department of Management Studies, Indian Institute of Science, Bengaluru, India
e-mail: kba@iisc.ac.in

existing infrastructure due to the ever-growing population migrating and living in these cities. Thus, these cities have to evolve to meet these growing demands.

The development of a smart city highlights the modification and enhancement of the existing as well as newly laid systems with the use of various technologies to manage assets and resources of the cities efficiently. Towards the end of the twentieth century, the word 'smart city' was coined, since then its meaning has been expanded to signify development of cities and their future.

### 4.1.1   Need for Smart Cities in India

According to the predictions, by the year 2030 India will be the most populous country in the world. The latest phase of demographic change is witnessing a rapid shift towards the urban areas, especially to big cities.

The government estimates say that in search of better lifestyle and better livelihood, every minute, 25–30 people are migrating from the rural areas towards the major Indian cities. If migration continues at this pace, by the year 2050 Indian cities will be a home to nearly 80 crore people, which makes 70% of the country's total population.

As cities are considered to be the growth engines of the economy, such huge population in the cities would be the biggest market in the world and potentially be the source of 80% of the economic growth of the country. But on the other hand, such a huge population in the cities will also be requiring accommodation, jobs, water supply and other civic amenities, faster communication means, speedy and hassle-free transportation system and clean uninterrupted power.

## 4.2   Smart City and Smart Governance

A global trend of leveraging innovation and high technology for solving difficult problems which are generated due to high population density, smart cities are helping in solving diversified urbanization issues by building better transportation systems and endorsing creative innovation. So in a nutshell, smart cities make use of sensor-enabled data collection systems to accumulate and process the data collected to manage the assets and resources efficiently. This data is collected from the citizens, public assets and various devices so as to keep a track on the traffic and transportation systems, water supply networks, waste management systems, public and community services, law enforcement, etc.

## 4.2.1  Major Components and the Key Stakeholders of Smart Cities

People, government, industry and university are the main stakeholders involved in the smart city creation. Natural environment, built environment, mobility, government, economy, services and community are the major components of smart cities (Exploratory Research on Smart Cities-Theory, Policy and Practice 2015).

## 4.2.2  Models for Assessing the Performance of Smart Cities

The two frameworks which use the six-dimensional model for ranking the smart cities are mentioned below; these models are also called hexagonal models for the reason of using six dimensions for assessing the performance of the smart cities. The relationship between the dimensions associated with smart cities, indicators of the dimensions and assessing and ranking smart cities based on these models will be clarified by understanding these models and will help in enhancing our knowledge for the same.

Giffinger's model: This model proposed smart people, smart governance, smart mobility, smart environment and smart living as the six dimensions of a smart city (Fig. 4.1).

The study is accredited to be the first attempt towards understanding the smartness of a city. This study adopted a systematic methodology to identify the key factors and derive indicators for each factor. The study proposed 31 major factors and 75 indicators. It also suggested that in the cases where the data is available these factors can be derived further establishing the framework as a robust model (Fig. 4.2).

These dimensions, factors and indicators will be a valuable resource for understanding the process of smart city development.



**Fig. 4.1**  Six-dimensional model. *Source* Exploratory research on smart cities (2015)

| SMART ECONOMY | SMART PEOPLE |
|---|---|
| (Competitiveness) | (Social and Human Capital) |
| Innovative spirit | Level of qualification |
| Entrepreneurship | Affinity to life long learning |
| Economic image & trademarks | Social and ethnic plurality |
| Productivity | Flexibility |
| Flexibility of labour market | Creativity |
| International embeddedness | Cosmopolitanism/Openmindedness |
| Ability to transform | Participation in public life |
| **SMART GOVERNANCE** | **SMART MOBILITY** |
| (Participation) | (Transport and ICT) |
| Participation in decision-making | Local accessibility |
| Public and social services | (Inter-)national accessibility |
| Transparent governance | Availability of ICT-infrastructure |
| Political strategies & perspectives | Sustainable, innovative and safe transport systems |
| **SMART ENVIRONMENT** | **SMART LIVING** |
| (Natural resources) | (Quality of life) |
| Attractivity of natural conditions | Cultural facilities |
| Pollution | Health conditions |
| Environmental protection | Individual safety |
| Sustainable resource management | Housing quality |
| | Education facilities |
| | Touristic attractivity |
| | Social cohesion |

**Fig. 4.2** Characteristics and factors of six-dimensional model. *Source* Exploratory research on smart cities (2015)

Limitations of this model: Nearly 35% of the identified indicators were at national level.

Also further scope of improvement of this model includes introducing the time series data analysis for indicating the progress of the smart city in each of the indicators.

Boyd Cohen's 'Smart Cities Wheel': Similar to the above model, this model also identifies six dimensions but the number of factors and their type for each of the dimension are limited to three and are different.
Objectives of this model:

- Supporting the development of holistic smart city strategies
- Developing baselines
- Transparently tracking their progress

This model had been used for ranking top 10 North American smart cities, smart cities in Asia Pacific region, smart cities in Latin America and European region (Fig. 4.3).

So, taking the reference from these two models, out of the six dimensions identified by the models for gauging the performance of the smart cities, we will keep our focus on the 'Smart Governance' dimension of the smart city and will discuss the enablers of this dimension in detail in the subsequent sections.
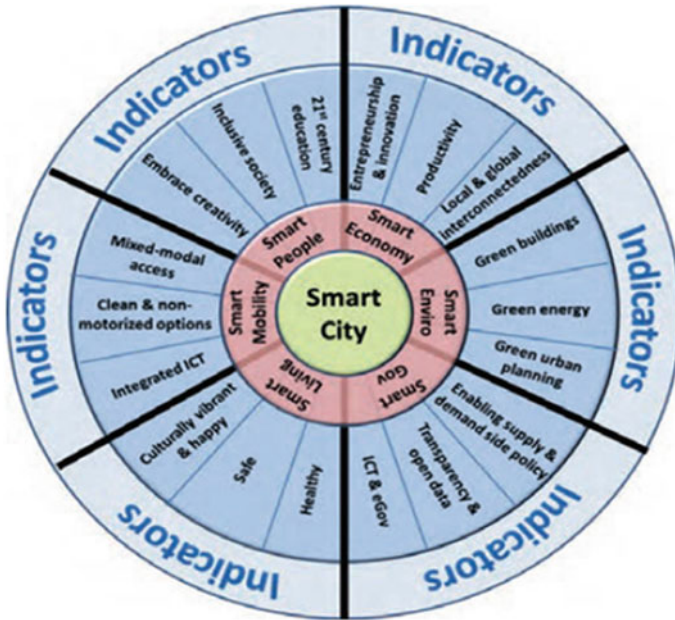
**Fig. 4.3** Boyd Cohen's 'smart cities wheel'. *Source* Exploratory research on smart cities (2015)

### 4.2.3 Smart Governance for Smart Cities

Smart and good governance go hand in hand. Progressive government-public partnership is created using the digital technology and the Internet, which is strengthening the government institutions and is helping in integrating all sections of the society.

Modern lifestyle has become unimaginable without the digital technology and the Internet. Nearly all the segment of the society is dependent on it, whether it is transportation, education, telecommunications, security and health care.

A smart administration and governance are required for the effective management of the sections of the society. The leaders, bureaucrats and the government officials require smart tools and systems for effective coordination and management of different departments, sectors, agencies in order to ensure the efficient implementation of the new developmental and welfare schemes, have an access to real-time data and also the sharing of information.

As the emerging and existing urban areas are developing on the basis of smart city model, the governments are trying to incorporate e-governance for strengthening of the democracy, public welfare and maximizing citizen participation in the decision making.

### *4.2.4   Smart Governance-Models*

- **Government to Citizen Model (G2C)**: Government and citizens directly connect under this approach by the means of different communication channels like the radios, newspaper, Apps, blogs, Web portals, forums, etc. with an aim of reaching out to the citizens and allowing themselves to raise the issues faced by them, getting to know issues, problems, complaints, and their advice and applying them. Singapore, European Nations and the USA are the leading examples
- **Government to Business Model (G2B)**: Entrepreneurs play a vital role in taking the economy of a region ahead, this model aims at removing the bottlenecks faced by the entrepreneurs, traders and startups and reduce the 'red tapism.' It aims for the direct interaction between the government and the businesses. For expanding and improving business, companies can get knowledge about latest credit facilities, policies, taxes, regulations and schemes. This encourages business transactions to be online-saving cost, time and providing the real-time data for forecasting and planning the economy
- **Government to Government (G2G)**: Aiming at direct interactions between different government organizations to create more accountability and transparency, it integrates all the channels of governance. ICT will help in reducing corruption and clutter by making the processes more transparent, which will also increase efficiency and accountability by setting a two-way communication channel between citizens and the officials
- **Government to Employee (G2E)**: Creating interaction channels between companies, government and employees such as online softwares and tools. Many tasks related to employees can be enabled by the maintenance of their personal account consisting of bank account, personal information and social security number (Smart City 2017).

## 4.3   Big Data Analytics for Smart Governance in a Smart City

We often come across the term 'Big data Analytics' these days; let us explore what does this term really mean. It refers to the large volumes of datasets which are processed and analyzed to explore some trends and patterns. The data that is available these days is because of the multitude of ways in which it is being generated, stored, linked and analyzed. Previously, the notion of data was about the data which was held in closed government and company database which is termed as structured data because of the way it is captured and tracked with the help of forms, e-mail or the CRM system. This kind of data was easily manageable and recognizable.

Big Data: 'Big data is high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making' (Gandomi and Haider 2015).

According to the Gartner's 3V model, the big data is high in the following 3V's:

Volume: The volume of data that the organizations can handle these days progresses from megabytes to terabytes to even petabytes.
Velocity: Speed at which data is being handled, the speed has evolved from the data being processed in batches to be handled and processed in real time.
Variety: The data has moved from being in the structured to unstructured form; it has moved from being in tabular format to being in the form of mobile, social, photo, etc (Computer Business Review 2017).

Now, the data is generated in multiple number of ways, i.e., through social media, smartphone applications and also through the search engines. As this kind of data is not organized in any defined manner, it is called unstructured data. But this data is highly rich pool of the information and can be called as the ocean of information diving into which pearls of insights can be obtained.

### 4.3.1  Big Data Analytics

'Big Data Analytics is the use of advanced analytics techniques against very large, diverse data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes from terabytes to zettabytes' (Ibm.com 2017).

Using advanced analytics techniques, new insights can be gained by analyzing the data and better decisions can be made. Machine learning, text analytics, predictive analytics, data mining and natural language processing are few of them.

### 4.3.2  Sources of Big Data in Smart Cities

We will discuss some of the sources from which data is generated in the cities. The data generated can be broadly classified into two categories:

- **Directed and volunteered data**: The notion of 'everyware' corresponds to the devices that are used in the very construct of the urban environment which are pervasive, ubiquitous and digitally instrumented (Kitchin 2014). Data coming from sensors and networks of the camera, transportation infrastructure and also the utility services which are controlled digitally, fixed and wireless telecom networks, location and activity data produced by active navigation of the citizens by the virtue of their smartphones can also be put in this category.
- **Automated forms of data generation**: surveillance, tracking and tracing of the people and objects, Internet of things (IoT) generate this kind of data. The constellation of instruments which are connected by the virtue of multiple networks providing continuous data related to the movements of people and material, e.g., smart cards, automatic number plates (ANPR), RFID chips attached to garbage bins, automatic meter reading (AMR) communicates the utility usage.

This data helps in improving the delivery and performance of public services and supporting public participation, making the city more controllable and knowable, interconnected and fine-grained (Kitchin 2014).

Abundant data is gathered by the sensors which are very small, cheap and easily embeddable in different structures to provide variety of data such as humidity, gas, acoustics, air pressures, movement speed, temperatures and light intensity. This data can either be broadcasted at regular intervals (active sensors) or be collected as and when read by scanners (passive sensors).

### 4.3.3  How Big Data Analytics Enables Smart Governance

Different government agencies have very large volumes of data and especially in India, the possibility of these agencies working together for decision making using collective information is curbed by the fact that there is very little or no dialogue happening between these departments as they essentially work in silos. It is left to one's imagination as to what insights can be derived from the common data warehousing and collective knowledge sharing between various departments. The outcome that it could generate will be more than the sum of its parts.

Looking into the typical problems that a city government faces would make us ponder over certain questions as to how the toughest of these problems are tackled by analytics along with its arsenal of tools.

The current problems and few ways in which analytics can be used by the governments to serve the people better:

- Reducing and eliminating financial leakages from the public welfare schemes;
- Identifying the most crime-prone areas in the city;
- Eliminating the fraud and waste in government agencies;
- Dealing with disaster response by the use of predictive analytics;
- Data-driven amendments to the policies and laws;
- Improving emergency services like 108 by the use of predictive analytics;
- Resource allocation to the various departments, as in allocation of monetary, human and other resources.

The rapidly evolving field of big data analytics when explored and applied is offering significant insights to uncover deeper insights. The application of the big data analytics is being proliferated from the private organizations and is becoming an integral part of the critical decision making these days.

Huge amounts of data from various sources such as transactions, manufacturing, employment and agriculture are being generated by the public sector, thus application of big data analytics can significantly aid the government in achieving efficiencies, bringing transparency, combating fraud, and fostering economy and spiking the productivity and growth. These applications can help government in responding more accurately and quickly to the citizen's need in collaboration with the private organizations.

Taking the example in the Indian context, the Indian government has formed an open data platform to offer public data to be used by the analysts, practitioners and researchers. The Indian government in the past three years has started leveraging the power of big data analytics by the virtue of various initiatives such as digital India, use of Aadhaar and MyGov to form a citizen-centric platform, helping the citizens to connect with the government directly and contribute towards good governance. Customizing social benefits and offering subsidies to each and every citizen of the country is what the government aims at by using data generated by some of these initiatives.

Some examples of potential benefits of the governments collecting and generating vast amount of data from their everyday activities such as tax collection and health systems are as follows:

- Sentiment analysis of the citizens: Citizen's interest and opinions can be prioritized by the policymakers with the help of both traditional and new type of data coming from social media such as blog posts, Twitter feeds and Web sites.
- Segmentation of the citizens, personalization along with preserving the privacy: Citizen satisfaction, efficiency and effectiveness can be increased by tailoring government services to the individuals.
- Economic analysis: More accurate financial forecasts can be made with the help of correlation of the multiple sources of data.
- Tax departments: These agencies will be benefitted with the automated algorithms available for the analysis of large datasets along with integration of the social media data, helping them to validate the information and prevent frauds.
- Internet of things (IoT) applications for a smart city: Location of municipal vehicles, usage levels of waste containers, traffic volumes, environmental pollution and detection of abnormal behavior are being increasingly used by the public sector for resource management. Sensors measure these physical phenomena for various applications, among which management of the resources optimally is the primal. Safety of the citizens can be positively impacted by the integrated analysis of these high 3V's IoT data along with significantly improving urban management.

The three broad application areas of the big data analytics in governance:

- **Service Delivery**: It can be used by governments to improve existing services and to draw on novel datasets to drive entirely new public services.
- **Policy Making**: Policymakers are using satellite imagery, cell phone data and more, to produce alternative economic indicators for new—and real-time—policy insights.
- **Citizen Engagement**: By applying machine learning to online and social media, governments can be more responsive to citizen sentiment, ushering in a new dimension of civic engagement (Big Data in action for government 2017).

## 4.4   Use Cases of Big Data Analytics from Different Cities in the World

### 4.4.1   Owl Bus, Seoul, South Korea

The owl bus is the public bus service provided in the nighttime in Seoul, South Korea. This came into existence due to the necessity of the lower-income group workers who have to return from their work during nighttime (especially after midnight) to their homes, mostly in the outskirts of the city and their inability to spend on high fares charged by the taxis during night and cab driver's resistance to agree for such a long drive to the outskirts of the city at night. The owl bus used data from 3 billion call and text data points and 5 billion points from the corporate and private taxi data in order to design nighttime bus routes optimized to match the origin and destination points of the passengers (Sung 2015).

### 4.4.2   Centro De Operacoes Prefeitura Do Rio, Rio, Brazil

In Rio, Brazil, the data streams from multiple government agencies (30) are fed to the single analytics center, where it is visualized, analyzed and predictions are made for certain emergency situations such as floods, medical help and traffic decongestion. The data comes from various agencies ranging from municipality, utility, traffic, weather departments giving periodic weather feeds, news feeds, radio, Internet, public transport, etc. Sophisticated predictive models are built from the data coming from the varied sources and varied predictions in line with city development and safety are made based on the data.

### 4.4.3   Use Cases from the Indian Cities

#### 4.4.3.1   Ensuring Public Safety in Smart City by the Use of Big Data Analytics

Predictive policing with the help of The Crime Mapping, Analytics and Predictive System (CMAPS) in Delhi.

**Predictive Policing**: Use of data analytics technique to identify likely targets for crimes in a city which would require police intervention. It makes use of various statistical predictions. In a nutshell, it is the use of analytical, mathematical and predictive technique to identify potential criminal activity.

**How it works**: (1) it collects large amounts of data on past crime and co-relates them with present crimes. CMAPS is integrated with Delhi Police's new software, and it allows the information getting generated though emergency service Dial 100

to be plotted on geospatial map of the city. (2) Analyzing the Data: The CMAPS then looks for correlations and patterns of crime data of the past. (3) Predictive Maps: The powerful algorithm predicts the place and time (essentially where and when) a crime is most likely to happen in the future. (4) Increased surveillance: Thus based on the prediction of the possibility of the crime, police then redeploys or adds its resources during certain period to prevent crime.

Thus, it results in the maximum utilization of police resources which decreases the chances of crime.

### 4.4.3.2  Checking Unaccounted Water Supply Using Big Data Analytics

Collaboration of The Bangalore Water Supply and Sewerage Board (BWSSB) with IBM is ensuring that no water supplied by the public authority goes unaccounted. This is done with the help of big data analytics and predictive analytics techniques. Data from sensors installed on the pipeline network is analyzed by monitoring sudden changes in the flow of water, leakage points are predicted beforehand to ensure minimum wastage and increase accountability.

### 4.4.3.3  Smart Street Lights for Smart Cities: Ongoing Research in IISc Bangalore

Robert Bosch Centre for Cyber-Physical System, IISc, Bangalore is carrying numerous research works on the deployment of IoT-based solutions for smart cities. The one worth mentioning is smart street lights for smart cities. These street lights are sensor enabled with various kinds of sensors deployed on them, these street lights will optimize the light intensity according to the number of people passing or surrounding it, which will optimize energy utilization. Other than this, it will collect various other kinds of data such as temperature, humidity, light intensity and pollution levels for further analysis (Sharma 2017).

> *We are actively working on providing IoT based smart solutions in the 900 acre of the Electronic city, Bangalore. This industrial township has all the problems of a big modern urban city. We have developed sensor enabled smart street lights, these sensors collect various types of data such as temperature, humidity, light intensity, pollution levels* etc.*, this data collected will further be used to solve various problems-pollution control, easing traffic congestion to name a few.*
>
> Dr. Abhay Sharma, Member of technical staff, *Robert Bosch Centre for cyber physical systems, IISc, Bangalore*

## 4.5 Conclusion

We have looked into what are smart cities, the need of building them and formalized the dimensions on which their performance is being gauged. Further we looked onto the smart governance aspect of the smart city concept and exhaustively tried to see the aspects of smart governance, we started conceptually defining the smart governance, models for smart governance and discussed what constitutes it. Further, insights were gained about the term 'Big data,' constituents of big data and its characteristics. The sources from which different types of data is generated in the cities have also been looked at.

The amalgamation of the term big data analytics holds deep potential for solving the ever-growing and ever-demanding problems of a modern urban city. By the virtue of some use cases, we studied how big data analytics is solving various problems which are at the core of any city, be it related to urban transportation and mobility, security, water and utility supply or urban management as a whole.

The notion of smart city is just in an introductory phase in a developing country like India. There has been a fundamental shift in the governments and administrations approach in developing the modern urban areas or the future smart cities. With the help of some use cases from the Indian context such as CMAPS used by Delhi police for predictive policing or the Bangalore Water Supply and Sewerage Board (BWSSB) collaboration with IBM to leverage big data analytics as one-stop solution for solving urban issues shows that in India, we are now on a track of gleefully using the power of big data analytics in the context of smart governance.

Finally from the researchers and industry perspective, the development and deployment of IoT and analytics solutions for smart governance in the future cities are much appreciated, but with a slight concern regarding the researches being done in silos and lack of standardization in the technology that will be deployed in, particularly for smart cities.

## 4.6 Limitations and Further Research

The scope of the research can be improved by analyzing the views, concerns and aspirations of various stakeholders and sub-stakeholders of the different aspects discussed, possible solutions for which can be proposed. Further, the research can be expanded by exploring the other five dimensions responsible for the assessment of the performance of a smart city to get a holistic view of the relationship of big data analytics with these dimensions. Moreover, other enablers can be identified and further similar research can be done with respect to those enablers.

# References

Big Data in Action for Government. (2017). *Big data innovation in public services, policy and engagement.* World Bank Group. [online] Available at: http://documents.worldbank.org/curated/en/176511491287380986/pdf/114011-BRI-3-4-2017-11-49-44-WGSBigDataGovernmentFinal.pdf. Accessed November 8, 2017.

Big Data, Better Public Services. (2015). *PwC.* [online] Available at: https://www.pwc.co.uk/assets/pdf/big-data-better-public-services.pdf. Accessed November 15, 2017.

Computer Business Review. (2017). *What is big data and why is it important? Computer business review.* [online] Available at: https://www.cbronline.com/what-is/what-is-big-data-and-why-is-it-important-4172588/. Accessed November 22, 2017.

Exploratory Research on Smart Cities. (2015). *Theory, policy and practice. Peer experience and reflective learning.* [online] Available at: http://cidco-smartcity.niua.org/wp-content/uploads/2015/10/Exploratory_Research_on_Smart_Cities.pdf. Accessed November 4, 2017.

Gandomi, A., & Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics, *International Journal of Information Management, 35*(2), 137–144. Retrieved from https://doi.org/10.1016/j.ijinfomgt.2014.10.007.

Ibm.com. (2017). *Big data analytics|IBM analytics.* [online] Available at: https://www.ibm.com/analytics/hadoop/big-data-analytics. Accessed November 16, 2017.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal, 79*(1), 1–14. Retrieved from https://doi.org/10.1007/s10708-013-9516-8.

Sharma, A. (2017). *Role of IoT in smart cities.* Personal Interview.

Smart City. (2017). *Smart governance: A necessity for smart cities.* [online] Available at: http://www.smartcity.press/smart-governance-for-smart-cities/. Accessed November 18, 2017.

Sung, N. (2015). What does Big Data have to do with an owl? *Transport for Development.* [Blog] Available at: http://blogs.worldbank.org/transport/what-does-big-data-have-do-owl. Accessed November 9, 2017.