Financial Implication of Building Information Modelling (BIM) in construction industry of Pakistan

Final Year Project UG 2015

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ABSTRACT

Construction industry in Pakistan is growing and 2nd largest contributor in Gross Domestic Product of the country. In the recent years, there is massive growth in construction industry but it still follows conventional methods which hindering its steady progress. Building Information Modelling (BIM) is the promising technology in the developed countries that has revolutionized the working and outcome of the projects. However, in Pakistan Construction industry, it’s potential is vast but implementation is poor. It awareness in construction industry of Pakistan is minimal and only a handful of companies know about the potential of this technology. This study focuses on the investment model, the amount of money that would be needed to set up BIM culture inside the company. Furthermore, The return on investment model is based on the money that can be saved by BIM softwares, as stated by BIM experts.The comparison of the surveys and statistical analysis indicates the potential and its benefits to the construction industry of Pakistan.

Table of Contents

Table of Figures

Table of Tables

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND: CONSTRUCTION INDUSTRY PAKISTAN

Now-a-days construction industry can be regarded as the driving force for a country's economy. Today, infrastructure development is considered as backbone of industrial and economic growth of country. For instance, construction industry of China contributes about 5.7% in GDP. Whereas in Pakistan, this number is about 2.5% of GDP as given PAKISTAN ECONOMIC SURVEY (2017) Figure 1. Construction as a sub sector contributes 13.13% in industrial sector and in GDP its share is 2.74 % against the share of 2.65 % last year; it absorbs 7.31 % of labor force as stated by Economic survey of Pakistan 2016-2017. New technologies and innovations are being implemented in industries to improve growth and production. Pakistan Economic Survey (2017) mentioned that construction business in Pakistan is booming (9.7% growth) (Figure 2) with advent of CPEC projects contributing 60 Billion dollars in China Pakistan Economic Corridor (CPEC, 2018) towards construction industry but there are factors that if addressed, can enhance the performance of industry manifolds, these factors that include change orders, contractual anomalies, errors in drawings and specifications, lack of communication, estimation errors and insufficient drawing details are one of the most cited dispute causing creating mistrust among the stakeholders which eventually cause inefficiency in the project (Zubair (2016).

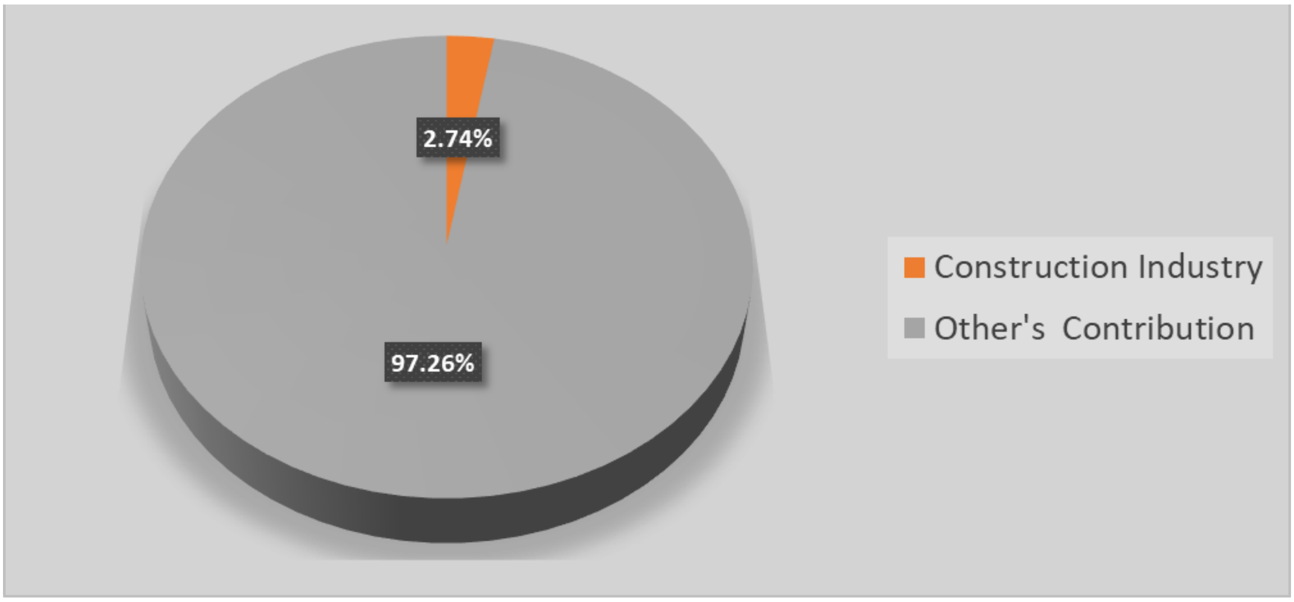


Figure 1: GDP of Pakistan

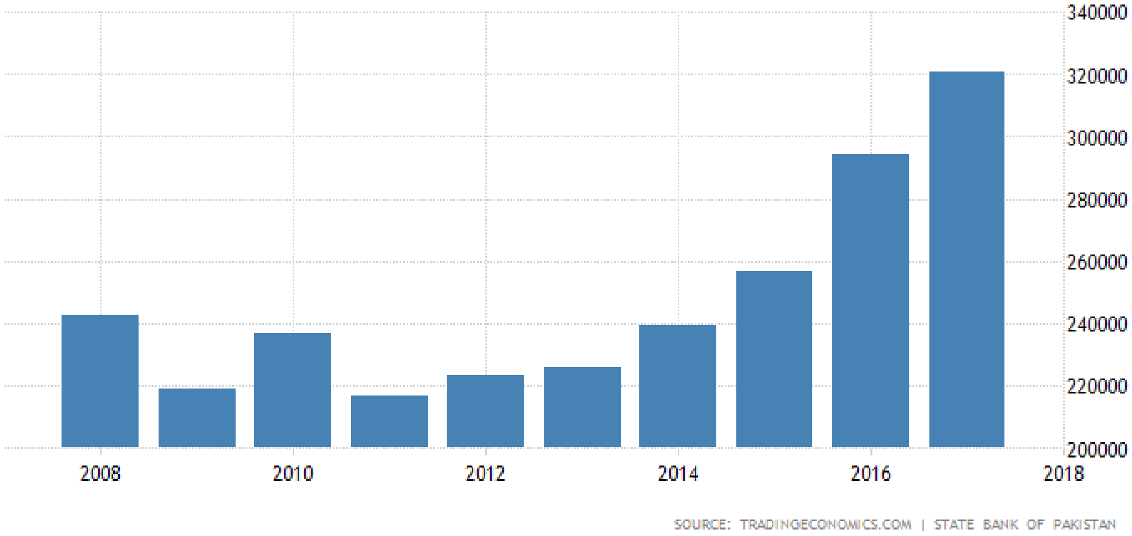


Figure 2: Growth of Pakistan's Construction Sector in PKR Millions

1.2 BIM:

BIM (Building Information Modeling) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. Technology is transforming the way that buildings and infrastructure are designed, constructed, and operated. And it's helping to improve decision making and performance across the building and infrastructure lifecycle (Azhar (2011).

BIM is one of the most promising concepts in the Architecture Engineering and Construction (Azhar. (2011). BIM is a process and not an object and has different levels of maturity, depending on its level of implementation. The concept took roots with the development of the first Computer Aided Design applications in the 60s and has evolved ever since with breakthroughs in technology and software. The highest BIM maturity levels allow the whole building system to stay integrated for its complete lifecycle -until it is demolished.

BIM system offers the integration of the roles of all stakeholders. It serves as a single reference point for each stakeholder making sure that every stakeholder is on the same page. This is done by allowing all the disciplines to connect their intelligence and allowing access to the current and projected project status thus making sure everyone is well aware of what is occurring and what is planned thus eliminating numerous conflicts of various nature and streamlining the whole process. (McPartland, 2014)

1.2.1 Levels of BIM Implementation:

The concept of ‘BIM Levels’ has become the ‘accepted’ definition of what criteria are required to be deemed BIM-compliant, by seeing the adoption process as the next steps in a journey that has taken the industry from the drawing board to the computer and, ultimately, into the digital age. Ranging from level 0-3 (Figure 3) and entering into talk of 4TH, the UK government has explained levels as follow: Level 0 BIM; Unmanaged computer aided design (CAD) including 2D drawings, and text with paper-based or electronic exchange of information but without common standards and processes. Essentially this is a digital drawing board. Level 1 BIM; Managed CAD, with the introduction of spatial coordination, standardized structures and formats it moves towards Level 2 BIM. This may include 2D information and 3D information such as visualizations or concept development models. Level 1 can be described as 'Lonely BIM' as models are not shared between project team members. Level 2 BIM; Managed 3D environment with data attached, but created in separate discipline-based models. These separate models are assembled to form a federated model, but do not lose their identity or integrity. Data may include construction sequencing (4D) and cost (5D) information. This is sometimes referred to as 'pBIM' (proprietary BIM). Level 3 BIM; A single collaborative, online, project model with construction sequencing (4D), cost (5D) and project lifecycle information (6D). This is sometimes referred to as 'iBIM' (integrated BIM) and is intended to deliver better business outcomes. Level 4 BIM; Level 4 introduces the concepts of improved social outcomes and wellbeing (McPartland, 2014).

In the UK the Government Construction Strategy published in May 2011, stated that the 'Government will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016'. This represents a minimum requirement for Level 2 BIM on centrally-procured public projects.

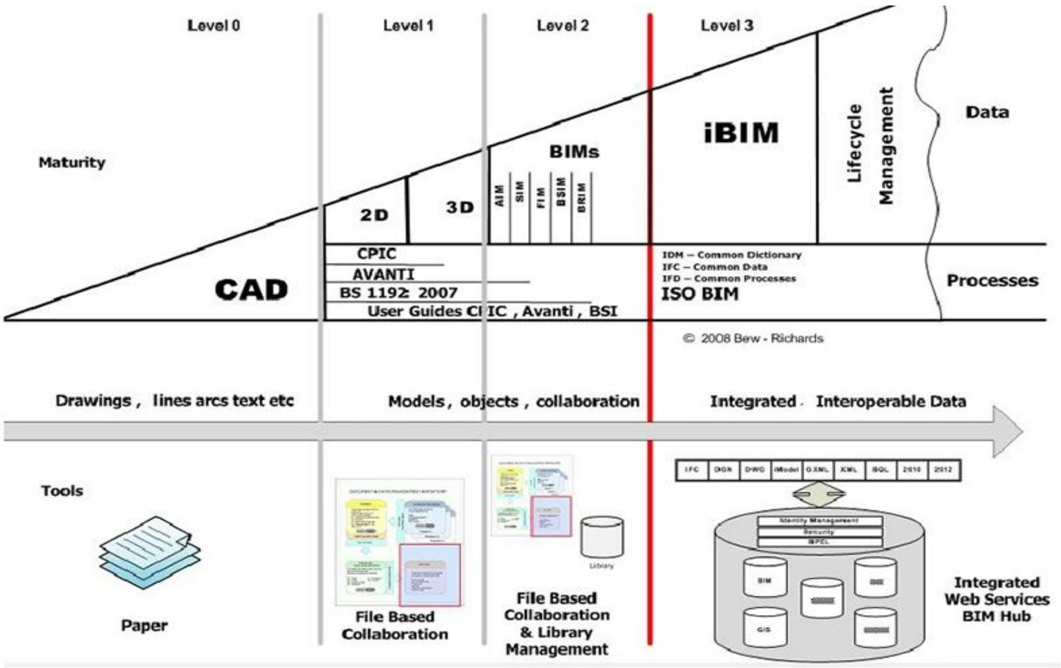


Figure 3: Levels of BIM

1.3 BIM's current situation in Pakistan's Construction industry:

Construction industry Pakistan is facing problems of delays and miscommunications at all stages of project starting from preliminary studies till the end of the project and these lacking have been a barrier for further advancement and efficiency in industry. BIM if implemented will result in facilitating in cost estimation, safety, risk management, energy analysis, and life cycle analysis(Ali, Zahoor, Mazher, & Maqsoom, 2018).

BIM being new dimension of construction industry, BIM based automation would bring that significant optimum performance by industry and play GDP development role if implemented (R. Masood, M. Kharal, & A. J. P. E. Nasir, 2014b) but construction industry Pakistan, the trivial method of using 2d Cad drawings, with some large scale projects using 3d visualizations, and non-compliance of integration with managerial, contractual and infrastructure works (Fatima et al. 2015) has deemed project managers to spend significant time and effort to find out the useful information such as plans and specifications for field management, and for communicating to construction participants at the site and offices (Park et al. 2016)

These researches indirectly indicate that BIM maturity level has been between '0' and '1', thus significantly raising question of ,'Why?'.

1.4 Problem Statement:

Despite benefits of using BIM, in cost industry there is considerable amount of buzz among contractors, A/E and clients about the financial implications of BIM, risk involved in its implementation and contractual arrangements for incorporating BIM in market. Three dynamics model (gives definite data for BIM but only researches being carried out in contracts and risk (Tomek, Aleš & Matějka, Petr.2014) and lacking in terms of financial implications though work related to cost-benefit analysis or ensured Return on investment (Giel & Issa, 2011)) are available but these studies are aimed to highlight the amount of money BIM can save vis-à-vis conventional construction. Evidently users who are to adopt BIM need encouragement of empirical evidence to justify their investment of time and budget (Lu, Fung, Peng, Liang, and Rowlinson (2014), a cost-return data that would logically and analytically represent a structure that would ensure whether implementation from establishing Level 2 and Level 3 BIM department to its integration in construction would result in cost return? If! Then in what time and amount?

Thus, significantly completing the 3 Dynamics Model (contractual, risk and cost implications) and providing resourceful knowledge to construction industry and future BIM perspectives.

- **Knowledge on financial implication of BIM is not enough for Pakistan's construction industry.**

1.5 Objective:

- To develop investment and ROI model for BIM implementation in Pakistan

CHAPTER 2

Literature Review

2.1 Construction Industry of Pakistan

Pakistan is a developing country and its construction industry is growing and fostering. Construction sector has received a lot of foreign investment, especially from China, and it is likely to see more. The type of construction being carried out in Pakistan is of different nature and consist of diverse group of stakeholders.

Due to this diversity, difference of opinion is likely to appear which can generate conflicts and disputes (Jha and Jha, 2010).

According to some authors, disputes and clashes is good for the organization and can help in satisfactions of project participation. However, if the intensity of conflicts increases, it creates an environment of tension and the performance declines as a result (Zubair, 2016) harming the positive impacts of conflicts (Leung et al., 2005).

Stakeholders in construction industry are mainly client, contractor and designer. They are followed by the sub-contractors. Everyone has a set of objectives that they need to complete during their assign job (Zubair, 2016). The contractors are supported by various subcontractors and suppliers. By virtue of their function, magnitude and role, there is a huge amount of difference among the interests of these parties which may give rise to disagreements (Mitkus and Mitkus, 2014).

Construction Industry has also faced multiple problems in completing projects. Multiple projects suffered from delays which increased the cost of the whole project and ultimately reduced the growth of construction industry. The most common factors of delays are natural disaster in Pakistan like flood and earthquake and some others like financial and payment problems, improper planning, poor site management, insufficient experience, shortage of materials and equipment etc. (Haseeb, M & Bibi, Aneesa & Rabbani, Wahab. 2011)

Such delays directly affect the working of construction industry. It is found that delay in construction projects significantly lead to cost overrun, time overrun, litigation and project abandonment. (Haq, Saif & Rashid, Yahya & Shakeel Aslam, Muhammad.2014). Effects of Delay in construction Projects of Punjab-Pakistan: An Empirical). There can be multiple causes of Delays in any Project, hence it is crucial to find and list down the number of factors that causes delays in construction which leads to retarded growth of the project.(**Abdul-Rahman et al., 2006)**.

2.2 Automation in Construction Industry.

Since world is advancing at a rapid pace, new technologies and innovations are being implemented in industries to improve growth and production. More industries are moving towards automation to improve the quality of product. Use of robotics is of paramount importance in the manufacturing industry. (Kim, M. j., Chi, H.-L., Wang, X., & Ding, L., 2015).

Automation Industry has risen dramatically in multiple industries and enhanced the productivity and efficiency of the companies.

According to the (Reinschmidt, K. F. ,1987), Some of the largest U.S. corporations--General Motors, General Electric, Westinghouse, and so on--have established large robot marketing organizations, of which the largest is the General Motors-Fanuc (GMF) combine. Since the use of robotics and automation in manufacturing, the production has increased manifolds and quality has increased significantly. However, Automation in construction is still under ongoing process. Construction sites are least hospitable sites possible for robots. (Reinschmidt, K. F. 1987)

(Wu, Wang, & Wang, 2016) proposed an integrated system encapsulating Building Information Modelling (BIM) and Light Detection and Ranging (LiDAR) for on-site information collection and construction quality control. It can be used by engineers to spot any flaw in the design phase and making recommended changes that would not affect the productivity of the whole project. Decisions can be made and help the engineers to make proactive decisions.

(Luo, Gong, & Systems, 2015) utilized BIM to facilitate code checking and risk identification before the construction of deep foundation projects.

Automation in construction industry will help companies to be more organized and improve their productivity. It is a long process but step by step approach will be able to assist the companies to achieve this project. This is the need of the future. Automation in Planning, Designing and on site construction would solve much of the problems we are currently facing. (Joshi, D., & Shah, R. 2015).

Since BIM is an integral part of automated design of any structure, it uses in industry can help us understand about the structure in better way and decisions can be made if there are any flaws. Decisions can be made in design phase and flaws can be catered before any construction project can take place.

BIM eases clash detection and enhances coordination between different trades of construction industry (Aslani et al., 2009). BIM use can help in precise definition of scope. It helps in interrelating of contractual documents, drawing, procurement details and submittals can be interrelated with the efficient use of Building Information Model**. (Azhar, 2011)**

2.3 Knowledge of BIM in Pakistan

According to survey, 27% of construction industry in Pakistan industry has knowledge of capacity in some capacity while 73% of industry does not have any kind of knowledge relating to the use of BIM. Pakistan is a developing country and the use of BIM is in early stages. The studies have been conducted on the Advantages of using BIM in Pakistan. It has been found that BIM implementation has most influence on Design and Management of Construction, design capability and reduces the amount of rework that takes place during construction. It has least effect on reduction of cost, time and allocation of human resources in Pakistan Industry. About 96% of AEC personnel want BIM to be implemented in Pakistan. (Masood et al., 2014b)

Hence the question arises why BIM in not being implemented in Pakistan construction industry to its optimum use. Since there are two major risks that are associated with the use of BIM in any construction industry; Contractual and Technical. (Azhar, 2011)

Ample amount of work has been done in the field of Contractual implications of BIM (Zubair, 2016) and Risk associated with BIM ((Ahmad, Thaheem, & Maqsoom, 2018) but amount of investment that would be need to implement Building Information Model (BIM) for construction Industry of Pakistan is not available .

2.4 OBSTACLES TO BIM IN ITS IMPLEMENTATION

2.4.1 BIM Cross-Platform Software Compatibility and Integration.

To unlock BIM's full potential, integration of different BIM streams is vital. Different software and BIM modes are used for scheduling, cost estimation, architectural design etc. There needs to be a universal agreed upon format to offer cross-platform compatibility and integration.

2.4.2 BIM and the Educational System.

There are numerous obstacles that stand in the way of implementing BIM. Starting from the academic sector, a study carried out in the US identified a lack of availability of BIM education framework as a major obstacle (Hedayati, Mohandes, & Preece, 2015). The students were not presented with clear incentives as to why they should be getting BIM related education although they were clear of the advantages that BIM had to offer. The 3 major barriers identified as a result of this study were the time required to introduce a new curriculum, the high cost of training and c.

In the educational sector in Pakistan, awareness regarding BIM practices is increasing and so these barriers are being overcome.

2.4.3 General Perspective of AEC Industry towards BIM.

The problem remains severe in the industries. The industry is not yet clear as to what BIM is i.e. not just isolated CAD drawings but a collaborative environment. This problem was initially faced in the UK as stated in the National BIM Standard's NBS BIM Report.

2.4.4 BIM Standards and Government Strategy.

In Pakistan lack of standardization say, a specific compatible software format or lack of reference BIM compliant model and benchmarks, too are a hurdle that the government, through its laws, will have to address.(Porwal & Hewage, 2013) declared that unawareness among the stakeholders and lack of Governments mandate are significant reasons for lack of BIM practices in Pakistan. The NBS report (NBS, 2015) showed that the stakeholders in the UK who adopted BIM as it was made mandatory, found their experience to be better than the expectations. Another matter of significant importance for which BIM might be criticized is that people believe that it discriminates among the stakeholders i.e. by offering no clear financial advantages to the small stake holders. This, however, not true as small organizations in the U.K that adopted BIM, (as stated in the NBS report (NBS, 2015)) said that its financial advantages were beyond their expectations.

2.5 Level of BIM Implementation in Pakistan

There is however clear evidence and publications that establish Pakistan's A/E BIM maturity level to be between 0-1. Relevant studies are also available on why the A/E sector may be reluctant to adopt BIM that establish lack of insight into the financial implications as one of these factors. Another publication of significant importance deals with the contractual nature of BIM (Porwal & Hewage, 2013). Also, previous studies establish that 'lack of insight into the financial implications' as one of the main factors that is hindering promotion of BIM in the construction industry worldwide.

2.6 Research Framework

2.6.1 Investment model

To study how previous studies have addressed financial implications of BIM implementation, we divided our study into two parts i.e. investment model and return on investment. As far as investment in BIM is concerned, we did not find any detailed work in this regard. For instance, we found some data on what factors are involved while investing in BIM (hardware and software cost, training cost, salaries of staff using BIM), (Giel & Issa, 2011) but, the studies did not quantify these costs. Furthermore, we did not find any work that has addressed other probable costs of BIM implementation that may include networking cost (for integrated use of BIM), equipment maintenance cost (considering depreciation), software update cost and others (electricity cost etc.). However the mentioned paper gives a glimpse of investment cost and its return while citing a case study of "Holder's Hilton Aquarium project in Atlanta (Gilligan & Kunz, 2007)", where the total cost of BIM was reported to be $90,000 which, only by clash detection, saved up-to $600,000 and 1143 scheduling hours.

2.6.2 Return on Investment (ROI) Model

While researching on Return on Investment (ROI), we found good amount of work in which authors used different approaches to calculate ROI. The most pertinent study was done by (Giel & Issa, 2011). Stating approach, the paper used to calculate ROI, the authors refer Requests for Information and Change Orders as appropriate factors that can be translated into BIM's benefit cost. "After going through the available project documents, it was determined that the most valuable project documentations available to the authors were the company's RFI and change order logs for each job. Thus, this research is largely based on information obtained from those logs because they provided the most accurate record of events on each project. The RFI log specifically allowed comparable conflicts on past projects to be pinpointed and traced to specific change orders with cost data. Additional supplemental information was gathered through personal interviews with project management staff and the VDC manager when questions arose during this analysis process. RFIs that were related to issues capable of being discovered by BIM were counted and then sorted based on the type of issue. After reviewing all RFIs, the change orders that resulted from BIM discoverable RFIs were then studied more thoroughly. The knowledge of what issues were resolved on the BIM-assisted projects revealed several change orders that may not have occurred on the previous projects constructed without BIM", the paper states. The case study took 3 pairs of projects, each having projects of similar nature, one implemented with BIM and other without BIM. The study further highlights that if we calculate the ROI of a non-BIM project, it is significantly greater than that of BIM project. The reason behind this is the fact that major chunk of ROI calculated in case of non-BIM project is due to 2D design errors. Bearing this mind, ROI has to be carefully calculated if we are going to calculate the time an organization will breakeven its investment cost.

All this previous literature urged us to do research on cost implications i.e. quantifying investment and return on investment cost of BIM implementation for Pakistan, where construction industry is booming and accounts for nearly 2.5% of country's GDP. If such promising technology is encouraged in the industry, given that 27% of organizations are implementing BIM or in the process of implementing and 73% are neither using it nor in the process of adopting it but, 96% professionals are in the favor of implementing BIM in Pakistan (Masood et al., 2014a), it may result in efficiency and quality improvement within the industry. Therefore, to implement BIM in Pakistan's industry requires a thorough study on cost-implications (investment and ROI model) is needed in order to give an empirical evidence to A/E, contractors and clients to invest in BIM.

CHAPTER 3

METHODOLOGY

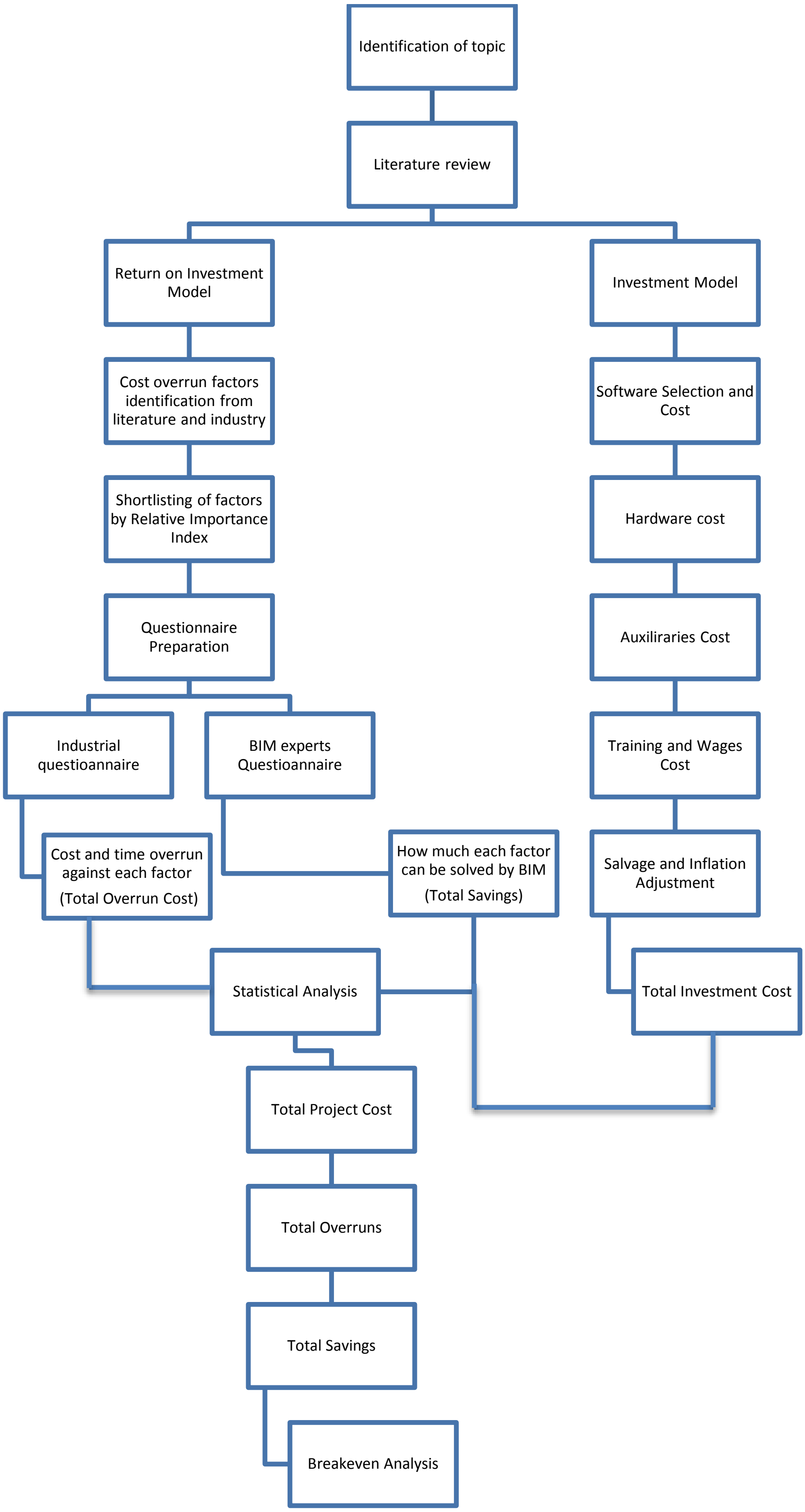


Figure 4: Methodology

3.1 Introduction

This chapter intends to discuss research framework while reviewing literature and the intended approach adopted to achieve objectives of this research; cost implications of BIM implementation in Pakistan's construction industry.

3.2 Research Design

Research was divided in two steps that were carried out simultaneously to devise following:

- Investment model
- Return on Investment model

3.3 Investment Model:

The First step in our project was to create the investment model. The purpose of developing an investment model is to find out cost that would be needed to set up the Building Information Modelling (BIM) culture inside the company.

Since the data availability was very limited and scarce. Building Information Modelling (BIM) exposure in construction industry of Pakistan is very low and a few companies using this new technology in their operations.

However, those companies do not fully utilize the potential of Building Information Modelling and retains at the lower level of BIM. We based our investment model for two kind of companies. The first kind of companies that can afford high end Personal Computers and would like to Building information modelling to its fullest potential to have a better efficiency and processing properties.

The second kind of companies are those that would like to use Building Information Modelling but they are unable to afford the high-end personal computers, so we identified the minimum requirement that they would need to use that technology.

Investment model is based for 15 computers and cost of hardware were calculated respectively. Since BIM is an integrated technology where multiple users are working on the same project from their perspective and whole work is being done by different users.

Number of users depend upon the kind of the project that is being worked on.

The average number of users are usually more than twenty. The source of this information is from Building information modelling experts and users.

The Maximum Cost of our Investment Model occurs: 20.00Million PKR

The Minimum Cost our Investment Model occurs at: 12.82 Million PKR

3.3.1 Industrial visit

In order to find out about the material that was needed to set up building information modelling culture we visit the newly build labs in Capital University of Sciences and Technology. The purpose of this visit was to find out about the hardware and their respective cost that was incurred for the construction of those labs. We also intended to find out what kind of planning they did for starting BIM courses in Islamabad and what were the wages being paid to the instructors?

We also met the program coordinator Dr Shuja Haider, who himself is Building Information Modelling Expert and has ample experience in it. After comprehensive discussion, we identified a few things that would help us build the investment model.

We made multiple visits to this organization to get more information for our investment model.

After visiting that lab, we decided to contact more BIM experts to have a better understanding of our requirements. It was important that our approach was in the right direction and we were working in correct way to develop our investment model. We contacted more building Information Modelling experts to approach in a better way.

Meeting with BIM experts helped us more in identifying the elements that would be needed to set up that culture inside the company.

3.3.2 Software Selection Study:

With the help of Building information modelling experts, we identified the most used BIM software that are widely. Afterwards, we visited the official websites of all that software that we isolated and we studied their minimum and maximum requirement.

After finding out the minimum and maximum requirement, we plotted the data matrix of minimum and maximum requirement. The minimum requirement is that requirement that would run all the software at their minimum requirement and maximum requirement is that requirement that would run all the programs at their maximum requirement. This would fulfil our objective of devising our investment model for two kind of companies with different Capital investment.

3.3.3 Software Cost:

The software subscription cost was calculated from the official website of all the identified software and then the cost was calculated for fifteen computers. The subscription cost was calculated for fifteen standalone licenses.

The network license requires quotation and application from the company. After verification of the request from the company, the software house grant the network license.

Since the demand of different companies was different for the use of license, so it was quite impossible for us to find out the cost of network license and the outcome of our investment model would have been vague.

That is why used the cost of 15 stand-alone license.

The collection of AECs was selected for our investment model since this include most of the software that works on Building Information Modelling (BIM) technology. The software cost is same for the maximum and minimum requirement of the personal computers.

3.3.4 Hardware Cost:

Once we calculated the software cost for our investment model, the next step was to study the hardware cost that would be needed to buy the hardware that would run software on minimum and maximum requirement.

The cost of hardware was calculated by making visits to Markets and from online sources. The opinion of Building information modelling experts was taken into the consideration when hardware was identified for our investment model.

Market visits.

Market visits were carried out in region of Islamabad and the cost of respected hardware was calculated. Multiple visits were carried out in the market and the net price was obtained after taking average of the all the cost we could find about the hardware.

Market visit were carried out in:

1. Hafeez Market, Lahore
2. Singapore Plaza
3. Dubai Plaza
4. Blue Area, Islamabad

Online Sources

Online sources were also consulted for calculating the price of the hardware and it was compared with the prices in the market. The purpose of doing so is to make it more convenient for our customers to shop online and can get the hardware at their doorstep and at the same time compare the prices in Market as well.

The Data of cost hardware at minimum requirement and maximum requirement is given in the pie chart below.

3.3.5 Auxiliaries Cost:

This the cost of the material that is indirectly related to the computers. These include wiring, ducts, Internet cost, UPS costs along with batteries.

These costs include the internet installation charges and annual subscription charges.

To find out about the auxiliaries that would be needed inside the company, we made visits to School of electrical and computer sciences, SEECS and School of Architecture and Design, SADA.

Also, the visits at Capital University of Sciences and Technology (CUST), Islamabad was of great help.

3.3.6 Training Cost:

Since our investment model is based for the construction industry of Pakistan where use of BIM is not so common and widespread. Companies still are trying to involve BIM in their daily operation.

The purpose of the training program was to involve the cost for those companies that are planning to hire trainers to train their employers to work on Building Information Modelling.

The source of this is both from Online and Building Information Modelling (BIM) Experts. The following data shows the minimum and maximum cost of training cost available in Pakistan construction industry.

Omni academy provides the minimum training cost over the span of 2 months. It includes the basic training and up to the 2nd level of BIM. The maximum cost is available for the time span of 12 months and include the both basic and advanced level training of Building Information Modelling. The source of this maximum cost is taken from experts who have been giving training in the respective fields.

3.3.7 Wages of Operators:

Once a person is certified with BIM based software, it is very likely that there will be increment in the salary of the person. We have also catered that in our investment model. This increment is for that person who is already an employer of the company. After receiving sufficient training of this software there would be increment in the basic salary.

This research is carried out because investment model includes the persons that will work on BIM after they have received training and what increment they would receive after their certification.

Furthermore, it is worth mentioning that there are diploma holders and engineers working side by side, so the increment for the diploma holders would be taken as minimum requirement and maximum requirement is for the increment in the salary of the engineers.

Since engineers hold leadership position in the companies and diploma holders work under the supervision of the engineers, so the major increment would fall under the domain of engineers and minimum increment in the wages would fall under the domain of diploma holders.

The source of this information is Building information experts and National Engineering Service Pakistan (NESPAK), Islamabad.

3.3.8 Salvage value:

Technology is changing rapidly and in order to keep upgraded, company intends to buy new hardware. So, salvage value is calculated for those companies that would like to buy new hardware and sell old ones, so that they can remain upgraded enough to run software at their high-end capacity. Salvage value is taken at 10% every 5 years. After 5 years, the hardware can be sold at their 10% of the original value.

We have specifically added this factor in our investment model so that companies can plan their finances accordingly if they intend to buy new hardware in next five years.

3.3.9 Inflation

Inflations rate is taken at 6% per year. The source is from market survey analysis.

3.4 Return on Investment Model.

3.4.1 Initial Research.

Research design is a work flow in logical way to achieve research objectives. Therefore, firstly, factors that are responsible for cost overruns in Pakistan's construction industry were identified. For this, "cost overrun factors in Pakistan's construction industry" were used as key words for search. Total of 4 papers from literature were found that listed cost overrun factors for Pakistan's construction industry. All factors were then listed against their frequency and intensity scaling from 1-5 as given by the corresponding literature source. Since, the amount of data for Pakistan's construction industry was not sufficient to carry out whole research, similar data of developing countries (Egypt, Malaysia, Ghana, India, Afghanistan and Uganda) was also collected from 16 literature sources. Hence, from 20 literature sources total 49 cost causative factors were identified. To authenticate these factors for Pakistan's construction industry, a questionnaire enlisting all cost overrun factors was prepared for the industry personnel. In this preliminary survey, respondents were asked to rate each of these cost overrun factors on the scale of 1-5 to depict its intensity; with 1 being lowest and 5 highest.

Furthermore, respondent’s organization and its role (A/E, Contractor or Client) and experience were asked as demographics

3.4.2 Industrial Survey (Cost Overrun).

To have quantitative data of cost and time overrun that can be caused by these 18 factors, a questionnaire was prepared for industrial experts with minimum 5 years of experience in building construction. To avoid complexity of large and simplicity of smaller buildings, building projects of 5-15 story were considered for the study. Respondents were asked to give total estimated cost (PKR millions) and time of completion (months) of a 5-15 story building project. Furthermore, they were also asked to give cost (PKR millions) and time overruns (months) against each cost overrun factor separately. Owing to their experience, most of the respondents assumed the total cost of the project and gave overrun cost against each factor as the percentage of project cost while others assumed project cost and gave discrete values of cost overrun of each factor.

3.4.3 BIM Expert Opinion (BIM Savings).

In order to quantify BIM savings, third questionnaire of the study was prepared for BIM experts. In this questionnaire, respondents were asked that how much each of the 18 cost overrun factors is solvable by BIM so that, its respective overrun cost can be saved. For instance, if the factor X is 30% solvable by BIM then 30% of overrun cost can be saved by BIM implementation.

CHAPTER 4

Results and Analysis

4.1 Investment Model

Total cost of investment model at maximum requirement comes around at **20 million rupees** and

Total cost of investment model at minimum requirement comes around at **12.82 million rupees**

4.1.2 Software Cost

Methodology → Software cost and selection

Software	Subscriptions (USD)			Annual cost in PKR
	Monthly	Annually	3 Years	
BIM 360	105	855	2310	120555
MAYA		1470	3970	207270
INFRAWORKS		1575	4255	222075
AEC COLLECTION		2690	7265	379290
NAVISWORKS		840	2270	118440
CIVIL 3D	265	2100	5670	296100
RHINO		995		140295
ARCHICAD 22		500		70500

Sources : https://www.autodesk.ae/collections/architecture-engineering-construction/subscribe?referrer=%2Fcollections%2Farchitecture-engineering-construction%2Fsubscribe&plc=AECCOL&term=1-YEAR&support=ADVANCED&quantity=1#

Figure 5: Software Selection

Above mentioned softwares (Figure 5) and their annual subscription was calculated and then , software cost for 15 stand alone servers were ascertained. The net cost that accounts for softwares for the investment model is given below

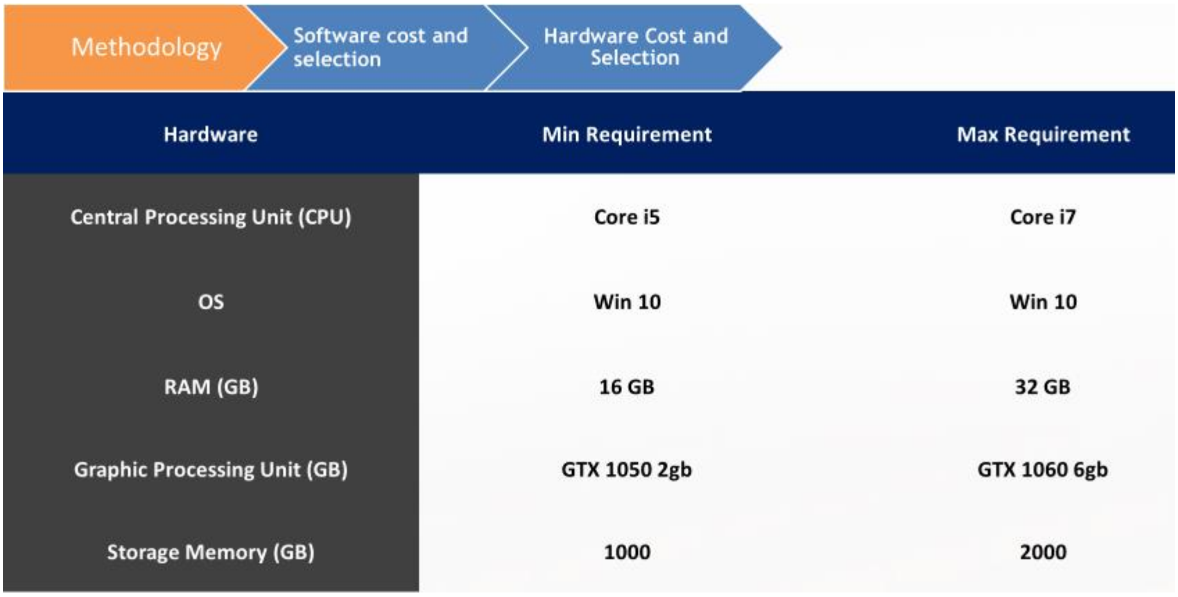
Figure 6: Software Investment Cost

Software cost accounts for **28**% of total investment model at maximum requirement and **44%** of investment model at minimum requirement respectively (Figure 6).

4.1.3 Hardware Cost:

Firstly, hardware selection was done to ensure that selected hardware is compatible with all BIM related software (Figure 7). For this, hardware requirements of each software at both standard and recommended level operations were determined from official sites of software. After consulting with computer experts, optimum specifications of hardware were selected for minimum and maximum requirements.

Cost of the hardware, both at maximum and minimum requirement, were then calculated by market and online surveys and analysis and net cost for the hardware was calculated which is displayed in the Pie chart. (Figure 8)



Methodology > Software cost and selection > Hardware Cost and Selection

Hardware	Min Requirement	Max Requirement
Central Processing Unit (CPU)	Core i5	Core i7
OS	Win 10	Win 10
RAM (GB)	16 GB	32 GB
Graphic Processing Unit (GB)	GTX 1050 2gb	GTX 1060 6gb
Storage Memory (GB)	1000	2000

Figure 7: Hardware Selection

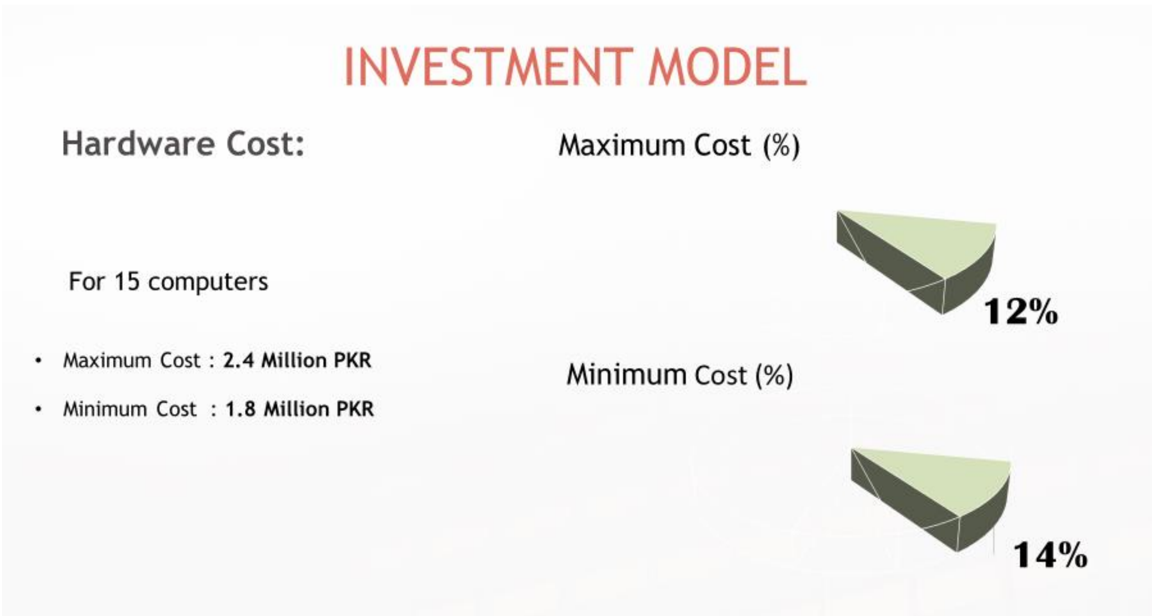
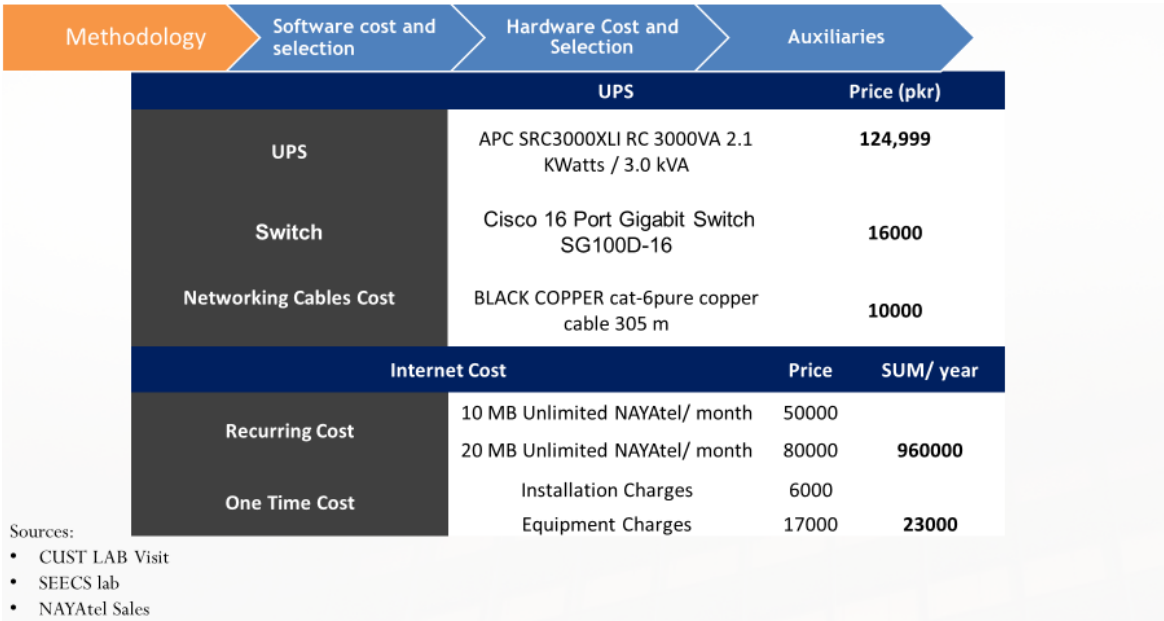


Figure 8: Hardware Investment Cost

4.1.4 Auxiliaries Cost:

Auxiliaries cost was ascertained by market and online surveys and analysis. (Figure 9)

The net cost is of all the element in hardware is shown below. The Pie-chart is demonstrating the auxiliary's percentage in the investment model. (Figure 10)



	UPS	Price (pkr)	
UPS	APC SRC3000XLI RC 3000VA 2.1 KWatts / 3.0 kVA	**124,999**	
Switch	Cisco 16 Port Gigabit Switch SG100D-16	**16000**	
Networking Cables Cost	BLACK COPPER cat-6pure copper cable 305 m	**10000**	
Internet Cost		**Price**	**SUM/ year**
Recurring Cost	10 MB Unlimited NAYAtel/ month	50000	
	20 MB Unlimited NAYAtel/ month	80000	**960000**
One Time Cost	Installation Charges	6000	
	Equipment Charges	17000	**23000**

Sources:
- CUST LAB Visit
- SEECS lab
- NAYAtel Sales

Figure 9: Auxiliaries Selection

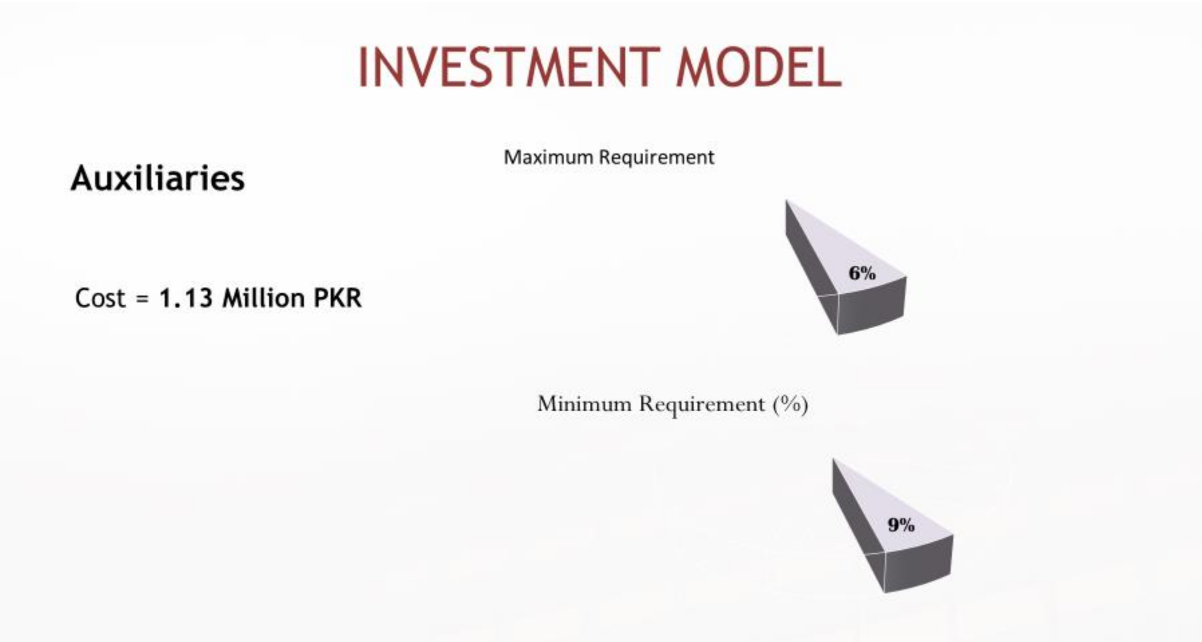


Figure 10: Auxiliaries Cost

4.1.5 Training Cost:

Training Courses that are available at minimum cost and maximum cost (Figure 11) is shown below and their Pie chart (Figure 12) is shown. Training cost was estimated from BIM experts who conduct BIM training courses and online sources. At minimum cost, training up-to level 2 of BIM is being conducted in two months whereas, all dimensions of BIM are being taught at maximum cost.

Training course, amount/head	
min	max
40000	120000

Sources : Building Information Modelling (BIM) Experts
Online Sources

Figure 11: Training Cost

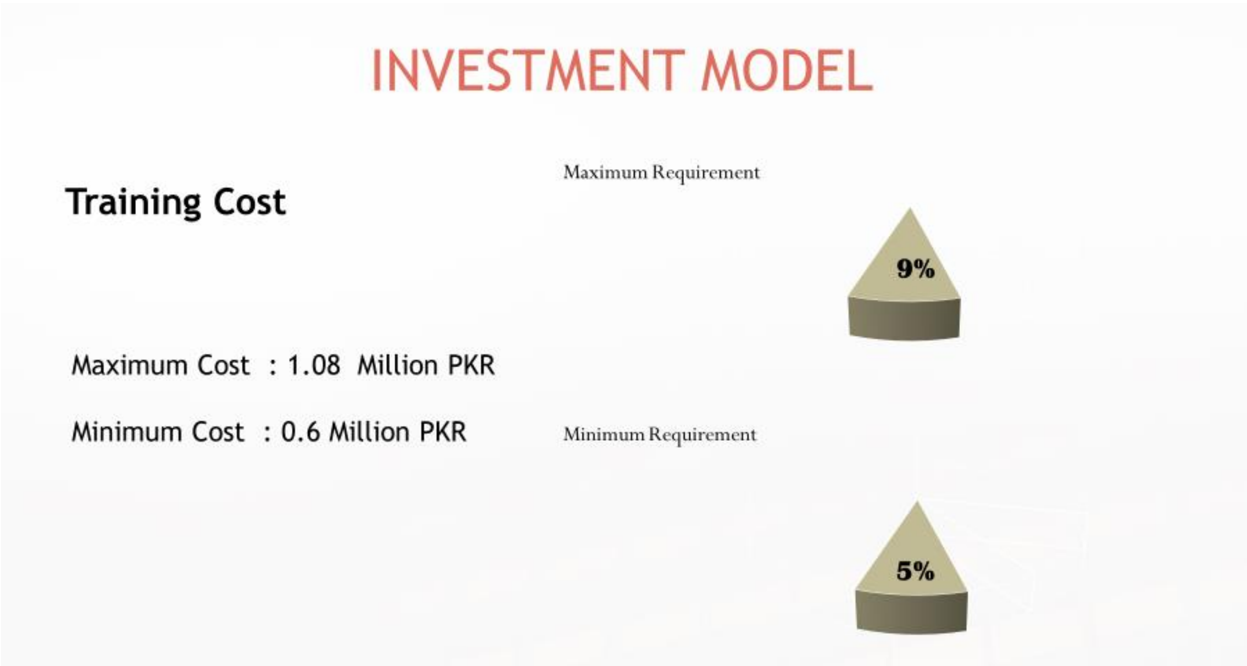


Figure 12: Training Investment Cost

4.1.6 Wages

Increment in the wages of the operator is calculated for 15 persons per months (Figure 13). It includes minimum increment for the modelers, diploma holders and maximum increment for engineers and designers.

Figure 13: Wages Increment

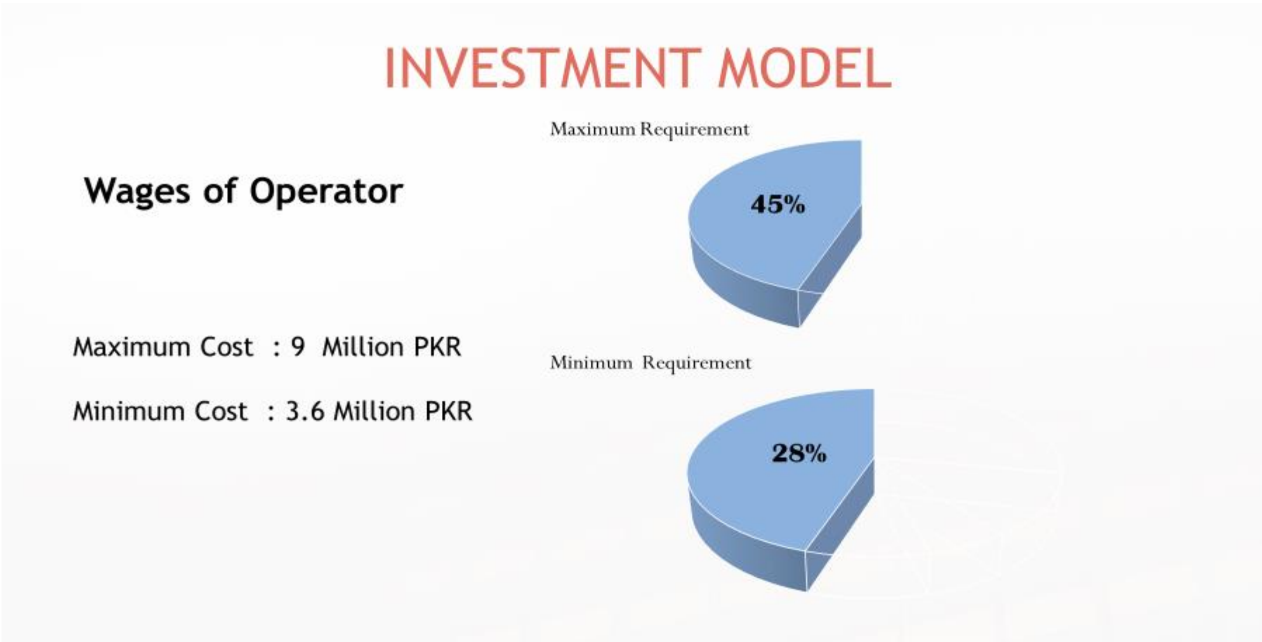


Figure 14: Wages Investment Cost

4.1.7 Total Investment model:

This Pie Chart presents the percentage of respective elements in investment model at maximum cost. (Figure 15)

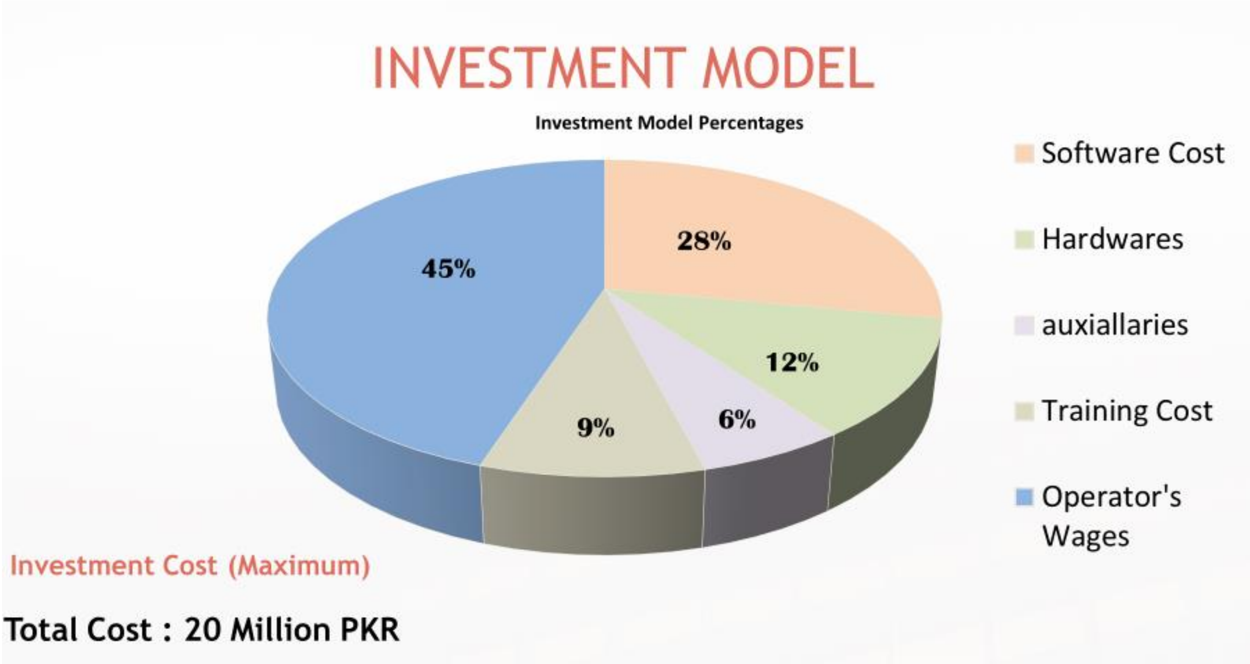


Figure 15: Maximum Investment Cost

This Pie Chart presents the percentage of respective elements in investment model at minimum cost. (Figure 16)

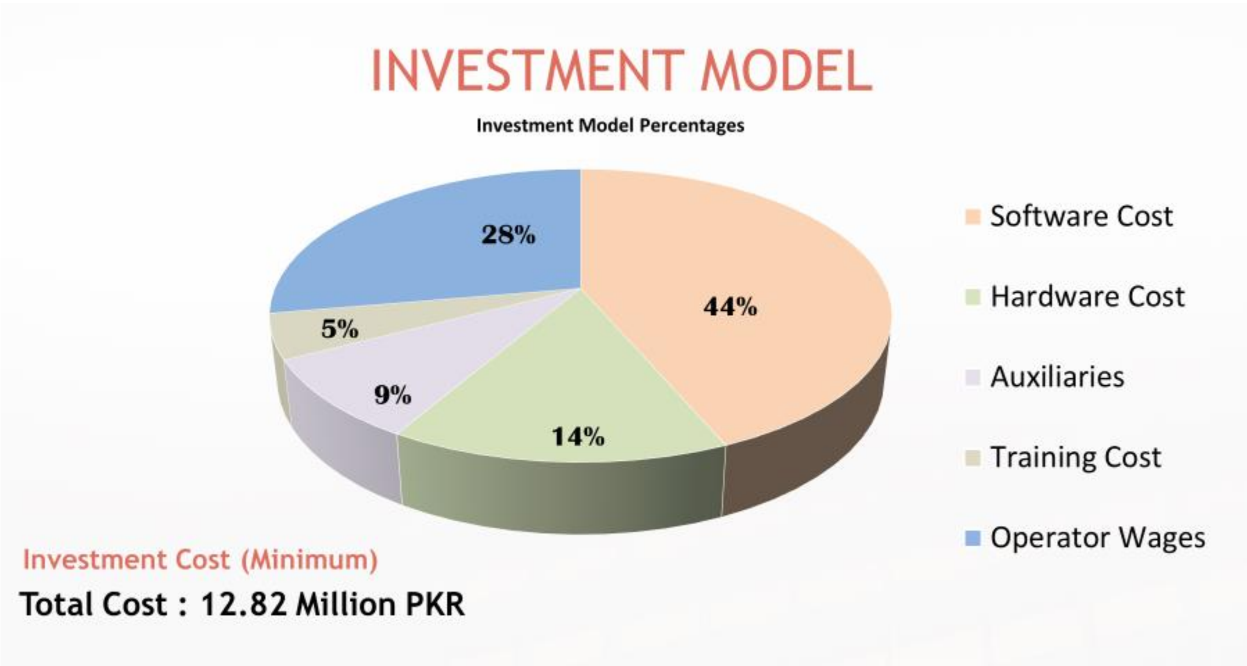


Figure 16: Minimum Investment Cost

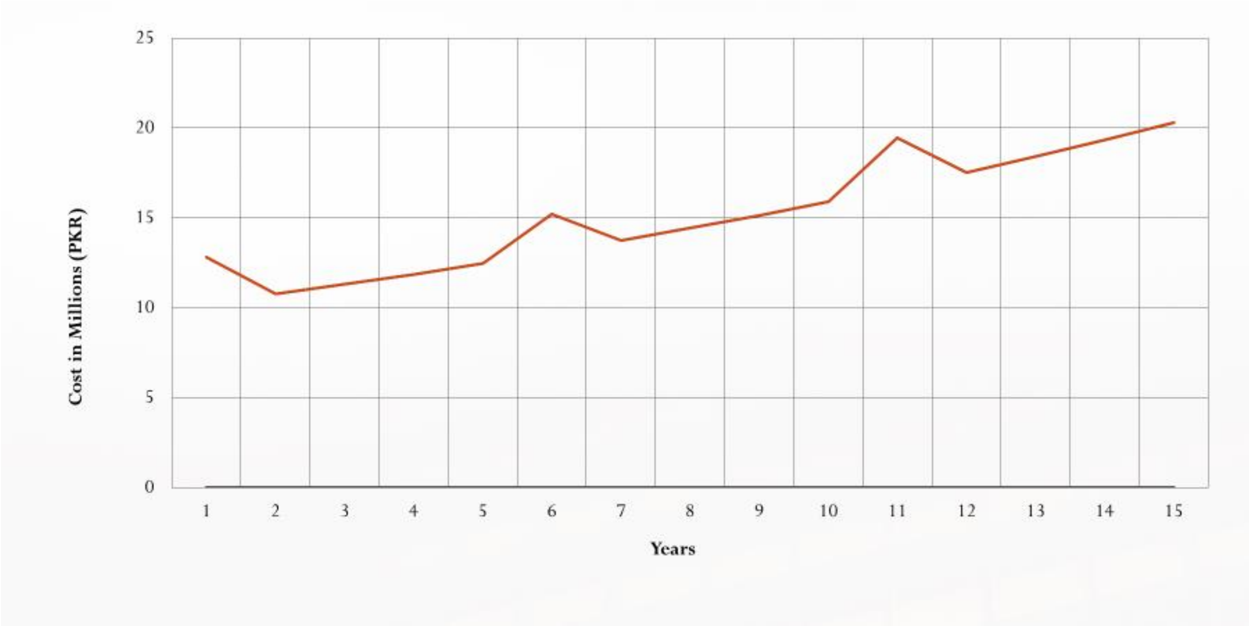


Figure 17: Total Minimum Annual Cost

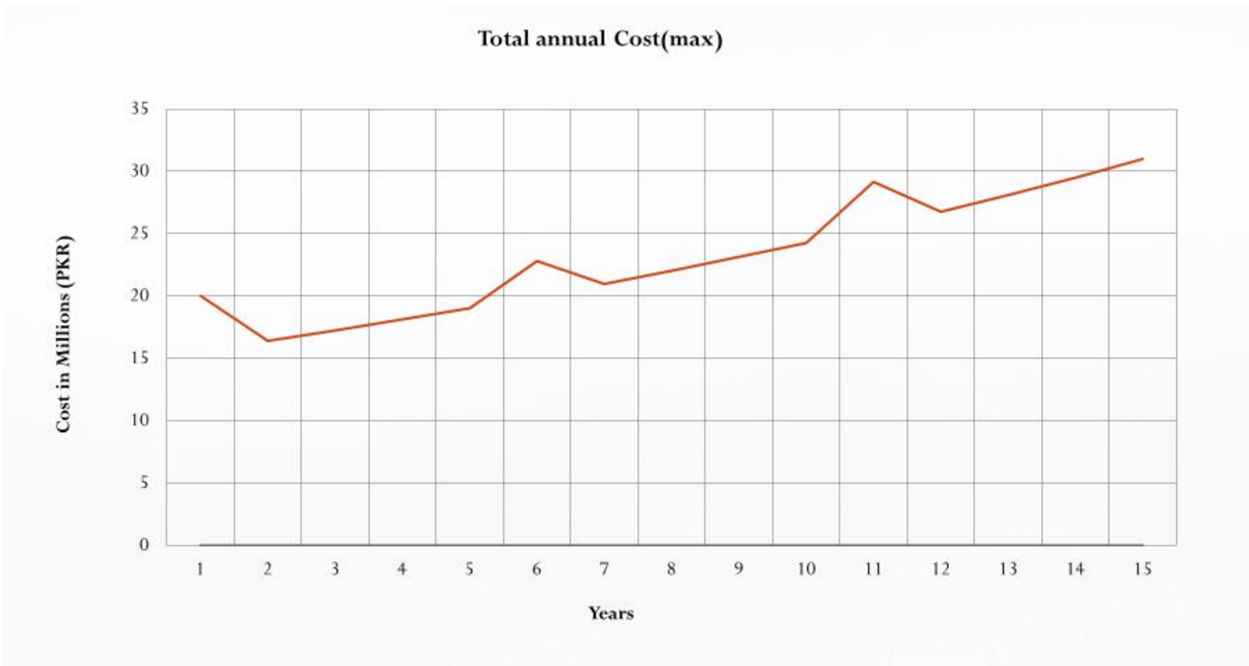


Figure 18: Total Maximum Investment Cost

The above two graph indicates that the investment model over the span of 15 years. Both follows the same pattern. (Figure 17, Figure 18)

Money is invested in buying of the hardware and other stuff in the start. Afterwards there is no paying of money apart from the subscription charges of the software and internet recurring cost. The factor of inflation is also incorporated in the graph.

Salvage of the old computers and buying of new ones are taken at every five years, which causes deviation in the graphs.

4.2 Return on Investment Model

4.2.1 Initial Research

The questionnaire was designed to identify factors that are responsible for cost overruns in Pakistan's construction industry. A total of 20 responses were collected (out of 25 distributed) from the following industry sources.

- NESPAK, Islamabad
- RADCO pvt. Ltd.
- Shahnawaz Associates
- Janjua Ent.
- Earth services Ent.
- MHU Brothers
- Habib Rafique
- MDA
- Capital Builders
- Sardar SB

After data collection from 20 literature and 20 industrial sources, a total of 49 cost overrun factors were identified (Table 1) each factor was assigned its Relative Importance Index (RII) based on its intensity/qualitative score (5 for High, 3 for Medium and 1 for Low) and its relative frequency. RII was assigned to each factor out of 10 with 5 marks for its qualitative score and 5 for relative frequency. Therefore, to obtain relative frequency score out of 5 following formula was used.

$$\boldsymbol{Relative\ Frequency} = \frac{(\boldsymbol{number\ of\ citations\ in\ different\ sources})}{\mathbf{49}} * \mathbf{5}$$

$$\boldsymbol{Relative\ Importance\ Index\ = Relative\ Frequency + Qualitative\ Score}$$

Table 1: Cost Overrun Factors

Sr. No.	Cost Overrun Factors	Relative frequency	Qualitative Score		Importance index
1	Delay in the involvement of contractor during design stage\Changes to initial design	2.702702703	Low	1	3.702702703
2	Constructability (design of building facilities with focus on ease in construction)	3.783783784	High	5	8.783783784
3	Incomplete drawings	2.972972973	High	5	7.972972973
4	Inadequate contract policies	2.567567568	Low	1	3.567567568
5	Lack of considerable data about labor productivity	2.972972973	Low	1	3.972972973
6	Absence of required clauses in the contract between client and owner	3.918918919	High	5	8.918918919
7	Poor construction skills in market	3.108108108	High	5	8.108108108
8	Lack of effective communications between stake holders	2.972972973	Medium	3	5.972972973
9	Poor assessment of the competency of the contractor	3.513513514	High	5	8.513513514
10	Inadequate planning and scheduling	3.783783784	High	5	8.783783784
11	Poor project management	2.837837838	Low	1	3.837837838
12	Poor work performance	2.972972973	High	5	7.972972973
13	Poor cost control	3.648648649	Low	1	4.648648649
14	Delays in decision making	2.702702703	Medium	3	5.702702703
15	Lack of professional behavior	2.567567568	High	5	7.567567568
16	Work suspension owing to conflicts	2.432432432	Medium	3	5.432432432
17	Delays in inspections	2.432432432	Low	1	3.432432432
18	Absence of construction cost data	3.108108108	Low	1	4.108108108
19	Poor contract management	2.432432432	Low	1	3.432432432
20	Instruction time	2.432432432	Low	1	3.432432432
21	Political unrest in the area	3.648648649	High	5	8.648648649
22	Economic ability of client	2.432432432	Medium	3	5.432432432
23	Previous working relations	2.432432432	Low	1	3.432432432

24	Category(Public, Private)	2.567567568	High	5	7.567567568
25	Client main concern construction time	2.567567568	Medium	3	5.567567568
26	Unclear perception of demand	3.243243243	High	5	8.243243243
27	Late payments of bills	2.567567568	Low	1	3.567567568
28	Wastage and scrap	2.702702703	Low	1	3.702702703
29	Delays in approvals	3.648648649	Medium	3	6.648648649
30	Design errors	3.243243243	High	5	8.243243243
31	Lack of project integration	2.702702703	Low	1	3.702702703
32	Not definite about material	2.972972973	Low	1	3.972972973
33	Incompetent site staff consultant	2.702702703	High	5	7.702702703
34	Poor site management	3.918918919	Medium	3	6.918918919
35	Change orders	3.918918919	Medium	3	6.918918919
36	Poor Cost estimation	3.243243243	Low	1	4.243243243
37	Lack of modern design tech	2.972972973	Low	1	3.972972973
38	Incompetent Subcontractor	2.837837838	Medium	3	5.837837838
39	Economic ability of Contractor	3.513513514	High	5	8.513513514
40	Cost over-runs due to EOT	2.432432432	High	5	7.432432432
41	Labor absentees and strikes	2.972972973	Medium	3	5.972972973
42	Material Shortages and its Price Escalation	4.189189189	High	5	9.189189189
43	Equipment Availability and Its failure	3.378378378	Medium	3	6.378378378
44	Project Complexity	2.702702703	Low	1	3.702702703
45	Labor Cost Estimation	2.297297297	Low	1	3.297297297
46	Shortage of Manpower	2.972972973	Low	1	3.972972973
47	Safety Managements	2.567567568	Medium	3	5.567567568
48	Environment Constraints	2.567567568	Low	1	3.567567568
49	Government Action	2.702702703	Low	1	3.702702703

Subsequently, all factors were arranged in descending order of their RII and Relative Score of each factor was calculated by the formula:

$$\boldsymbol{Relative\ Score} = \frac{\boldsymbol{Cummulative\ Score}}{\boldsymbol{Sum\ of\ RII}}$$

The analysis identified 18 factors that achieved 50% of the score, that is, they had the same potential of causing cost overruns in a project as rest of the factors combined. Therefore, these 18 factors were shortlisted as the basis of further study. (Table 2)

Table 2: Cost Overrun Factors with Highest RII

Sr. #	Cost Overrun Factors	Descending Order of Imp. Index	Cumulative Score	Relative Score
1	Material Shortages and its Price Escalation	9.189189189	9.189189189	0.032414911
2	Absence of required clauses in the contract between client and owner	8.918918919	18.10810811	0.063876442
3	Constructability (design of building facilities with focus on ease in construction)	8.783783784	26.89189189	0.094861283
4	Inadequate planning and scheduling	8.783783784	35.67567568	0.125846125
5	Political unrest in the area	8.648648649	44.32432432	0.156354276
6	Poor assessment of the competency of the contractor	8.513513514	52.83783784	0.186385737
7	Economic ability of Contractor	8.513513514	61.35135135	0.216417199
8	Unclear perception of demand	8.243243243	69.59459459	0.245495281
9	Design errors	8.243243243	77.83783784	0.274573363
10	Poor construction skills in market	8.108108108	85.94594595	0.303174754

11	Incomplete drawings	7.972972973	93.91891892	0.331299457
12	Poor work performance	7.972972973	101.8918919	0.359424159
13	Incompetent site staff consultant	7.702702703	109.5945946	0.386595481
14	Lack of professional behavior	7.567567568	117.1621622	0.413290113
15	Category (Public, Private)	7.567567568	124.7297297	0.439984746
16	Cost over-runs due to EOT	7.432432432	132.1621622	0.466202689
17	Poor site management	6.918918919	139.0810811	0.49060921
18	Change orders	6.918918919	146	0.515015731

4.2.3 Industrial Survey (Cost Overrun)

Questionnaires were distributed in hard form and a total of 42 responses were collected from industry, out of 50 distributed. The data was collected from the following sources of which 70% were contractors, 20% consultants and rest contractors:

- Bahria Town PVT. LTD.
- Izhar PVT. LTD.
- Sukh Chain Residency F-10 Islamabad
- FWO
- Kazmi Builders
- RADCO PVT LTD
- NESPAK, Islamabad
- Shahnawaz Associates
- Janjua Ent.
- Earth services Ent.
- MHU Brothers
- Habib Rafique
- MDA
- Capital Builders

- Sardar SB
- Malik Habib Hanan & Sons PVT LTD
- PMO NUST
- Zeerak Builder PVT LTD
- Mughal Contractors PVT LTD

The survey data showed that project cost of a 5-15 story building can range from PKR 40 million to PKR 1.62 billion and the time of completion from 8 months to 3 years. Similarly, the data showed that total overruns in the project can go up-to PKR 93 million if all 18 factors simultaneously occur. (Table 3)

Table 3: Cost and Time Overrun of Each Factor

Sr. #	Cost Overrun Factors	Response 1 (Bahria Town)		Response 2 (Sukh Chain)		Response 15 (NESPAK)	
		Total Cost= 1.0 Billion		Total Cost= 1.0 Billion		Total Cost= 70 million	
		Overrun Cost against each factor		Overrun Cost against each factor		Overrun Cost against each factor	
		%	cost	%	cost	%	cost
1	Material Shortages and its Price Escalation	20%	200000000	2%	20000000	10%	7000000
2	Absence of required clauses in the contract between client and owner	3%	30000000	5%	50000000	0%	0
3	Constructability (design of building facilities with focus on ease in construction)	0%	0	3%	30000000	0%	0
4	Inadequate planning and scheduling	0%	0	2%	20000000	0%	0

5	Political unrest in the area	2%	20000000	5%	50000000	0%	0
6	Poor assessment of the competency of the contractor	6%	60000000	5%	50000000	0%	0
7	Economic ability of Contractor	2%	15000000	5%	50000000	0%	0
8	Unclear perception of demand	2%	20000000	3%	30000000	0%	0
9	Design errors	2%	20000000	2%	20000000	2%	1400000
10	Poor construction skills in market	3%	30000000	1%	10000000	0%	0
11	Incomplete drawings	3%	30000000	1%	10000000	1%	700000
12	Poor work performance	0%	0	0%	0	1%	700000
13	Incompetent site staff consultant	2%	20000000	5%	50000000	1%	700000
14	Lack of professional behavior	0%	0	0%	0	1%	700000
15	Category (Public, Private)	6%	60000000	5%	50000000	0%	0
16	Cost over-runs due to EOT	2%	20000000	2%	20000000	15%	10500000
17	Poor site management	3%	30000000	5%	50000000	0%	70000
18	Change orders	5%	50000000	5%	50000000	0%	14000

4.2.4 BIM Expert Opinion (BIM Savings)

A Google questionnaire was sent to 6 BIM experts out which 5 responses were received. Two of the respondents had 0-5 years of experience while three had 5-10, 10-15 and more than 15 years of experience respectively. Sixty percent of the respondents were from academia and 40% were contractors. Credentials of BIM experts are as follows

- **Dr. Abdur Rehman (HOD Research, NICE, NUST)**
  Experience: DESCON Engineering Ltd. – (Contracts Engineer), SMEC Pty Ltd. – (Contracts & Planning Engineer)
- **Dr. S. Shujaa Safdar (PhD Uni. Teknologi PETRONAS, Malaysia**)
  (**Experience:** More than 15 years **(**NESPAK, CWO)
  Publications: "4D BIM Application in AEC Industry: Impact on Integrated Project Delivery", Research Journal of Applied Sciences, Engineering and Technology, Pages: 547-552, 2015)
- **Mr Abaid-ur-Rehman (SADA, NUST)**
  Experience: 3 years (Qatar Railways station facilities with Typccca, facility management in collaboration with Mitsubishi, Seimen's and Hitachi**)**
- **Mr Zubair (REDCO intl. Qatar)**
  Experience: 3 years (Qatar Railways station facilities with Typccca, facility management in collaboration with Mitsubishi, Siemen's and Hitachi**)**
- **Mr Sami-ur-Rehman: (MS in Construction Engineering and Management, NIT, NUST)**
  Experience: 4 years. Modelling of new Boys Hostel at NUST.
- **Rehan Masood (University of Auckland)**

The collected data quantified total savings from a project by giving the average response against each factor (Table 4). Total savings of a project came out to be PKR 38 million. Rest of the calculations will be discussed in statistical analysis.

Table 4: BIM Experts Responses

Sr. #	**Cost Overrun Factors**	**BIM Expert Opinion Response**				
		Response	**Response**	**Response**	**Response**	**Response**
		Zubair	**Abaid ur Rehman**	**Dr Shuja Safdar**	**Rehan Masood**	**Muhammad Sami**
		%	**%**	**%**	**%**	**%**

1	Material Shortages and its Price Escalation	65%	15%	15%	45%	25%
2	Absence of required clauses in the contract between client and owner	25%	5%	15%	35%	15%
3	Constructability (design of building facilities with focus on ease in construction)	65%	25%	75%	85%	45%
4	Inadequate planning and scheduling	45%	15%	65%	65%	55%
5	Political unrest in the area	0%	0%	0%	0%	0%
6	Poor assessment of the competency of the contractor	35%	25%	25%	55%	15%
7	Economic ability of Contractor	35%	15%	5%	45%	5%
8	Unclear perception of demand	45%	25%	5%	45%	15%
9	Design errors	75%	25%	35%	55%	65%
10	Poor construction skills in market	25%	25%	35%	55%	15%
11	Incomplete drawings	75%	25%	35%	85%	75%
12	Poor work performance	35%	15%	35%	75%	15%
13	Incompetent site staff consultant	25%	25%	35%	75%	15%
14	Lack of professional behavior	15%	15%	35%	75%	15%
15	Category (Public, Private)	35%	15%	45%	65%	15%
16	Cost over-runs due to EOT	25%	25%	55%	65%	45%
17	Poor site management	45%	15%	55%	65%	35%

18	Change orders	75%	15%	65%	85%	65%

4.3 Statistical Analysis

4.3.1 Total cost overrun

Results of industrial questionnaire were statistically analyzed to determine total cost overruns. For this, standard deviation formula was applied to get mean average cost of the project. Since, the project costs ranged from PKR 40 million to PKR 1.62 billion so to exclude outliers mean average cost of the project was calculated. (Figure 19)

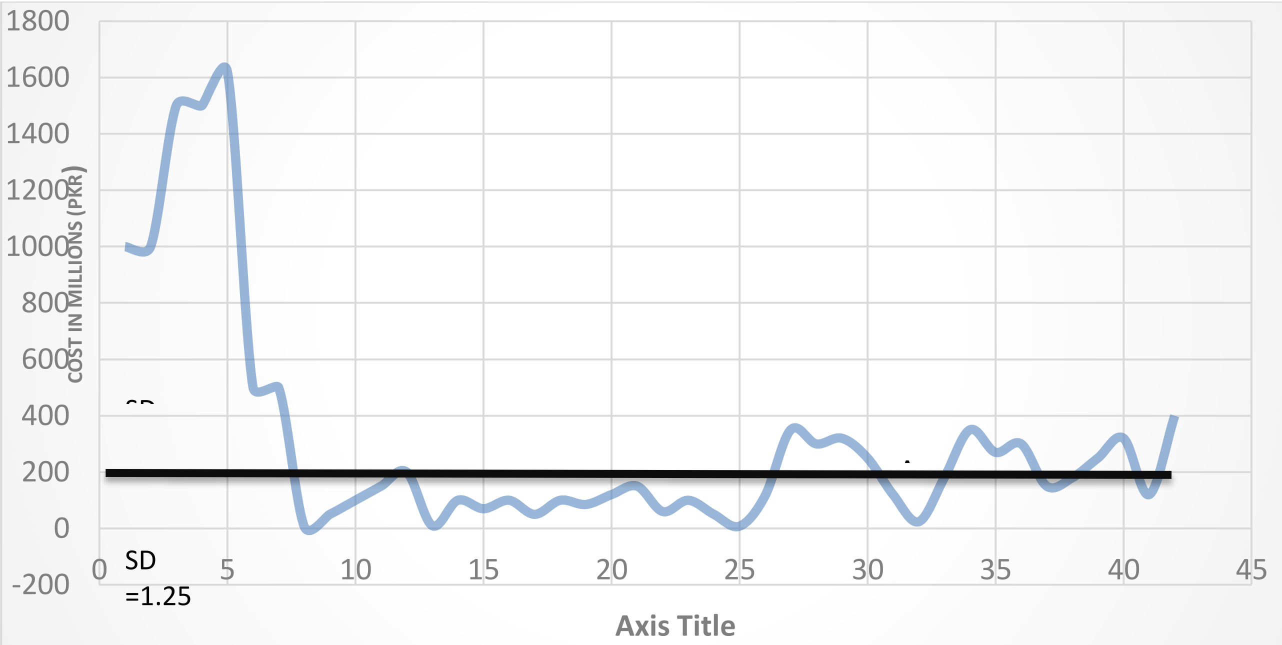


Figure 19: Total Project Cost

After applying 1.25 standard deviation (75% of data) mean average cost of the project turned out to be PKR 210 million. Horizontal line in above graph shows the mean average cost of project.

To find total overrun cost, average response of cost overrun against each factor by industry personnel was averaged and multiplied with the total project cost. The result showed that sum of overrun cost was PKR 94 million. (Table 5: Total Overrun CostTable 5)

Table 5: Total Overrun Cost

Sr #	Cost Overrun Factors	Average response 210000000 Overrun Cost against each factor	
		%	cost
1	Material Shortages and its Price Escalation	7%	14086577.38
2	Absence of required clauses in the contract between client and owner	2%	3583928.571
3	Buildability(design of building facilities with focus on ease in construction)	2%	3944040.179
4	Inadequate planning and scheduling	2%	4154315.476
5	Political unrest in the area	2%	4135565.476
6	Poor assessment of the competency of the contractor	1%	2797964.286
7	Economic ability of Contractor	1%	2206505.952
8	Unclear perception of demand	1%	2820535.714
9	Design errors	5%	10190334.82
10	Poor construction skills in market	1%	2797872.024
11	Incomplete drawings	3%	6034017.857
12	Poor work performance	1%	1947232.143
13	Incompetent site staff consultant	2%	3408340.825
14	Lack of professional behaviour	1%	1886064.758
15	Category(Public,Private)	2%	4098214.286
16	Cost over-runs due to EOT	6%	12856040.64
17	Poor site management	2%	3884436.063
18	Change orders	4%	9097698.686

4.3.2 Total Savings

To calculate total savings, average response from BIM experts against each factor (% solution of each factor) was multiplied with respective overrun cost of each factor calculated in pervious step. (Table 6). Sum of the total savings in a project turned out to be PKR 47.46 million

Table 6: Total Savings

Sr #	Cost Overrun Factors	(BIM Expert Opinion) Average Response Savings	
		Avg. Response (%)	Cost
1	Material Shortages and its Price Escalation	33%	4648570.536
2	Absence of required clauses in the contract between client and owner	19%	680946.4286
3	Buildability(design of building facilities with focus on ease in construction)	59%	2326983.705
4	Inadequate planning and scheduling	49%	2035614.583
5	Political unrest in the area	0%	0
6	Poor assessment of the competency of the contractor	31%	867368.9286
7	Economic ability of Contractor	21%	463366.25
8	Unclear perception of demand	27%	761544.6429
9	Design errors	51%	5197070.759
10	Poor construction skills in market	31%	867340.3274
11	Incomplete drawings	59%	3560070.536
12	Poor work performance	35%	681531.25
13	Incompetent site staff consultant	35%	1192919.289
14	Lack of professional behaviour	31%	584680.0749
15	Category(Public,Private)	35%	1434375

16	Cost over-runs due to EOT	43%	5528097.475
17	Poor site management	43%	1670307.507
18	Change orders	61%	5549596.199

The average project duration for 210 million project was 17 months which was calculated from the responses of industry personnel. Since, the last deliverable of the study, breakeven analysis, was based on annual costs of investment and return on investment, total savings were also required to be calculated annually. For that purpose, total savings per year were calculated to be PKR 38 million in 12 months.

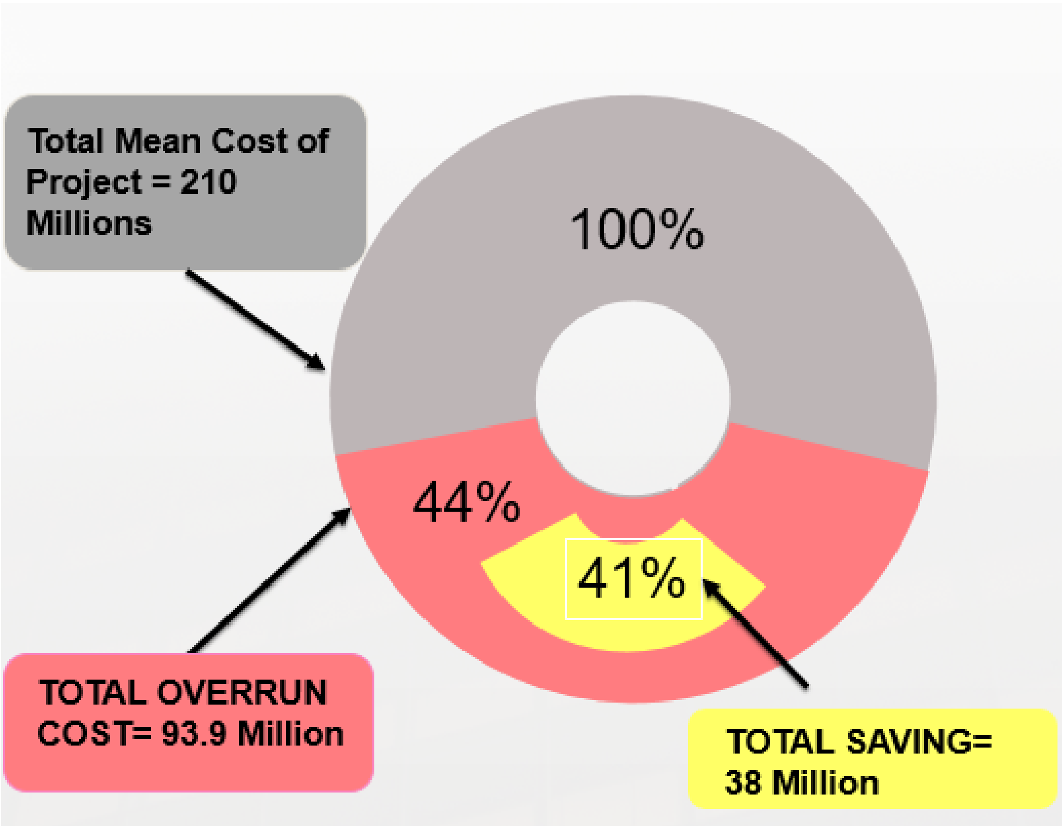


Figure 20: Return on Investment Model

4.3.3 Breakeven Analysis

Breakeven analysis was done to determine the time span in which total investment cost of BIM would be returned by BIM savings and the investor would eventually be able to reap financial benefits of BIM.

The analysis was carried out by simply subtracting cumulative total annual investment costs (min, max) of each year from cumulative total savings of the respective year. For the minimum investment requirements, breakeven was achieved in just 9 months. (Figure 21)

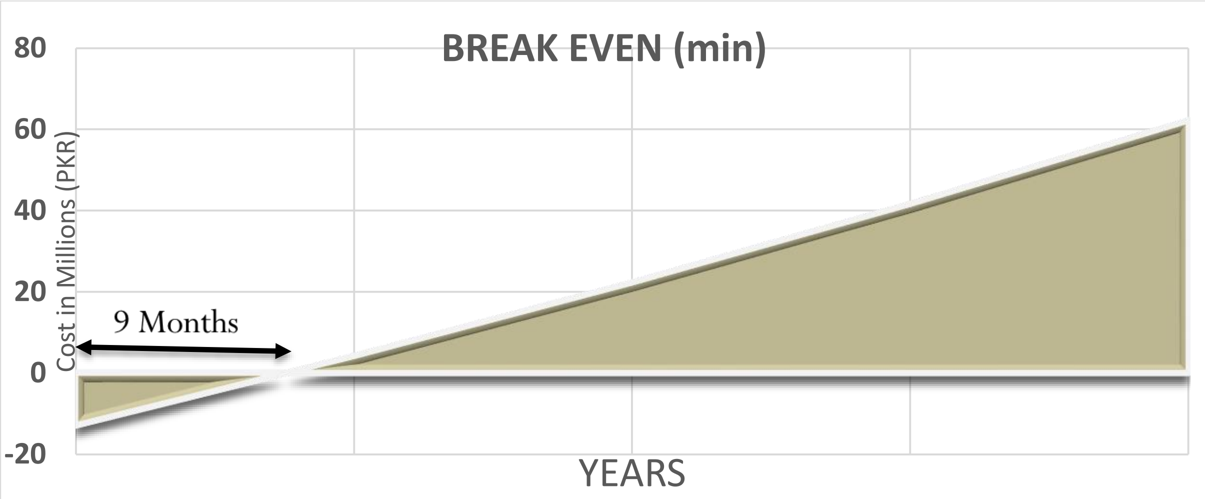


Figure 21: Minimum Breakeven Period

Whereas, for max investment requirements, breakeven was achieved in 21 months. (Figure 22)

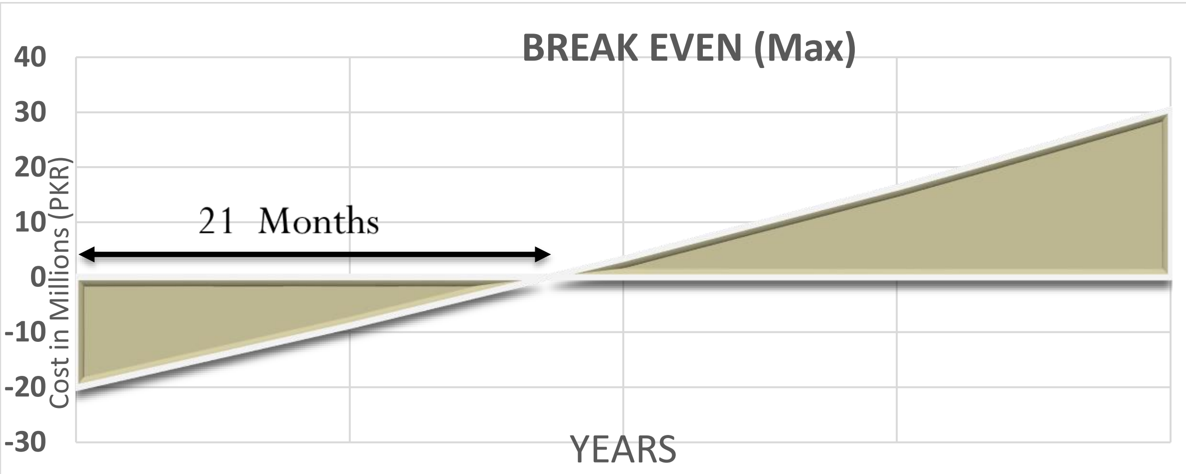


Figure 22: Maximum Breakeven Period

As stated by (Giel & Issa, 2011), Return on Investment is only the function of change orders and Requests for Information whereas, this study shows that change orders only accounts for 9.09 PKR million out of total overrun cost of 94 PKR million. This shows that only change orders and RFIs cannot be taken as the benchmarks for calculating total savings that BIM has to offer. Moreover, another study (Gilligan & Kunz, 2007)) states that, total investment cost of BIM at "Holder's Hilton Aquarium project in Atlanta was $90000 (Gilligan & Kunz, 2007)", which, only by clash detection, saved up-to $600,000 and 1143 scheduling hours. However, this study does not calculate time savings by BIM. Furthermore, (Gilligan & Kunz, 2007) relies on BIM benefits only in design stage but this study ranges cost overrun factors from design to execution phase of a project, for instance, incompetent site staff consultant, poor work performance and cost over-runs due to EOT

CHAPTER 5

5.1 Conclusion:

Focus of study was to evaluate BIM's financial stability for construction industry Pakistan if it were to be implemented. Results were achieved by developing investment and return on investment model.

This studies shows that after comprehensive analysis the cost of investing in BIM setup from hardware, software to operator training cost resulted in 12.8 Million PKR for first year, after that accommodating immediate years for non-recurring costs, with minimum recommended setup whereas for maximum and high end usage cost was 20 Million PKR.

Study was developed and carried out for average 210 million PKR project which was derived from detailed statistical analysis. The study shows that implementing BIM for single project of 210 Million PKR results in cost saving of 38 Million PKR per project. The study also indicates that projects costing more than averaged project resulted in increased saving whereas proportional behavior was also seen in low cost projects.

The ROI model presents that for minimum investment in BIM setup the breakeven was achieved in 9 months with a standard average single project of 210 Million PKR every year and after that revenues were increasing exponentially. ROI model for maximum investment in BIM for high end usage resulted in breakeven duration of 21 months for a standard average single project of 210 Million PKR every year and afterwards the similar exponential increase in revenues was seen.

Thus, this study concludes that BIM is financially stable setup for construction industry Pakistan with early break evens and will play key role in terms of saving project cost and eliminating inefficient practices. This study will prove to be a critical decision-making point for stakeholders interested in investing in BIM.

5.2 Suggestions and Recommendations:

Construction industry Pakistan still lacks even basic awareness of BIM. Majority of people are not aware about BIM and its functionality thus making it very difficult for studies and projects to be carried out related to BIM. Reluctance towards the adoption of BIM for construction industry still prevails as people are more leaned towards conventional construction practices and acceptability of new tools and techniques is relatively less

The results of above study are only achievable if BIM is integrated in whole life cycle of project since BIM is name of process rather than only analysis or modeling software. Therefore, integration of BIM in every phase of project construction is necessary in order to reap its full benefits.

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