CHALLENGES IN IMPLEMENTATION OF BIG DATA IN CONSTRUCTION INDUSTRY

FINAL YEAR PROJECT UG2016

By

Sulaiman Javed (G.L) **(00000130771)**

Furqan Ali **(00000192902)**

Wajahat Ali Khan **(00000175787)**

Hamza Nadeem **(00000129038)**

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Sciences and Technology, Islamabad, Pakistan.

Year 2020

This is to certify that the

Final Year Project Titled

CHALLENGES IN IMPLEMENTATION OF BIG DATA IN CONSTRUCTION INDUSTRY

Submitted By

Sulaiman Javed (G.L)	**NUST-BECE-2016-130771**
Furqan Ali	**NUST-BECE-2016-192902**
Wajahat Ali Khan	**NUST-BECE-2016-175787**
Hamza Nadeem	**NUST-BECE-2016-129038**

has been accepted towards the requirements
for the undergraduate degree

in

CIVIL ENGINEERING

_____

Dr. Khurram Iqbal Ahmed Khan
Assistant Professor
School of Civil and Environmental Engineering
NUST Institute of Transportation
National University of Sciences and Technology, Islamabad, Pakistan

ABSTRACT

Construction industry has an important part to play in the development of a country. There has been a recent growth in this sector after government incentivizing the industry; however, due to the prevalent traditional practices projects often exceed the constraints. With increasing infrastructure development, there has been felt a need to employ Big Data management in the construction sector to manage the huge chunks of data being produced annually. Big Data, being a rising concern, is driving huge IT investments to manage and maintain it in different sectors like genomics, simulations, environmental research, urban informatics, business and e-science etc. A research was carried out to identify the basic challenges that pose in way of formulation of a Central Big Data Management System in Pakistan for construction sector, under government supervision. The challenges were ranked through a frequency analysis of the respondents, which included clients, consultants, contractors and academia personnel. The study highlights the importance of a central management system to increase productivity and efficiency, lower costs and risk involved and optimize the construction practices.

DEDICATION

We would like to dedicate our efforts and this report to all the construction workers of Pakistan, on whose 'shoulders' stand the nation. They are the ones who bring dreams into reality and to whom we owe the gratitude for taking on the harder and unacknowledged part of the job.

ACKNOWLEDGEMENT

We take this opportunity to evince our profound appreciation to our supervisor, Assistant Professor, Dr. Khurram Iqbal Ahmed Khan, for his conscientious guidance and encouragement. His comments reflected his experience as a researcher and as an engineer; his actions manifested his willingness to devote his time and energy to help us, by always being available despite his busy schedule.

We sincerely thank all the industry and academia personnel who became part of this research and helped up through it.

Last but not least, we would like to offer our greetings and blessings to our parents and friends who have provided countless moral support throughout the project.

LIST OF ACRONYMS

RFI	Request for Information
AI	Artificial Intelligence
GD	Generative Design
BIM	Building Information Modelling
RFID	Radio Frequency Identification
BDMS	Big Data Management System
SPSS	Statistical Product and Service Solutions (Software)

LIST OF FIGURES

LIST OF TABLES

Table of Contents

CHAPTER 1

INTRODUCTION

1.1.Introduction

Once considered an archaic industry, the construction world is going through a rapid shift. Numerous people and organizations are trying their best to make this one of the modern industries. Now, technology is pouring a change in order to increase productivity, enhance efficiency, decrease project's costs and managing wastes generated in construction projects. Enhancement of all of the work process, whether its start or end of the project, has been changing and evolving this industry.

The construction industry is one of those industries that concludes the largest and expensive projects. It takes up an enormous amount of resources which results an enormous amount of data. As technology keeps changing, the construction industries are generating more and more data than ever before through different techniques, using different devices and utilities. This huge amount of data with various formats is being generated and processed at a greater speed and is being stored. This data includes project documents, files and specifications, plans, RFIs, estimates, change orders, etc. This whole bulk of data is considered as Big Data.

We can start from the classic Wikipedia definition which states,

"Big Data is a collection of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications"

TechAmerica Foundation Big Data Commission [Mills 2012] gave this definition:

"Big Data is a term that describes large volumes of high velocity, complex and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information."

Now, Construction firms can convert these huge piles of data and information that have been generated, collected and stored over the years, with the help of smart techniques, artificial intelligence (AI) and machine learning systems, so that the future outcomes could be predicted and construction industries could gain a competitive advantages while design, estimating or developing future construction projects. Bernard Marr (AI and Big Data guru) points out that alone waste and remedial work account for 35% of all the expenses in construction industry. As Big Data helps in reducing project risks or costs, consequently, it can increase percentage of profits for construction companies.

There are four general areas in design and construction industry in which Big Data can significantly improve:

- Tracking and Management
- Budgeting
- Reducing risks
- Decision-making processes

In other countries, Big Data is already improvising abovementioned four areas. But the adoption of Big Data in Pakistan is still at emerging phase. The purpose of this research aims to discover why Pakistan's construction Industry is reluctant in implementing Big Data and what hindrances towards this technological advancement are.

1.2. Problem Statement

Construction projects are always information intensive and characterized by diverse and scattered information such as working drawings, cost analysis charts, measurement sheets, risk registers and progress reports etc. That data is collected by organization, prevalently on paper and once a construction project is finished, all the information is filed away.

But that has been changing in the course of recent years as construction industries are understanding the focal points and advantages of knowledge that large information and big data analysis can render.

Despite the widespread increase in digitization, we found a shear lack of research in this regard in Pakistan and policy making is almost none as far now. We must have the correct methods and software in place so that all the data being collected can be used effectively and efficiently because as construction projects are becoming more difficult, Big Data is high likely to become one of the most significant and essential things for construction industry. But there are a number of roadblocks which pose in the way of adoption of Big Data which needs to be identified and analyzed.

Moreover, there is a lack of Central Management system for the management of Big Data in the construction Industry which is major hindrance in improving efficiency in this sector which should be addressed as per policy making and its implementation.

Henceforth, the purpose of this project is to identify the probable barriers in implementing Big Data in construction industry of Pakistan which will help in the development of a framework for the adoption of Big Data.

1.3. Research Objectives

- To identify challenges in implementation of Big Data in Construction Industry
- Proposition of Solution to eradicate roadblocks in adoption of Big Data
- To develop a framework in the form of central Big Data Management System (BDMS)

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter gives us a comprehensive review of literature related to Big Data in the Construction Industry. It discusses the research carried out on implementation of Big Data in construction industry. In addition, it summarizes the former efforts to make Big Data Management System.

2.2. Construction Industry: Importance and Characteristics

Construction industry has an important part to play in development of economic and social aspects of a country. Sectors of construction industry involves any piece of infrastructure, development, construction and engineering works around us. The scope of construction industry is too extensive and further expanding. A slight upsurge in disbursements in the construction industry results in multiplier and the ability to produce earnings are five times more than cost of that investment. In an expanding economy of 10% growth rate, the housing sector has the potential to grow at 14%, which results in the creation of thousands and millions of new jobs, over the period of time (World Bank, 2008).

Pakistan's construction industry has remained an important driver in the socio-economic uplift of the economy. Economic Survey of Pakistan (2017) testified that contribution of Pakistan's construction industry was 2.74% in the country's GDP with a growth rate of 9.05%. Country's construction industry also facilitates 7.31% of labor force directly (Ministry of Finance, 2017), and overall, 30-35% of population depends upon construction industry (Farooqui & Ahmed, 2008). Construction industry's manifold backward and forward linkages with other industries pave the way for country's survival, development, and growth (Farooqui et al., 2008).

Pakistan's construction sector has a great potential role national growth, especially after the inception of China-Pakistan Economic Corridor (CPEC), which is expected to boost the construction industry. But construction industry remains neglected in Pakistan. The government bodies have failed to make policies and reforms to incorporate the modern practices in the construction industry. Pakistan Engineering Council (PEC) and the respective ministries have made some strides, but with ineffective implementation. Nevertheless, to satisfy the national needs, construction industry needs an efficient and proactive management of projects to increase the performance and hence the profitability.

2.3. Big Data Management

2.3.1. Data and Information

We use the terms data and information extensively, frequently in an interconnected perspective. In most cases, they indicate different levels of concept, understanding, or reliability. Data represents the instructions, details or concepts in a formal way appropriate for communication, processing, or interpretation by humans or machines. Whereas, Information is the use of computer sustained, interactive, and visual illustrations of nonconcrete data to increase and amplify thought, contains meaning, is created when data is interpreted and has both qualitative and quantitative aspects (Chen, et al., 2009).

Information contains meaning, implication, or input for decision and/or action. Information is thus the meaningful form of data, which is used in the understanding, learning and modifying of the user experience and practices (Liev, 2007).

2.3.2. Big Data

Big data is a term for immense data sets containing huge, much diverse and both multifaceted structured and unstructured data that is so huge that it is problematic to process and utilize that using customary catalogue and software methods and has the problems of storage, analyzing, evaluating and envisioning for more processes or results (Sagiroglu S. et al., 2013).

2.3.3. Big Data Analysis

The method to examine and research into data of enormous extent to disclose secret connections and unseen patterns is named as big data analytics. This valuable data helps industries in getting competitive advantage and the acquisition of deeper insights. That is why, Big Data applications require analysis and execution with highest degree of accuracy. (Sagiroglu S. et al., 2013).

Big data is useless in vacuum. Its importance is revealed while making decisions. To allow such evidence and research-based processes for making decisions, organizations need effective methods and processes to make data of high variety and fast-moving large volume into significant results.

The process for the extraction of results could be further distributed into 5 more processes (Labrinidis et al., 2012), shown in figure 1 below.

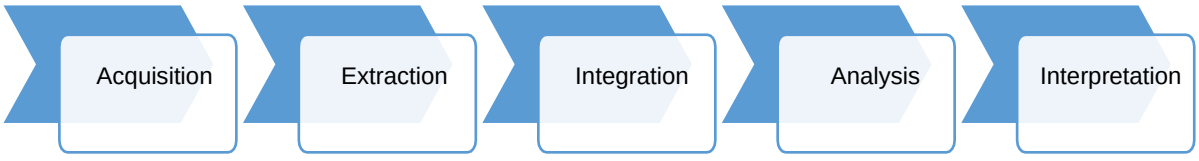

Figure 1: Processes for extraction of Results.

This five-stage process can be further divided into two key sub-processes: first one is Data Management, which includes Acquisition, Extraction and Integration while Analysis and Interpretation are included in Analytics. Data management incorporates different processes and subsidiary skills and the technologies helpful to obtain, store, organize and recover the data for examination and analysis. Analytics, on other side, tells about the methods used in analyzing and collect meaningful intellect from the big data. (Gandomi et al., 2015).

2.3.4. Attributes of Big Data

Most of the explanations of big data emphasize on the magnitude and extent of the stored data. Yet there are further essential attributes of the big data, known as variety and velocity. a. Furthermore, each of these three Vs has its own implications for analytics. (Kang, et al., 2017).

2.3.4.1. Volume

Data volume is the primary attribute of big data and it has been increasing exponentially. From Terabytes to Exabytes and Zettabytes of data is being generated by organizations or individuals. However, the big data can also be computed by counting records, transactions, or piles of files. The opportunity of big data affects its computation, too. Furthermore, each of these quantifications and computations of big data grows endlessly (Russom., 2011).

2.3.4.2. Variety

Big data is unusually diverse in terms of sources, types of data, and entities represented. Since Big Data is coming from a larger variety of sources, the diversity and heterogeneity of data sources and storage has increased in big data. Generally, Big Data has three types: structured, semi-structured and unstructured. Structured data is relatively easy to sort since it is already in a well form and coming from a specific source, but unstructured data is disorganized and very hard to analyze. Semi structured data does not follow to fixed fields but comprises of tags to separate and sort out data elements (Kang, et al., 2017).

2.3.4.3. Velocity

Velocity of the big data is the speed at which the data is being produced from numerous sources and is being stored into storage. Furthermore, data variety and data volume help each other for big data analysis. For numerous implementations, the velocity of creating and sorting data is even more vital than the data volume.

Real-time information makes it possible for an industry or company to be much faster and easier to use than its competitors do (McAfee & Brynjolfsson, 2012).

Table 1: Attributes of Big Data

VOLUME	**VARIETY**	**VELOCITY**
Zetta-bytes	Structured	Speed
Files	Semi structured	Near time
Records	Unstructured	Real time
Transactions	Varied	Streams

2.3.5. Big Data Implementation

Big data is unbearable to process using customary methods and management systems. New ground-breaking methods and technologies were required instead of traditional technologies and Google found the way out for this by using a processing model known as Map Reduce. There are also other ways to process and use Big Data, but the most used method is the Hadoop, which is based on Google's Map Reduce method and Google File System. Hadoop is a distributed batch processing infrastructure which consists of the Hadoop kernel, Hadoop Distributed File System (HDFS), Map Reduce and several related projects. The great benefits of using Hadoop, and specially Hadoop Distributed File System, are the consistency presented by reproducing all data on various Data Nodes and other methods of avoiding failure (Garlasu D., 2013).

2.4. Big Data in Construction Industry

Taking a clue from other industries, big data is believed to make a headway and to spark researcher's interest to promulgate big data from the lens of construction industry. Despite, research of big data from the lens of construction industry is limited in contrast to other industries (Bilal et al., 2016), leading big data research in this industry are rather technical (Barista, 2014; Chen, et al., 2017; Olsson et al., 2015).

Organizations are leveraging big data to lead their market. With big data, industries increase understandings and increase efficiency, and reduces cost and risks (McAfee and Brynjolfsson, 2012). Big data provides higher profitability of 5-6% to organizations (McAfee & Brynjolfsson, 2012). Also, the Centre of Economics and Business Research (CEBR, 2012) published an expected revenue of £24 billion through big data to the UK economy. This proposes a connected influence of the big data and its implementation across different industries (Chen, Mao, & Liu, 2014).

From construction industry's point of view, big data altered and remodeled the customary design delivery towards the data driven design (Barista, 2014). While retail industry is using Big Data for product offering innovation, the construction industry applies big data for the optimization of building models. Furthermore, construction planning process optimization through algorithmic analysis of external and internal data can be done because project activities' durations and working schedule can be determined at conceptual stage. Big data empowers architects to understand how end-users utilize building spaces. Thus, designers have the flexibility to produce such designs which are tailored to usage pattern and the user preference. (Maaz Z., et al., 2018).

As far as now, research on big data's usage in construction industry is narrow but supposed to have extraordinary influence in changing and improving industry's overall productivity, efficiency and enhancing the performance. The constructed domain of environment is a data intensive and demanding industry (Deutsch, 2015).

Furthermore, big data can transmute and alter waste management process and methods in the construction industry. Through incorporation of construction and waste data Big Data also improves the waste management process.

Construction firms can have better construction waste management by further strategizing of waste reduction during the reconstruction phase. (Chen, Lu, & Liao, 2017; Lu, Chen, Ho, & Wang, 2016; Lu, Chen, Peng, & Shen, 2015). This shows that big data is being utilized by construction industry to change the way of do things (Wamba F., et al., 2015).

2.5. Big Data for Construction Management System

The Construction Industry generates huge amounts of information. But, due to lack of proper storage and analytics in the construction information, the Civil engineering people are not using the past data. Still, most of the civil engineering people are using computers only designing the structures and for graphical illustrations of the designs. Civil Engineers are not aware of the trends in the storage and processing of data. Here, we addressed how do we store the huge amounts of data and how those data can be processed with the commodity hardware. Design of Civil Construction is not different from the construction of any software. As the software has different phases / levels, the construction industry also requires initial information gathering, followed by planning and then designing before actual implementation and then goes to the next stage of implementation. (Kang Y., et al., 2017).

In design of Construction Management System, the various people involved in the process were given access as per their access levels. The Management is responsible for managing the resources like task management, scheduling, budgeting, raw materials, crew(staff), inventory etc. In big data analytics, the large amounts of data gathered from various resources will be stored in the HDFS (Hadoop Distributed File System) and then for better results the data is processed through Map Reduce. The construction management will store the data produced from the project construction and will be stored for the future projects. Without the use of computers, the data may be lost or the person handing the management tasks may not carry the past data to the present. But, with the use of computers in the construction management, every piece of information generated will be pushed on to the database and will be accessed in future for further processing to yield better results (Kang Y. et al., 2017).

2.6. Opportunities of Big Data in Construction

There are a lot of opportunities available for the construction industry and in near future it will continuously provide advantages for the sector. In many enterprises, built up contenders and new participants the same will use information driven techniques to develop, contend, and catch an incentive from profound and up to constant data (James M, Michael C, 2011).

2.6.1. Resource and Waste Optimization

Overall quick increment in urbanization has expanded development and construction exercises. Subsequently, development industry is expending majority of regular assets and creating gigantic development and demolition (C&D). M. Osmani, J. Glass, A.D. Price (2006). Waste Intelligence (WI) is the base of existing waste administration approaches which medicinal measures to oversee waste simply after it occurs. (Z. Wu, et al., 2014). In any case, an information driven basic leadership at configuration stage can fundamentally lessen construction waste (W. Lu, et al. 2011).

Waste Analytics incorporates the examinations of huge arrangements of information to find the connections identified with structure, acquirement, material and store network, which could prompt waste during construction stage. WA relies upon superior calculation and information stockpiling on huge scale. It requires assorted information of building structures; material properties and development intend to complete the procedure. Presently it needs enormous information applications for powerful waste management (Bilal M., et al., 2016).

2.6.2. Generative Design

The idea is to generate automatic designs based on specified requirements and design objectives also including cost restriction, material type and manufacturing method. There are many challenges ahead to achieve GD realistically. Generating and exploring design space is quite time-consuming process, which is a major challenge. This can be countered by using Big Data applications (Bilal M., et al., 2016).

2.6.3. Clash Detection and Resolution

Identification of design clashes is an important part of building model. BIM-enabled automated approaches have substituted the conventional paper-based approaches. However, conflict resolution solutions provided by BIM are time-consuming. So, Big Data technologies comes to rescue representation of expanding knwoledge (Bilal M., et al., 2016).

2.6.4. Performance Prediction

Performance prediction models have been wide pertinence in different areas of the construction industry. Especially, these models are instrumental for the board frameworks, where engineers are encouraged to take right choices while building, keeping up, and restoring the structures. These models utilize an enormous number of factors and their extraordinary blends, in which they impact each other just as by and large model execution and performance. Also, it is featured that high dimensionality is inborn to the dataset created for these applications, where the very enormous number of factors add to the model improvement. To this end, performance prediction field offers chances to use Big Data advancements (Bilal M., et al., 2016).

2.6.5. Social Networking Services/Analytics

Larger part of construction industry issues is correspondence related. Web-based social networking is another intriguing pattern that can assist the business with improving correspondence among the venture group. This pattern is gradually infiltrating the business. Long range interpersonal communication administrations to share refreshed task data alongside more extensive practices for imparting the accepted procedures of supportability could be the following application regions.

The proposed methodology encourages the coordination of helpful task information with BIM and the combination of RFID, and internet-based life to help facility managers in finding information from different records (Jiao Y., et al., 2013)

2.6.6. Energy Management and Analytics

Building energy simulation software to model the total consumption of energy. Precision of given parameters that are consummated by specialists control their exactness. This fine tweaking is relentless and time taking. A great deal of calculations is done in programmed fine tweaking. the programmed age of precise information model with proposed Auto-tune work reenactment programming. It is accounted that product works on crude information of around 270 terabytes and consolidates to helpful information of roughly 80 terabytes. Information stockpiling and moving are the subjects of Big Data expertise (J. Sanyal, et al., 2013).

2.6.7. Big Data with BIM

Building Information Modeling (BIM) has reformed the construction industry in numerous viewpoints. BIM is enabled with an additional layer of information, caught all through the entire structure lifecycle. This information can be released to create helpful applications for improving the general structure conveyance process (S. Azhar, 2011; K. Barlish, K. Sullivan,2012). J.D. Goedert, P. Meadati (2008) extended BIM for the documentation of construction activities. U.Isikdag (2007) developed a fire response system by integrating BIM with GIS data.

These show the progressive increment in the size and extent of the substance of BIM models, which in the long run confines the capacities of customary BIM-based stockpiling and handling frameworks. To handle this, Y. Jiao (2014) custom fitted Map Reduce for capacity and handling BIM.

2.7. Types of Big Data Challenges

Between the numerous Big Data challenges, the enormous datasets and the capability to analyze and process enormous amount of data is the biggest challenge for data handling systems and database management system (Jiang et al., 2015).

2.7.1. Data Challenges

The different collection of the challenges that are caused by characteristics of data are known as Data Challenges. Data characteristics includes huge datasets that may contain terabytes, petabytes, zettabytes of data, data from various formats and sources and high speed of data coming in and going out. (Sivarajah U., et al., 2016).

2.7.2. Process Challenges

Challenges that are associated with handling and processing of the Big Data are the process challenges. (Kaisler, et al., 2013). While analyzing the data challenges, they can be divided into 5 steps, that are:

2.7.2.1. Data Acquisition and Warehousing

It is the catch related and significant data, smart channels are required that ought to be vigorous and astute to catch valuable data and dispose of futile that contains impressions or irregularities – this is a challenge in itself. For the last mentioned, effective explanatory calculations are required to comprehend the provenance of information and procedure the huge spilling information and to decrease information before storing it (Zhang, Liu et al., 2015; Zhang, Hu et al., 2015).

2.7.2.2. Data Mining and Cleansing

This challenge recognizes with mining, scrapping and vacuuming data from various disorganized sources. Backers of Big Data and Big Data Analytics see that in recognizing a superior path to mine and clean the Big Data can bring about huge effect and worth (Chen, 2012). Because of its strident, dynamic, various, interrelated and untrustworthy highlights, the mining, purifying and examination demonstrates to be extremely testing (Chen, 2013).

2.7.2.3. Data Aggregation and Integration

This process challenge identifies with integrating and coordinating clean information and data extracted from huge formless information. This typically undefined information normally comes up short on any coupling data. Aggregating this information clearly

goes past the capacities of current information mix systems (Carlson, 2010).

The accessibility of information in huge volumes and various sorts of portrayal, brilliant mix of these information sources to make new information – towards serving coordinated effort and improved dynamic, stays a main challenge. (Karacapilidis, et al., 2013).

2.7.2.4. Data Analysis and Modelling

When the data has been caught, mined, cleaned, incorporated, and stored, comes the data investigation and displaying for Big Data. Obsolete information and data investigation and displaying bases on illuminating the multi-layered nature of networks among illustration authorized data (Shah, 2015).

2.7.2.5. Data Interpretation

Envisioning data and making it eligible for interpretation and for better examination comes under this process. Aim is to make the data as simple as possible for the reader to interpret (Simonet, et al., 2015).

2.7.3. Management challenges

Management challenges identified with Big Data are a those which are faced while administering or managing data. Industries must assure that they have a strong and safe framework that authorizes representatives and workforce of all units to work only in the area of their specialization and given authority. Additionally, there should be some standard security rules that may oversee the utilization of these data and information so that security of data is not being compromised. (Sivarajah U., Kamal M. K., 2016).

Challenges related to data management can be divided into different areas are as follows.

2.7.3.1. Data Privacy

Big Data presents huge protection and privacy and confidentiality concerns and how to safeguard security in the advanced time is a major difficulty. Massive investments have been made in Big Data undertakings to simplify forms; nonetheless, associations are confronting difficulties in overseeing security issues, and enrolling information experts, in this way obstructing associations in pushing ahead in their endeavors towards utilizing Big Data (Krishnamurthy & Desouza, 2014).

2.7.3.2. Data Security

On the off chance that security challenges are not fittingly tended to, at that point the marvel of Big Data will not get a lot of acknowledgment all around. Verifying Big Data has its own unmistakable difficulties that are not significantly unique to customary information. Among the few Big Data related security challenges are the circulated idea of huge Big Data, which is mind boggling however similarly helpless against assault (Yi, 2014). Investigating logs, organize streams, and framework occasions for crime scene investigation and interruption location has been a test for information security (Cárdenas, et al., 2013) and absence of advanced foundation that guarantees information security, for example, uprightness, secrecy, accessibility, and responsibility become amplified when information bases converted into universal (Demchenko, et al., 2013).

2.7.3.3. Data Governance

As the interest for Big Data is continually developing, associations see information administration as a potential way to deal with justifying information quality, improving and utilizing data, keeping up its incentive as a key hierarchical resource, and backing in accomplishing bits of knowledge in business choices and tasks (Otto, 2011).

A noteworthy challenge during the time spent administering Big Data is classifying, demonstrating and mapping the information as it is caught and put away, predominantly because of the

disorganized pool of information. In addition, powerful Big Data administration is basic to guarantee the nature of information mined and broke down from a group of huge information sets (Mars D., 2012).

2.7.3.4. Data and Information Sharing

Where associations store datasets, it likewise represents a mind-boggling assignment of sharing and incorporating key data crosswise over various organizations (OSTP, 2012).

2.7.3.5. Cost/Operational Expenditures

The always expanding information in every single distinctive structure has prompted a rising interest for Big Data handling in advanced data hubs. These are commonly dispersed differently over numerous topographical areas to implant strength and spread hazard, this led to high stockpiling and information handling large expenses (Raghavendra et al., 2008).

The expense of information handling and other operational consumptions of the server farm are a delicate issue that may likewise affect in the manner associations embrace and actualize innovative arrangements (Al Nuaimi, 2015).

2.7.3.6. Data Ownership

Like other information and data linked administration challenges, the information proprietorship is basically imperative to understand the guarantee of Big Data Information proprietorship is a lot further public matter. These worries are past the attention on a few claims (Web, 2007)

2.8. Downsides of Big Data in Construction Industry

2.8.1. Security of Data

Issues related to security, ownership and management of the data are the main concerns for organizations that stores big data. In addition, some storages of big data can be eye-catching aims for hackers and other potential threats. Some research studies have suggested and applied actions in order to control data access and control. (R. Wong, 2012).

2.8.2. Quality of Data and Data Set

Construction industry famous for practices having divided data. Invalid and deceptive principles, anomalies, non-normalized standards, between others, are a portion of basic attributes. Because of poor information administration practices, producing important analytics is challenging. Top notch data is essential for Big Data Projects. Otherwise the results can be misleading which thus will bring about unsavory and pessimist feeling in the construction industry (Bilal M & Oyedele L., 2016).

2.8.3. Cost Implications

As the construction industry is considered as a low-profit business so adding a costly technology like Big Data to the project is more probable to be opposed and defended. Because Big Data will demand data centers, software licenses and skilled IT personnel. It is difficult to quantify the exact amount for Big Data implication (Bilal M. et al., 2016).

2.8.4. Connectivity Issues

As the projects like dams, highways and railways etc. are in rural or underdeveloped areas there is unavailability of networking infrastructure and have low bandwidth. For real-time monitoring of project activities instant data transmission should be maintained. To tackle internet connectivity issues wireless sensor networks should be extended in these type of Big Data applications (Bilal M. et al., 2016).

2.8.5. Manipulating the Prospective of Big Data

The adequacy of Big Data cannot be estimated just by aggregating huge volumes of information; it is a greater amount of the utilization cases or mechanical issues that direct the value of these innovations. It is expected that the development business probably will not remove the full estimation of available Big BIM Data if the considered use cases are ambiguous. Gifted experts and area specialists, enabled with refined explanatory work processes, are similarly important to receive the general rewards. Without whom, the applications are probably going to get into the trap of creating an excessive amount of data that ought not be conveying huge bits of knowledge for the reason (Bilal M. et al., 2016).

2.9. Types of Big Data Analytical Methods

Big Data containing huge datasets and piles of information and in order to extract required data, the way to analyze it also differs. So, Big Data has different sorts of analytical methods in order to analyze it by different characteristics and expected outcomes (Sivarajah U., Kamal M. K., 2016).

The Big Data Analytics methods are classified into 3 groups, these are.

2.9.1. Descriptive Analytics

It includes the synopsis and portrayal of information designs utilizing basic factual techniques, for example, mean, middle, mode, standard deviation, fluctuation, and recurrence estimation of explicit occasions in Big Data streams (Rehman, 2016). Regularly, enormous volumes of authentic information is utilized in clear examination to distinguish designs and make the executives reports that is worried about demonstrating past conduct (Assunção, 2015).

Descriptive analytics are viewed as in reverse looking and uncover what has just happened. Be that as it may, a pattern that is being received in descriptive analytics currently is to utilize the discoveries from prescient examination (Sivarajah U., et al., 2016).

2.9.2. Predictive Analytics

These is worried about gauging and factual demonstrating to select the expected outcome that is best suited according to our requirements (Waller and Fawcett, 2013; Rehman, 2016).

Predictive investigation is primarily created on measurable methods and looks to disclose models in order to predict the outcomes of Big Data (Gandomi et al., 2015).

2.9.3. Prescriptive Analytics

This kind of analytics is done to conclude the reason impact association among logical outcomes and business procedure advancement strategies. The outcomes of the prescriptive analytics are dependent on the outcomes of predictive analytics (Bihani et al., 2014).

Though prescriptive analytics are difficult to deliver yet they help in the progress of industry's procedure models. Overall, the prescriptive measures help industries in estimating outcomes and achieving their goals and aims (Rehman, 2016).

CHAPTER 3

RESEARCH METHODOLGY

3.1. Introduction

This chapter provides an understanding into the multi-stage applied research undertaken in order to identify the challenges that pose in way of the adoption of Big Data Management in the field of Construction. It will describe the utilization of literature and other research tools to meet the research objectives and foster the basis and effectiveness of information management framework.

3.2. Research Design

The general plan for addressing the research questions is known as research design (Saunders , et al., 2009). It involves deciding among research strategies for data collection and analysis, validation and output of results. It is a roadmap which guides the researchers throughout for completion of the research program.

Before proceeding to research design for this study, the research objectives are reproduced here;

- To identify challenges in implementation of Big Data in Construction Industry
- Proposition of Solution to eradicate roadblocks in adoption of Big Data
- To develop framework in the form of Big Data central Management system

The research begins with the status of Big Data Management in the local Construction industry of Pakistan. Literature review provides an insight about what Big Data is and what can be the probable central management system for the big chunks of data being produced in the construction industry. Afterwards, the research objectives are targeted using appropriate toots and techniques, which themselves are formed on the basis of the correlation of the research objectives.

3.2.1. To identify challenges in implementation of Big Data in Construction Industry

A questionnaire was developed to asks the construction industry personnel, including the contractors, site engineers, construction managers, project managers, and project developers, about the existing techniques for managing big data in this field and the acceptance of the modern data management software for the huge chunks of information produced in a project , plus all other alternatives that are coming up with the outcome of the challenges that hinder the way of the implementation of the idea

3.2.2. Proposition of solutions to eradicate the roadblocks in adoption of Big Data

Industry experts were consulted in the carried survey out to map a list of probable causes that are major barriers in adopting of the proposed central Big Data Management System in Construction Industry. Literature review enabled us get to know the modern techniques that are being employed in the developed world for the management of data being produced in different fields of research.

3.2.3. To develop framework in the form of Big Data Central Management System

The mechanism for developing a Big Data Management System (BDMS) was proposed based on the literature review, questionnaire survey and expert opinion, and different management techniques were studied to make a realistic flowchart, the one that is cost effective and can be employed in the local construction industry

3.3. Qualitative Literature Review

To carry out a survey and develop a framework, it was necessary to get an insight of the previous work done on the management of Big Data in various other fields, and know the factors which were responsible for posing a hindrance in managing Big Data. This review was entirely aimed to map out the potential factors that are influencing the implementation of Big Data in construction industry. A thorough study of more than 30 research papers highlighted twenty-eight factors which were significant in Big Data management. All the factors were assigned frequency and ranking (Low, Medium, High according to its emphasis in research paper) and were later shortlisted based on their normalized score obtained through computations on Microsoft Excel

Below in Table 2, are shown various factors which were common among the many research papers and were felt to be responsible in the Construction Industry too.

Table 2: Normalized Score of Content Analysis

Factors Affecting Adoption of Big Data	Literature Score	Factors Affecting Adoption of Big Data	Literature Score
Data Management	0.4	Acquisition of Data	0.1
Data Volume	0.36	Complexity of Data	0.1
Data Storage	0.35	Adopter's Readiness	0.1
Data Quality	0.35	Legal Issues	0.09
Data Analysis	0.35	Lack of Technology	0.09
Type of Data	0.27	Lack of Senior Management's Interest	0.09
Security of Data	0.2	Innovation	0.09
Data Collection Capacity	0.2	Hadoop Expertise	0.06
Lack of IT expertise	0.2	Policy Making	0.06
Organizational Capability	0.15	Pressure from Business Partners	0.05
Regulatory Support (Govt. Support)	0.15	Attitude towards technology adoption	0.05
Data Sharing	0.15	Trust and Cooperation	0.04
Confidentiality	0.15	Competitive Advantage	0.03
Data Velocity	0.12	Client Requirement	0.01

3.4 SURVEY

In order to validate the potency of factors extracted from qualitative literature review, a web-based questionnaire was developed using Google Forms. The questionnaire consisted of three portions; first section was about respondent's profile; second section was about awareness of Big Data; and the third section consisted the list of these factors on Likert scale of 1 (Very Low) to 5 (Very High).

Respondents were asked to provide information on the various shortlisted factors of Qualitative Literature Review on a scale of 1-5 based on their prior knowledge of Big Data. Experts from all segments of the market related to Civil Engineering Projects participated in the survey including Contractors, Clients, Consultants and Academia Personnel. Those who had no prior knowledge of Big Data were not incorporated in the survey. It was ensured that the government and private sector has equal representation in the survey.

The questionnaire was shared via emails and was circulated through personal contacts among concerned academia and industry personnel with experience and knowledge of Big Data in construction Industry. A total of 129 responses were received from the survey conducted.

This data was then analyzed based on the rating; each factor was given by the respondents.

3.4.1 RESPONDENTS' PROFILE

It has been observed that majority of our respondents were contractors (47%) followed by consultants (23%), client (15%) and academia (15%). These respondents were contacted by email and in person. To have a framework acceptable to all the entities in field of civil engineering it was necessary to include people from every sector.

Figures 2 shows respondents' percentage depending upon their professional background.

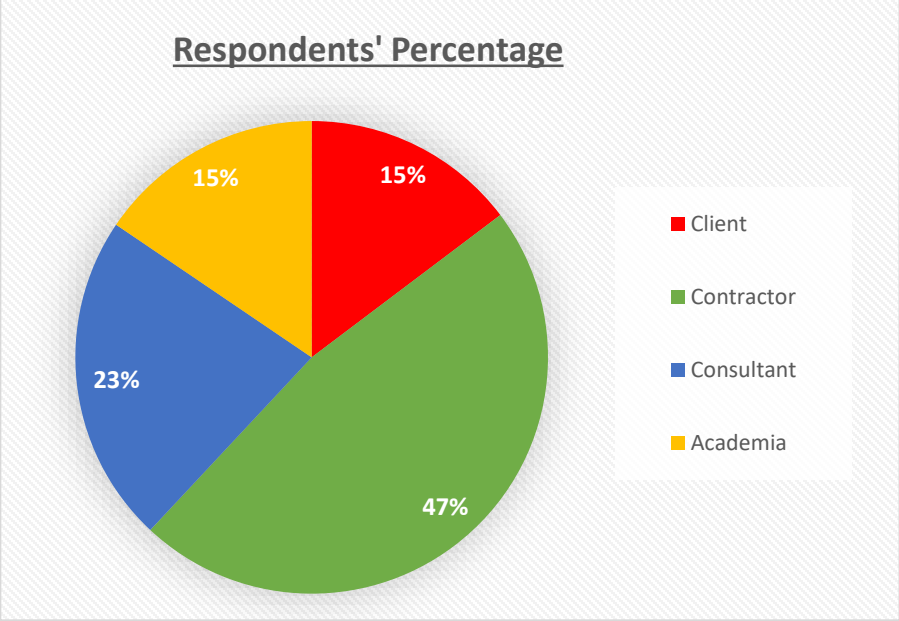

Figure 2

Another important demographic variable was the representation of the respondents from

government sector and private sector, and to maintain an equity, both sectors were given equal representation in the survey. 53% of the respondents were from Government Sector and 47% of the respondents were from private sector.

Figure 3 gives the percentage of government and public sector representation of the participating respondents.

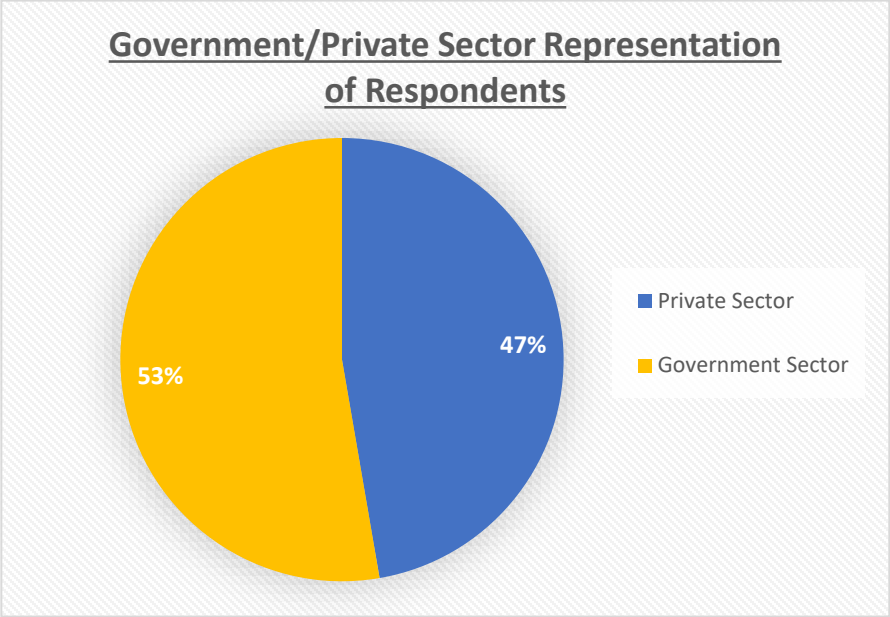

Figure 3

3.5 FREQUENCY ANALYSIS IN SPSS

After receiving 12 responses, the next step was to logically analyze the obtained data. And for that IBM SPSS Statistics 20 software was used to carry out the frequency analysis and shortlist the factors based on their mean value of rating obtained in the survey.

All the factors were imported from the Microsoft Excel File and using the functions of Mean, Median, Standard Deviation, Maximum and Minimum value, in the descriptive analysis section of SPSS , the factors were ranked from highest to the lowest mean rating to identify the factors greatly responsible for posing a hindrance in adoption of Big Data in Construction Industry. Based on these shortlisted factors, the framework was to be devised addressing these barriers.

To explain the SPSS findings, an example of one of the factors is shown below {Regulatory

Support (by government)} which gives the table for the rating obtained in survey and a bar chart constituted on the data which gives an idea of the maximum rating respondents gave to it and its deviation from the mean value of it obtained from the frequency analysis.

Table 3: Survey responses of a factor {Regulatory Support (by government)}

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Low	4	3.1	3.1	3.1
	Low	3	2.3	2.3	5.4
	Medium	26	20.2	20.2	25.6
	High	71	55.0	55.0	80.6
	Very High	25	19.4	19.4	100.0
	Total	129	100.0	100.0	

Here, it graphically evident that respondents considered it highly responsible to be a roadblock in the adoption of Big Data in Construction Industry which is why 71 out of 129 respondents rated it high and 25 of them considered it very highly responsible factor among the listed ones.

Similar calculations and graphs were made for all of the factors in the survey to deduce analysis based on the responses.

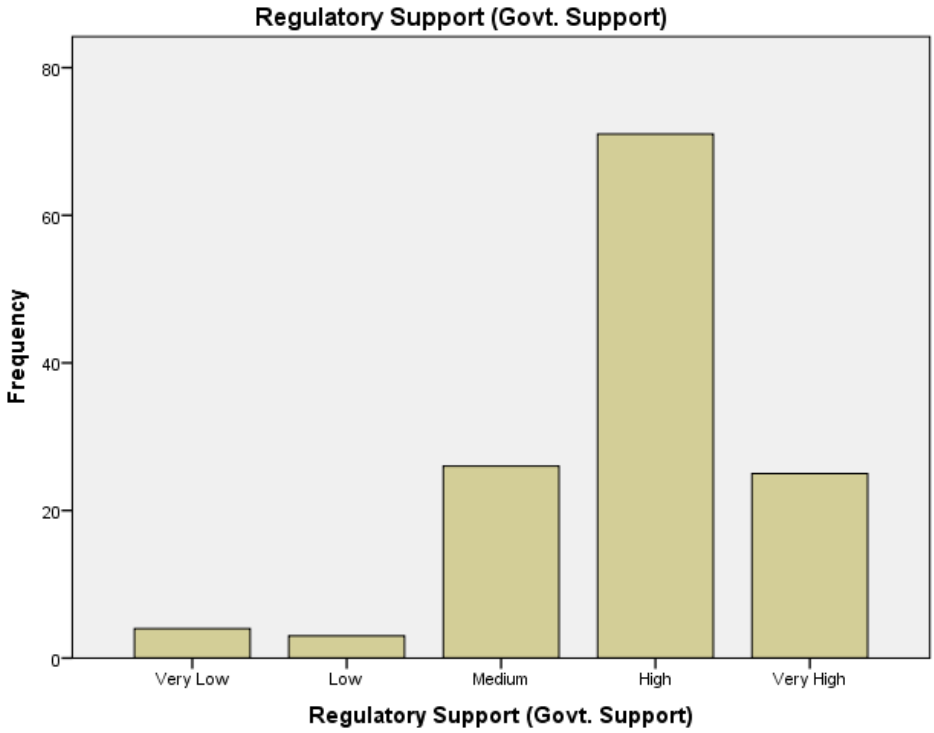

Figure: 4

Table 4: The Rating of Importance of Factors After SPSS Frequency Analysis.

Factors	Mean Value of rating	Standings
Security of Data	**4.17**	1st
Acquisition of Data	**4.03**	2nd
Policy Making	**4.02**	3rd
Data Management	**3.96**	4th
Lack of Technology	**3.96**	5th
Data Sharing	**3.93**	6th
Data Storage	**3.89**	7th
Hadoop Expertise	**3.89**	8th
Data Volume	**3.88**	9th
Lack of IT Expertise	**3.87**	10th
Regulatory Govt. Support	**3.85**	11th

Factors	Mean Value of rating	Standings
Legal issues	**3.79**	12th
Data Quality	**3.79**	13th
Lack of Senior Management's Interest	**3.76**	14th
Organizational Capability	**3.69**	15th
Type of Data	**3.62**	16th
Complexity of Data	**3.61**	17th
Data Collection Capacity	**3.6**	18th
Data Velocity	**3.49**	19th
Data Analysis	**3.41**	20th
Innovation	**3.28**	21st
Adopter's Readiness	**3.28**	22nd

Based on importance of these factors, a comprehensive framework was formulated which has been discussed in the following chapter

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Results

Responses obtained from the survey were analyzed through frequency analysis in a statistical software “IBM SPSS Statistics 20”. It particularly ranked the factors that are major roadblocks in the way of adoption of Big Data on the basis of their frequency. SPSS generated report is enclosed as Annexure B which shows frequency of each factor in 129 collected responses as well as bar chart of each factor against frequency.

Result comes out that Security of data, Data Acquisition and Policy Making are the forefront issues in establishing a Big Data Management System. Likewise, Lack of technology, Data management, Data sharing, Data storage, Hadoop expertise, Data volume, Lack of IT expertise, Regulatory Govt. support, Legal issues, Data quality ,Lack of senior management interest , Organizational capability, Type of Data and Complexity of Data are potentially obstructing the way forward to a centralized Big Data Management System. Following list shows the major barriers in adoption of Big Data in construction industry of Pakistan.

Challenges influencing adoption of Big Data in Construction Industry
Security of Data
Acquisition of Data
Policy Making
Data Management
Lack of Technology
Data Sharing
Data Storage
Hadoop Expertise
Data Volume
Lack of IT Expertise
Regulatory Govt. Support
Legal issues
Data Quality
Lack of Senior Management's Interest
Organizational Capability
Type of Data
Complexity of Data
Data Collection Capacity
Data Velocity
Data Analysis
Innovation
Adopter's Readiness

Following Chart shows the spectrum of factors along with their average value on Likert scale.

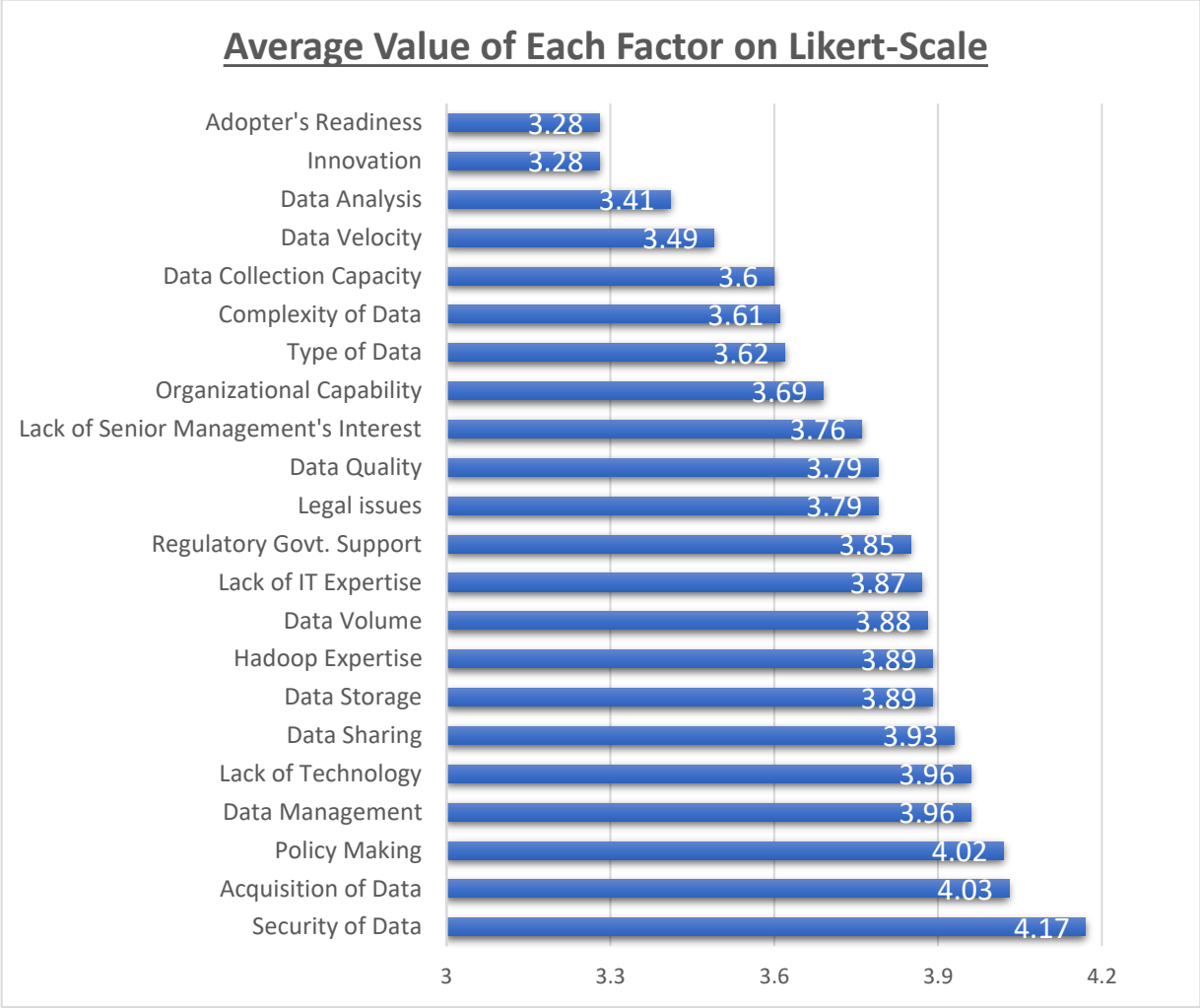

Fig. 5: Average value of each factor on Likert scale

4.2. Conceptual Framework

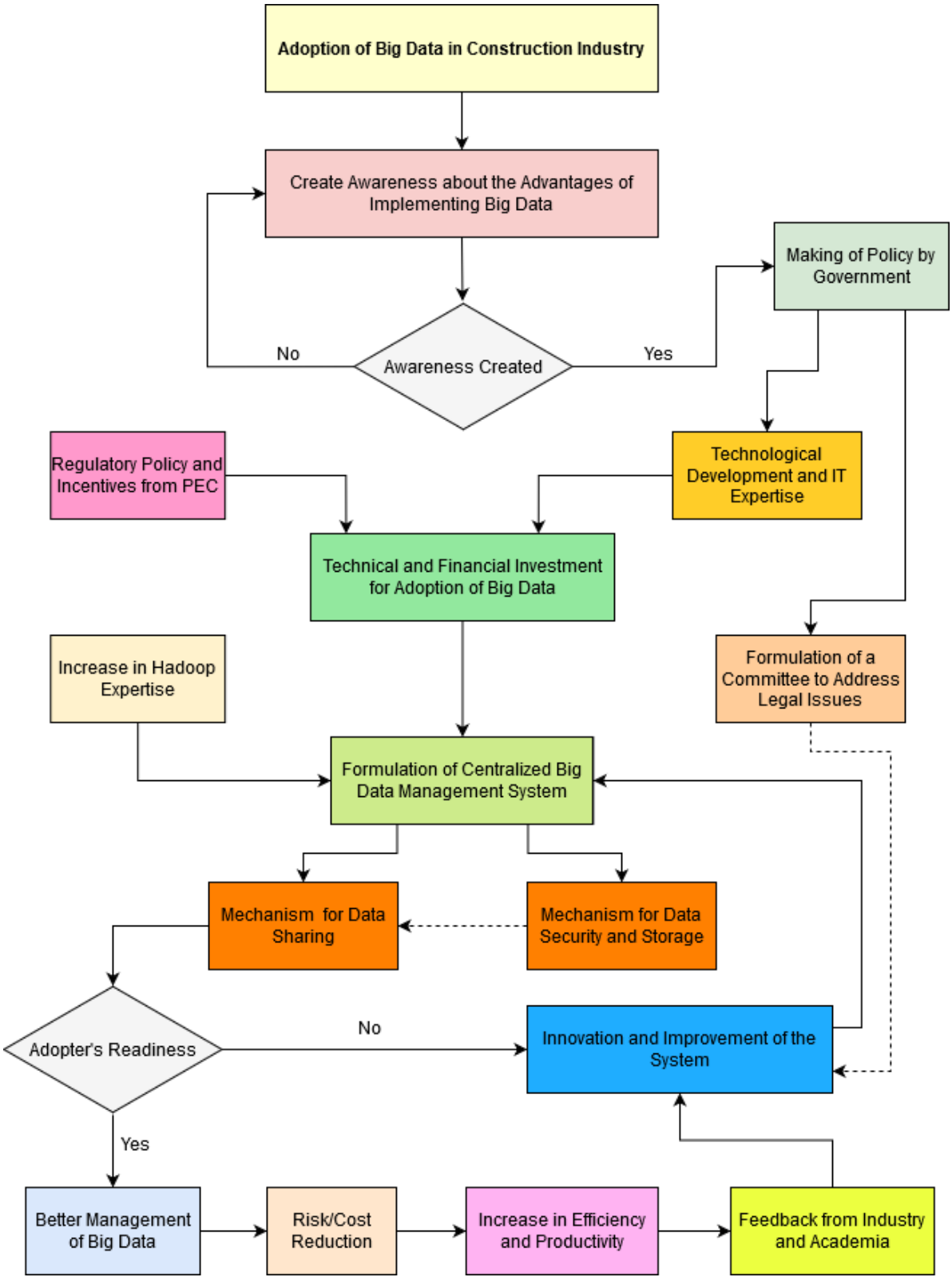

Figure: 6

4.3. Discussion of Framework

After identification of the factors, a conceptual framework has been devised to map out a way forward for the adoption of Big Data in the Construction Industry of Pakistan. It comprised of, and not limited to the following major steps:

- The framework begins with the substantial awareness about the advantages of Big Data for the construction firms which are working under Pakistan Engineering Council (PEC).
- Awareness will help Government in setting out a policy to formulate a centralized Big Data Management System (BDMS) to store and share data which will largely require technological development and financial Investment.
- IT Expertise and Data Analytics would be significantly needed to set up mechanisms of Data Acquisition, Data Storing and Data Sharing.
- A separate committee should be mandated to circumscribe legal issues in order to make this system more efficient.
- Improvements can be made in this system depending upon adopter's readiness and level of awareness.

Eventually, A successful implementation of Big Data Management System (BDMS) will lead to the better data management of the past projects and increased productivity for the future projects. It will lessen not only the roadblocks but converge people towards relying on better technologically advanced methods for construction practices in Pakistan and applying them in order to achieve more beneficial results.

CHAPTER 5

CONCLUSION

5.1. Conclusion

The scope of this project focusses on identifying hindrances in the adoption of Big Data in construction industry. Qualitative literature review was carried out and based on the obtained literature score, challenging factors were shortlisted. It was followed by Frequency Analysis of the responses received from survey, which helped ranking the challenges which inhibit the leveraging of Big Data among practitioners. A conceptual framework was proposed highlighting that a proper management system shall be made under government support that can ensure the collection, secure storage, and retrieval of data maintaining the competitive advantage of the contributing firms. This will largely require technological development and financial investment. Government should lower the legal barriers as well as take measures to make the senior management in the construction firms' adaptive to the new technology.

The project scope encompassed a general roadmap towards the implementation of Big Data in the local industry whereas upcoming research should endorse the validity of proposed framework by translating it into practice and amending new possibilities that may arise with time.

5.2. Limitations

The research on Big Data adoption had several limitations, first one being the lockdown situation during the outbreak of pandemic COVID-19, due to which we had to limit our scope and physical outreach to the stakeholders. Secondly, a large number of people in Pakistan are not even aware of the term Big Data, and hence could not participate in the survey.

References:

C. Chiang, T. Ho, & C. Chou (2012), A BIM-enabled platform for power consumption data collection and analysis, Computing in Civil Engineering, pp. 90–98

CEBR. (2012), Data equity Unlocking the Value of Big Data, Centre for Economics and Business Research

D. Barista (2014), The Big Data Revolution: How Datadriven Design Is Transforming Project Planning, Building Design and Construction Online magazine

Dan Garlasu ; Virginia Sandulescu ; Ionela Halcu ; Giorgian Neculoiu ; Oana Grigoriu, Mariana Marinescu & Viorel Marinescu (2013), A Big Data Implementation Based On Grid Computing, IEEE Xplore

J. C. Cheng & M. Das (2013), A cloud computing approach to partial exchange of BIM models, in Proc. 30th CIB W78 International Conference, pp. 9–12

K.-C. Yeh, M.-H. Tsai, & S.-C. Kang (2012), On-site building information retrieval by using projection-based augmented reality, Journal of Computing in Civil Engineering

M James, C Michael, B Brad, B Jacques (2011), Big Data: The Next Frontier for Innovation, McKinsey: McKinsey Global

M.Osmani, J.Glass & A.D.F.Price, Architects' perspectives on construction waste reduction by design, Waste Management

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A. H. (2011), Big data : The next frontier for Innovation , Competition, and Productivity

Min Chen, David Ebert, Hans Hagen, Robert S. Laramee, Robert van Liere, Kwan-Liu Ma, William Ribarsky, Gerik Scheuermann & Deborah Silver (2009), Data, Information, and Knowledge in Visualization, IEEE Computer Graphics and Applications

Min Chen, Shiwen Mao & Yunhao Liu (2014), Big Data: A Survey, Springer Link

Muhammad Bilal, Lukumon O.Oyedelea, Junaid Qadir, KamranMunir, Saheed O.Ajayia, Olugbenga O. Akinade, Hakeem A.Owolabia, Hafiz A. Alakaa & Maruf Pasha (2016), Big Data In The Construction Industry: A Review Of Present Status, opportunities, and future trends, *Advanced Engineering Informatics, 30(3), 500–521*

Nils O.E. Olsson & Heidi Bull-Berg (2015), Use Of Big Data In Project Evaluations, IJMP in Business

Oguntimilehin, A. & Ademola, E.O, (2014), A Review of Big Data Management, Benefits and Challenges, AFE Babalula University

P. Meadati, J. Irizarry, and A. K. Akhnoukh (2010), BIM and RFID integration: a pilot study, Advancing and Integrating Construction Education, Research and Practice, pp. 570–78

Philip Russom (2011), Big Data Analytics, TDWI Best Practices Report

Rizwan U. Farooqui R. U., Hussain E., Umer M. & Lodi S.H. (2012), Factors Affecting Construction Cost in the Pakistani Construction Industry, Third International Conference on Construction in Developing Countries (ICCIDC–III)

Samuel Fosso Wamba, ShahriarAkter, AndrewEdwards, GeoffreyChopin & DenisGnanzou (2015), How 'Big Data' Can Make Big Impact: Findings From A Systematic Review And A Longitudinal Case Study, International Journal of Production Economics

Seref Sagiroglu & Duygu Sinanc (2013), Big data: A review, IEEE Xplore

W Toga, Ian Foster, Carl Kesselman, Ravi Madduri, Kyle Chard, Eric W Deutsch, Nathan D Price, Gustavo Glusman, Benjamin D Heavner, Ivo D Dinov, Joseph Ames, John Van Horn, Roger Kramer, Leroy Hood (2015), Big Biomedical Data As The Key Resource For Discovery Science, Journal of the American Medical Informatics Association, Volume 22, Issue 6

W. Lu, X. Chen, Y. Peng, & L. Shen (2015), Benchmarking construction waste management performance using big data, Resources, Conservation and Recycling, vol. 105, pp. 49–58

Weisheng Lu, Xi Chen, Daniel C. W. Ho & Hong di Wang (2016), Analysis Of The Construction Waste Management Performance In Hong Kong: The Public And Private Sectors Compared Using Big Data, Journal of Cleaner Production

WeishengLu, XiChen YiPeng & LiyinShen (2015), Benchmarking Construction Waste Management Performance Using Big Data, Resources, Conservation and Recycling

World Economic Forum (2011), Personal Data : The Emergence of a New Asset Class. World Economic Forum, Retrieved from http://www.weforum.org/

Xi Chen, Weisheng & LuShiju Liao (2017), A Framework of Developing aBig Data Platform for Construction Waste Management: A Hong Kong Study, Proceedings of the 20th International Symposium on Advancement of Construction Management and Real Estate pp 1069-1076

Yi Jiao, Yinghui Wang, Shaohua Zhang, Yin Li, Baoming Yang & LeiYuan (2013), A Cloud Approach To Unified Lifecycle Data Management In Architecture, Engineering, Construction And Facilities Management: Integrating Bims And SNS, Advanced Engineering Informatics

Zafira Nadia Maaz, Shamsulhadi Bandi & Roslan Amirudin (2018), A contextual parsing of big data values to quantity surveyors, International Journal of Built Environment and Sustainability, Volume 5, Issue 3, 2018

Survey for Final Year Project

In the construction industry, Big Data refers to the huge quantities of information that have been stored in the past and continues to be acquired today and it describes the large volumes of high velocity and complex data that require advanced techniques for management and analysis.

The construction industry is responsible for undertaking some of the biggest projects on Earth. Huge amounts of resources and work generates huge volumes of data in this industry.

The lack of Central Management System for managing Big Data in the construction industry is the major hindrance in improving efficiency in this sector and this needs to be addressed as per policy making and its implementation.

Your response will help us a lot in conducting our research. Thanks in advance for filling it !
*Required

1. Email address *

_____

2. Name *

_____

3. Name of Organization *

_____

4. Organization type *

Mark only one oval.

- ◯ Government
- ◯ Semi-Government
- ◯ Private
- ◯ Other: _____

5. Organization Structure *

Mark only one oval.

- ◯ Academia
- ◯ Contractor
- ◯ Sub Contractor
- ◯ Consultant
- ◯ Client
- ◯ Other: _____

6. Designation *

_____

7. Year of Experience *

Mark only one oval.

- ◯ 0-1
- ◯ 2-5
- ◯ 6-10
- ◯ 11-15
- ◯ 16-20
- ◯ 20 & Above

8. Do you have any knowledge about Big Data *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ Other: _____

Challenges in Implementation of Big Data in Construction Sector

What are the factors and their importance that you think are resisting the adoption of Big Data in Construction Sector.

9. Data Management *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

10. Data Volume *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

11. Data Storage *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

12. Data Quality *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

13. Data Analysis *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

14. Type of Data (Structured, Unstructured, Semi-Structured, system generated, human generated, etc.) *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

15. Security of Data *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

16. Data Collection Capacity (Efficiency of Data Collection Mechanism) *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

17. Lack of IT expertise *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

18. Organizational Capability *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

19. Regulatory Support (Govt. Support) *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

20. Data Sharing *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

21. Data Velocity (Speed of Data Generation and Processing) *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

22. Acquisition of Data *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

23. Complexity of Data (How complex it is to Process, Manage and Analyze data) *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

24. Adopter's Readiness *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

25. Legal Issues *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

26. Lack of Technology *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

27. Lack of Senior Management's Support *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

28. Innovation *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

29. Hadoop (An open-source software framework used for storing and processing Big Data in a distributed manner) *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

30. Policy Making *

Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

31. Any Suggestions/Comments