THE REPUBLIC OF TURKEY
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DETERMINING SCALE FOR BIM IMPLEMENTATION IN ARCHITECTURAL DESIGN PRACTICE: THE CASE OF PAKISTAN

Master's Thesis

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THE REPUBLIC OF TURKEY

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Istanbul, 2018 Uzair Maqsood

ABSTRACT

DETERMINING SCALE FOR BIM IMPLEMENTATION IN ARCHITECTURAL DESIGN PRACTICE: THE CASE OF PAKISTAN

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Digital media is reshaping our community by bringing significant changes to each discipline. Many professions are converting to digital tools such as architectural, engineering, and construction (AEC) field. Among various digital AEC tools in the market, Building Information Modeling (BIM) has been gaining a significant appreciation for making the design, construction and operation of buildings much more streamlined and efficient (Coates et al., 2010). Implementation of BIM in developing countries such as Pakistan, is still facing a bundle of limitations, such as lack of investment, trained personnel and conventional ways of practice, etc. This thesis aims to determine optimum scales, adoption strategies and introduce a roadmap for BIM implementation for architectural design practice in Pakistan. In chapters, firstly, a literature survey will be conducted in which BIM concept will be explained within its historical development and BIM applications in different countries will be examined. In case study, surveys and face-to-face interviews will be conducted with BIM users and non-BIM users in the architecture offices throughout Pakistan. Based on the results of the survey, the most optimum scales for BIM applications in Pakistan will be determined and a roadmap for BIM implementation process will be proposed.

Keywords: BIM, Implementation Strategies, Architectural Project, Scale, Pakistan

ÖZET

MİMARİ TASARIMDA BİM UYGULAMALARI İÇİN ÖLÇEK BELİRLENMESİ: PAKİSTAN ÖRNEĞİ

Uzair Maqsood

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Dijital medya, her alanda önemli değişiklikler yaparak toplumumuzu yeniden şekillendirmektedir. Mimarlık, mühendislik ve inşaat gibi çoğu alanda projeler sayısal araçlarla yürütülmektedir. Piyasadaki çok çeşitli sayısal araç arasından, Bina Bilgi Modellemesi (BBM), binaların tasarımlarını, inşalarını ve işletimlerini daha akıcı ve verimli hale getirmede önemli bir değer kazanmıştır (Coates et al., 2010). BBM uygulamaları, Pakistan gibi halihazırda gelişmekte olan ülkelerde, yatırım eksikliği, eğitimli personel ve geleneksel uygulama yöntemleri gibi nedenlerden ötürü gibi bir takım sınırlamalarla karşılaşmaktadır. Bu tez, Pakistan'da mimari tasarım alanındaki BIM uygulamaları için bir yol haritasının sunulmasını, uygun ölçek ve uyum stratejilerinin belirlenmesini amaçlamaktadır. Bölümlerde öncelikle BBM kavramı tarihsel gelişimi ile açıklanarak, farklı ülkelerdeki BBM uygulamalarının inceleneceği bir literatür araştırması yapılacaktır. Alan çalışmasında, Pakistan genelindeki mimarlık ofislerinde BBM kullanıcıları ile kullanıcı olmayanlar ile anketler ve yüz yüze görüşmeler yapılacaktır. Anket sonuçlarına dayanarak, Pakistan'daki BBM uygulamaları için en uygun ölçekler belirlenecek ve BBM'ye uyum süreci için bir yol haritası önerilecektir.

Anahtar Kelimeler: Bina Bilgi Modellemesi, Uyum Stratejileri, Mimari Proje, Ölçek, Pakistan

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ABBREVIATIONS

AEC	:	Architecture, Engineering and Construction
BIM	:	Building Information Modeling
BSA	:	Building Smart Alliance (UK)
CAD	:	Computer Automated Design
CDE	:	Common Data Environment
COBie	:	The Construction-Operations Building Information exchange
CoPS	:	Complex Products and Systems
DDB	:	Det digital biggeri" (The digital construction)
FRS	:	Framkvæmdasýsla Ríkisins
GSA	:	General Services Administration
IFC	:	Industry Foundation Classes (IFC)
L	:	Large
LOD	:	Level of development
M	:	Medium
NGO	:	Non Governamental Organizations
NIBS	:	National Institute Of BIM Services (USA)
S	:	Small
XL	:	Extra Large

1. INTRODUCTION

This thesis aims to find out BIM adoption levels in Pakistan and to define the most optimum project scales, roadmap, and BIM adoption strategies. Pakistan is a developing country with immense current and forecast investment projects in AEC industry. Due to the increasing necessity of collaboration between different groups of architects, engineers, and constructors, the notice about the potentials of BIM shall be spotted, and barriers to its implementation shall be removed. Hence it is essential to understand the current strengths, weaknesses, and limitations of BIM implementation.

1.1 AIM AND SCOPE OF STUDY

This thesis aims to specify the BIM implementation strategy for architectural projects in Pakistan. Professionals in developing countries still handle their projects through traditional ways which lead to several limitations and complexities in professional practice. The research will be examining the Pakistan case through surveying professionals in the architecture industry.

This research focuses on professional architectural practice in Pakistan and its implementation of BIM, which is considered to be one of the most promising tools for information visualization and collaboration. Throughout the thesis, general information about BIM was given, and various BIM implemented local projects were referred. To detect the limitations and complexities of BIM implementation, a questionnaire was conducted with local professional architects. The data was then converted into graphs and tables, in order to find out the specific scales at which BIM may be useful for overcoming the limitations and complexities of conventional practice and provide a strategy for BIM implementation in Pakistan. Besides, face to face interviews were held in order to question the general tendency and the need for further BIM implementation.

1.2 METHODOLOGY

This study emphasizes on determining a roadmap for BIM implementation in architectural design practice in Pakistan. After the introduction part, Chapter 2 is a literature review, focusing on BIM implementation around the globe in seven continents and NGO’s working on several BIM related issues such as policies, regulations, implementation scales, and levels, etc., In Chapter 3, a survey was designed to find out about the existing BIM implementation levels in Pakistan. The survey was classified into three categories: Common Questionnaire, BIM User Questionnaire, and NON-BIM User Questionnaire. The common questionnaire was filled by all the firms to define their position in the market of Pakistan Professional Practice. BIM User Questionnaire is handled to BIM implementing firms in order to determine the limitations they have to overcome and the scale of projects BIM is most efficient in professional architectural practice. On the other hand, Non-BIM User Questionnaire is handled to firms practicing with traditional/conventional methods to find out the kind of limitations and the scale of projects which have more limitations in professional architectural practice.

After conducting these surveys, desired information is gathered to define the significance and necessity of BIM implementation, roadmap for implementation and specific project scale of for efficient BIM implementations. Future suggestions will be made for the advancement of BIM implementation through educational and institutional systems.

2. LITERATURE REVIEW

The literature review includes a definition of BIM, its dimensions, benefits, advantages of BIM over the conventional method, adoption of BIM globally, organizations working for the optimization of BIM implementation.

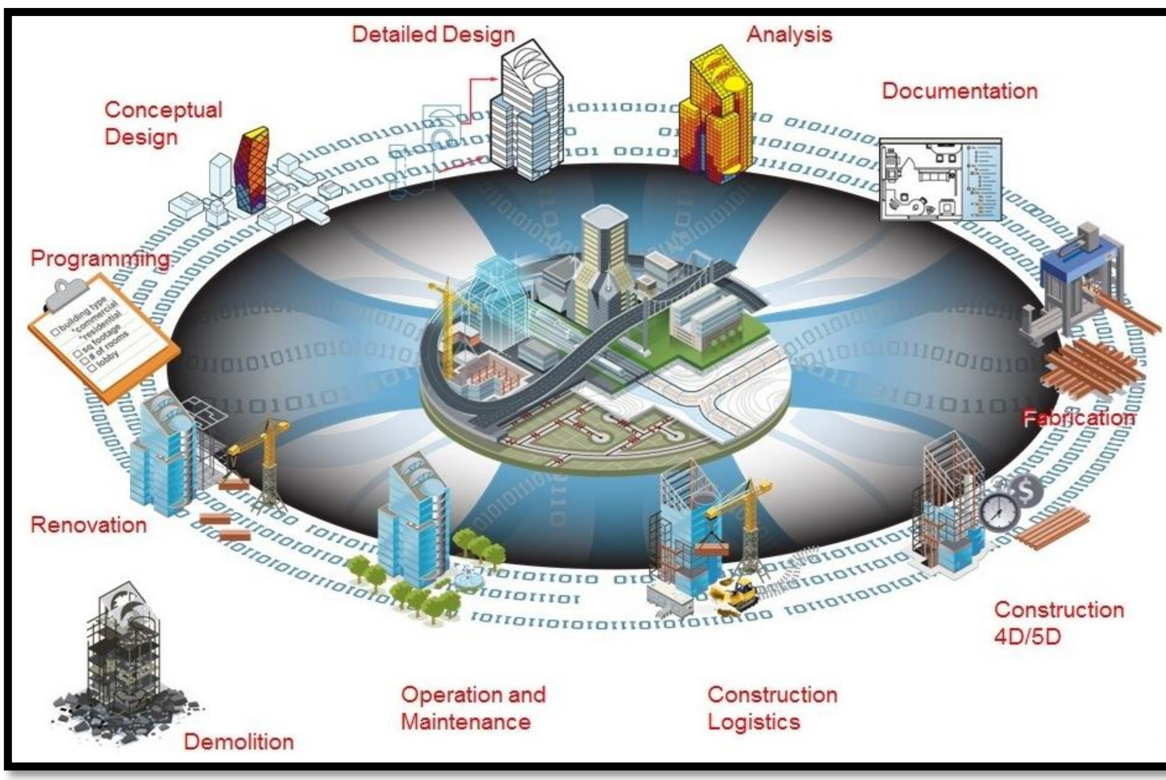
2.1 DEFINITION OF BIM

Definitions of BIM are changing continuously due to the rapid development of AEC industry (Migilinskas et al., 2013). Due to of rapid evaluation BIM is described in different ways at different times, thus still it has no standard definition (Lee et al., 2013). Similarly, U.S. Government General Services Administration defines BIM as "*the development and use of a multi-faceted computer software data model to not only document a building design but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility* (GSA, 2007)". British Standard Institution defines BIM as "*the process of design, construction and use of the building or facility infrastructure using information about virtual objects* (P.A.S., 1192-3: 2014)". Building Smart, a non-profitable organization working in UK which supports the idea of Open BIM gives a more detailed description of BIM "*a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition* (building smart, 2010)".

To sum up, as seen in Figure 2.1, within AEC industry BIM presents a collaborative model between the different phases of the project which depends on simulating physical characteristics of the building. These characters are present regarding several dimensions (3D Model, 4D time, 5D scheduling, 6D energy sustainability, and facility management, nD several other facilities such as information, etc). In another way, BIM can also be defined as the act of creating and using a building information modeling. Considering the context of AEC industry BIM helps to achieve project goals of a team in efficient time with precise numbers. (Haron, Marshall, and Aouad, G.F., 2010)

Probably the most robust vision about architect's BIM implemented work belongs to American Engineer Englebart: "*(...) the architect next begins to enter a series of specifications and data–a six-inch slab floor, twelve-inch concrete walls eight feet high within the excavation, and so on. When he has finished, the revised scene appears on the screen. A structure is taking shape. He examines it, adjusts it… These lists grow into an ever-more-detailed, interlinked structure, which represents the maturing thought behind the actual design* (Engelbart and English., 1968)". His description may be accepted as an early impression of how BIM can have significant and inevitable influence on architectural practice. Such as Similov's (2007), who affirms that the reduction in tedious computation from 2D drawings for many tasks is a 'step in the right direction' for building project delivery(Smilow, 2007). Such a change is likely to have a significant impact on the time for any project. To understand the benefits of BIM implementations, we need to know the dimensions of BIM.

Figure 2.1: BIM process



Source: www.Autodesk.com

2.1.1 Dimensions of BIM

BIM dimensions are referred to a specific type of Data, a link with information model. By the addition of dimensions, we can get a better understanding of the construction project (delivery of the project, cost, facility maintenance, etc). Following are the Dimensions of BIM discussed in detail, according to National BIM services in the UK (McPartland, R., 2017).

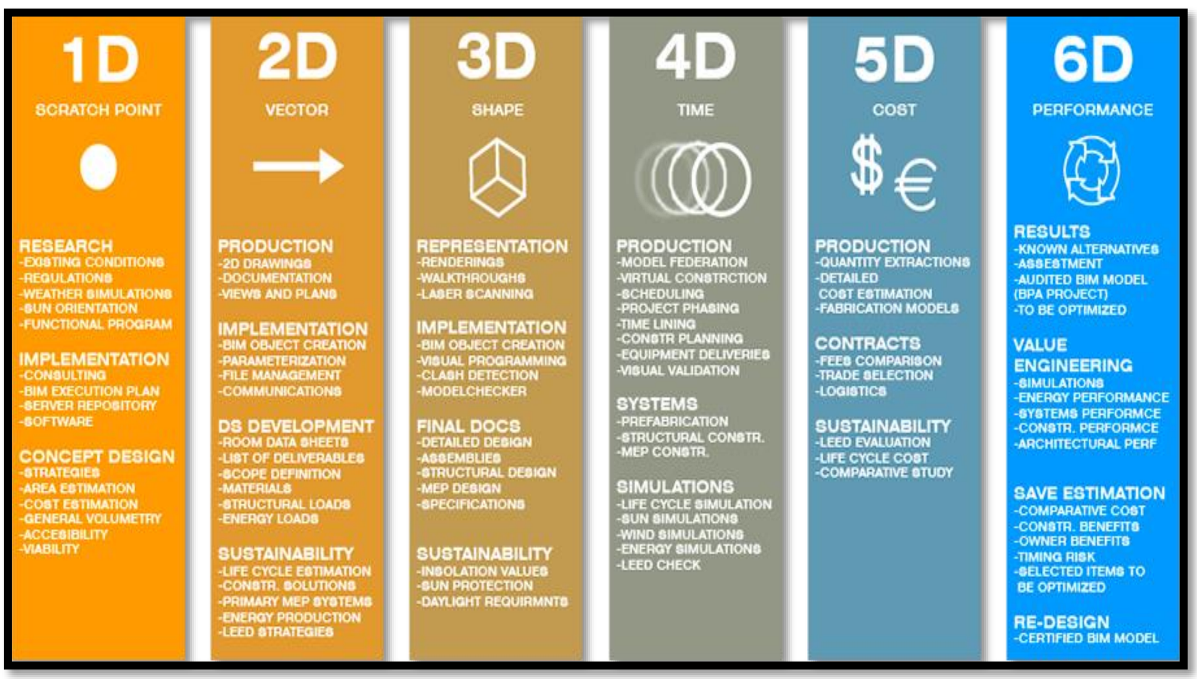
BIM 3D is perhaps the BIM we are most familiar with. It is a process of creating graphical and non-graphical information and sharing this information in a Common Data Environment (CDE) (McPartland, R., 2017). It is also known as the Virtual 3D Parametric model, which is widely accepted and practiced by designers. In the project of life cycle progression, this information of 3D becomes more productive by introducing more dimensions (4D – 6D) into it.

4D BIM adds an extra dimension of information to a project model in the form of scheduling data. This information is used to develop an accurate construction sequence of the project. Accurate construction sequence is directly linked with time management "scheduling" of the construction process. By creating the accurate project plan, this data is linked to the graphical representation of component installation. This visual database makes it easy to understand construction sequence and overtime at each stage how the structure will visually appear. Adding 4D to any project not only helps in the design phase but also for creating the feasibility of the project for taking offs. 4D assists to boost the confidence level of the team by giving them briefing about the and discussing issues before time.

5D BIM is the add-on benefit of precise cost estimation information. This dimension in BIM associates with running, renewal and replacement of components cost. These calculations take on the bases of information stored in the parametric 3D model of the project. After getting precise information of scheduling by implementing 4D, 5D efficiently to predict actual spending on each stage of the project, this information lends a hand to get the precise cost at the design stage, which assists estimators to manage the cost of projects by managing the quality and quantity of components. Extrapolating cost from the information model helps in keeps on updating the cost of the project every time. This "living" cost plan of the project aids to define the budget by design teams while working with cost estimators.

6D BIM comes in, for determining elements/materials for the project that keeps the idea of sustainability together with cost saving. This idea of 6D is also known as integrated BIM or iBIM which supports facility management to drive better outcomes. This data includes information about details of installation, required maintenance, configuring for optimum performance, energy saving and lifespan details from the manufacturer of the component. Adding such information into the model allows making decisions during the design process for thinking over the sustainability, life cycle, and maintenance of the building. This kind of data was hidden before in files and papers, but now we can access such data via graphics and compare it with other manufacturers. This approach of pre-planning maintenance activities come with facility managers who develop the profile for building lifecycle asset.

Figure 2.2: Dimensions of BIM



Source: www.BIMCommunity.com

Indeed, current BIM modeling can function to an Nth dimension of works – this progress more as technology evolves and as the BIM process is refined. With all these dimensions, uses of BIM can vary through a broad scope of works such as design visualization, design assistance and constructability review, site planning, and site utilization, scheduling, and sequencing (4D), cost estimating (5D), integration of subcontractors and supplier models, systems coordination, layout and fieldwork, prefabrication, operations and maintenance (including as-built records) (Campbell, 2007). The next chapter will be a detailed description of the benefits of BIM implementation.

2.2 POTENTIAL BENEFITS OF BIM

Till the mid of nineteenth century, there were no significant changes to building design methods, engineers, and architects used to describe their design through traditional methods. With time, due to advancement on technology, building materials, mathematics and the design process in construction industry underwent a dynamic change. BIM is a product of all these developments which is highlighted by AEC industry as a robust design and management tool with advantages over building design management and lifecycle (Yan & Damian, 2008). BIM can be seen through as having positive economic benefits and improvement in productivity, with a better understanding of projects (Bernstein and Pittman 2005).

According to Azhar (2011), BIM Adoption will benefit AEC industry in the following aspects:

i. Cost estimating: BIM software can perform quantity measures and automatically adjusts any changes occurring throughout the design and construction processes.
ii. Fabrication drawings: With the help of BIM, developing Fabrication drawings are simple for different systems of buildings.
iii. Construction sequencing: BIM helps to develop sequencing and coordinating fabrications, materials order and delivery schedules for project components.
iv. Conflict and collision detection: BIM Model can detect conflicts and clashes between building and elements, as all of the models in BIM are created in proper scale in a 3D space.

Following benefits of BIM are defined after gathering data on 32 major projects as mentioned in the report of Stanford University's Center for Integrated Facilities Engineering (Azhar, 2011).

i. By early problem detection, 40percent of work gets decreased.
ii. BIM produces estimates within 3percent of accurate results as compared with traditional methods of estimation.
iii. Reduces 80percent of time consumption in making cost estimation.

Table 2.1: Benefits of BIM

Long-Term Benefits	Short-Term Benefits
Fewer claims/litigations	Reduces conflicts
Reduces construction cost	Better understanding of design intent among team members
Increase in profits	Enhances project quality
Reduces project duration	Decrease in number of RFI's
Marketing new business	Better construction cost predictability

Source: (Nanajkar, 2014 - McGraw Hill Construction, 2012)

Design issues in construction phase cause delays due to of redesign. These delays not only affect the timeline of the project but also increase the cost of the project which results in much more negative economic impacts than the rework itself (Won, Lee, Dossick, & Messner, 2013b). According to the report of Autodesk, firms are unwilling to invest in BIM setup because of costs and BIM ROI calculating difficulty, whereas the study on BIM ROI customer perception shows that mostly all architectural firms need time to calculate ROI via BIM but do experience clear benefits (Autodesk, 2016).

This thesis aims to find the constraints for BIM implementation and debate about the strategy for further implementation of BIM in Pakistan. To understand the importance of the transition from traditional process to BIM process we do need to know the impact of BIM over traditional methods.

2.2.1 BIM Design Process versus Traditional Design Process

Previous research and practices have provided sufficient knowledge that "BIM is certainly viable and offers many achievable advantages over CAD (Howell and Batcheler, 2005)". As many also agree that BIM can deliver tremendous benefits, but we have to move from traditional ways of working (Arayici et al., 2009). To understand the comparison of BIM versus traditional design method four main phases of design methods need be explained (Yan and Demian, 2008).

Original design

The general method of design was the same until the mid of 19th century. Engineers and architects use standard tools (pen, paper, and ruler) to describe their designs. With the time advancement has taken place in mathematics and building materials which impacted the process of design. (Rabun, 1996)

2D CAD method

The invention of the computer revolutionizes AEC industry around the world (Phiri, 1999). After world war two, digital technology was applied in the construction and civil field of works. As a result, a tool "sketchpad" was introduced by Ivan Sutherland. Development of sketchpad became root for computer-aided designs. Initially, the technology was not that much famous but with the time when personal computers became famous Autodesk introduced "AutoCAD." The concept of Computer Aided Designs (CAD) suddenly spread around the world, and everyone related to AEC industry adopted and started implementing them. (Leondes, C.T. ed., 2010)

Current/traditional design methods

The development of 2D CAD drawings into 3D model made a significant shift in the process of building design. It influenced the relationship between an architect and engineer. This shift not only changed the way of building design thinking by visualization but further developed into a 3D Model simulation for the building (Carver, G. and White, C., 2013). Development of this 3D modeling simulation became Building Information Modeling (BIM).

Building information modeling (BIM)

BIM is the new emerging tool which is further development of 3D CAD model into 3D information model. The idea of BIM not only carries the points, lines, masses and shapes within it but a "symbolic" and abstract "meaning" to all this as qualitative and quantitative data. BIM is rapidly taking the place of traditional methods of designing because of its advantages and benefits for AEC industry.

2.2.2 Comparison of BIM and Traditional Method:

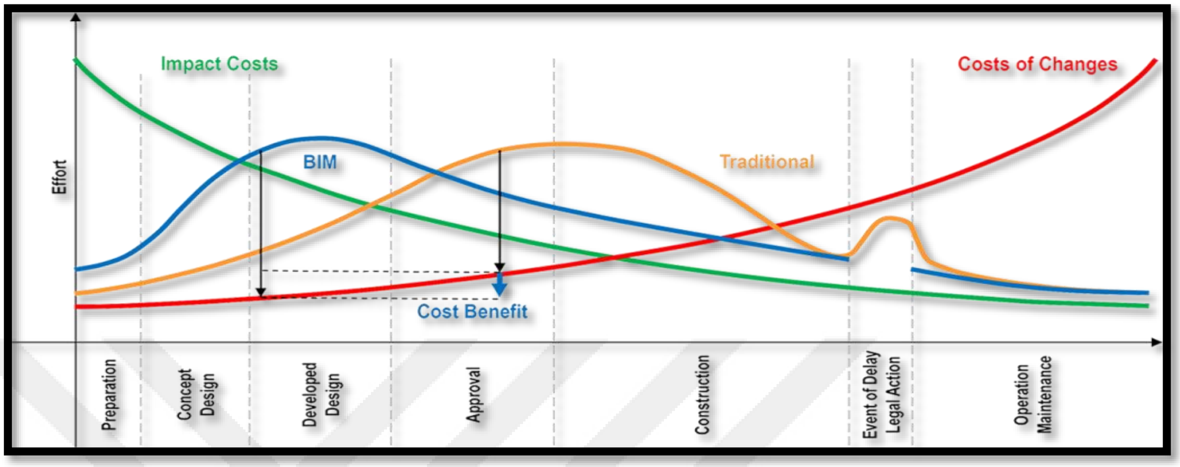
Significant researches are done to determine the level of BIM in comparison to the traditional method of designing. In 2007 a research took place in Penn State University - USA by Leicht and Messner in which they design a building of "Dickson School of Law" with two different methods (BIM method and traditional method) as a case study (Leicht, and Messner 2007). As a conclusion to it, BIM method was more efficient in terms of time taken and precise in numbers than the traditional method. According to Table 2.2, we can understand the efficiency of BIM in different phases of the project regarding time-saving. Whereas Figure 2.3, identifies the cost-saving benefits of BIM in different phases of a project in comparison to the traditional method. After understanding the importance of BIM in AEC industry in comparison to traditional CAD method, its implementation around the globe is given (Smith and Tardif, 2009).

Table 2.2: Efficiency difference between traditional CAD process and BIM process

The Efficiency Difference Between CAD and BIM Applications for Particular Project in Different Phases				
Task	CAD (Hours)	BIM (Hours)	Hours Saved	Time Savings
Schematic	190	90	100	53%
Design Development	436	220	216	50%
Construction Documents	1023	815	208	20%
Checking and Coordination	175	16	159	91%
Totals	1824	1141	683	

Source: (Kumar & Mukherjee, 2009)

Figure 2.3: Traditional workflows versus BIM workflows relative to cost of change over a project timeline



Source: Building Information Modeling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers

2.3 IMPLICATIONS OF BIM ON ORGANIZATIONS

Organizations of the AEC sector involve in prefabrication, Sustainable development, value engineering, precise cost estimation, optimized saving efficiency and etc., which can be termed as Complex Products and Systems (CoPS) (Gann and Salter, 2000). For such project development and deliveries, specialists and experts are hired by organizations. Thus, for these CoPS projects, to to people, process and organizational point of view adoption of BIM process and technology becomes essential (Dubois, A. and Gadde, L.E., 2002). However, implementing BIM on organizational level causes two complications.

i. The unique nature of the project-delivery network in construction:

   In build environment projects every project is unique from others, which causes it difficult to select the most optimal process for project delivery. There is a plethora of project-delivery systems available, the major differentiator is the exclusivity of each project and the resultant modified processes, functions and outputs. Figure 2.4 shows the project-delivery network for a typical AEC project. As compared to the traditional process, BIM process is considered to own a novel nature due to its challenges of implementation by any organization.

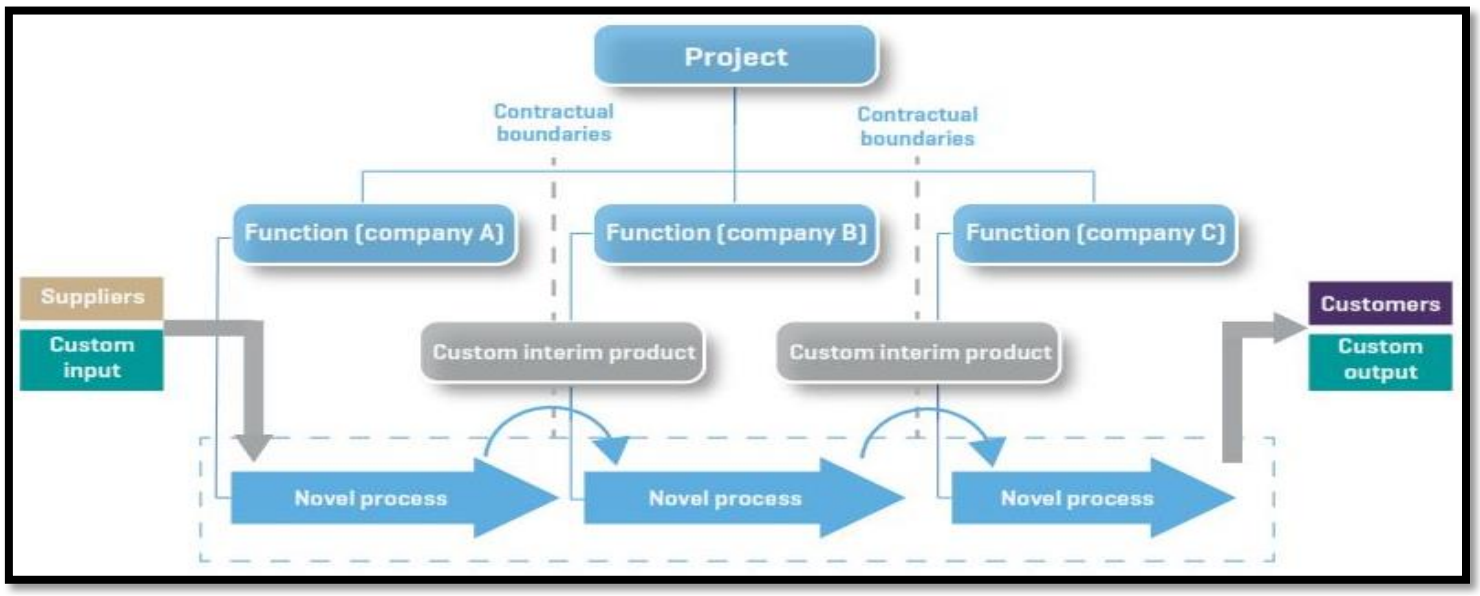
ii. The complicated transition process from traditional to BIM Process
AEC industry is currently in the phase of transition. Most firms are adopting both BIM and non-BIM process together, which is a mix nature process, depending on the scale of the project. Decidedly few firms have entirely shifted to BIM process which even makes adoption of BIM much more complicated (figure 2.5). There are also those firms, which have never implemented BIM in project delivery. In a significant number of projects, all aspects of BIM aren't utilized due to organizations lack of professional BIM experience (AIA, 2014). So, as a result, while some phases of the project are done by BIM, the rest of the phases are handled in traditional ways. BIM adoption is a difficult shift as there are some of the undocumented stories regarding failure of BIM implementation in projects. As it is always highlighted that improper use of data for BIM process can cause a misleading end (Figure 2.6).

Despite the complications, implementing BIM at the organizational level for project delivery is crucial due to potential benefits in AEC sector, which have already been detailed in Chapter 2 (Figure 2.3 and Table 2.2). Thus, instances and strategies are to be discussed before implementing it for long-term benefits (Table 2.1). For such purpose, a J-curve diagram (Figure 2.7) can be referred to explain the journey of BIM implementation (Oakley, 2011). According to J-curve organizations need to thrive to follow the optimal path on this journey. There is a huge gap between the expected path and the actual path which shows a high level of risk for BIM adoption. This may cause failure or reverse the process to traditional methods (Davies, R. and Harty, C., 2011). It is important to highlight the challenges, and origination of the new issues origination that organizations may face while shifting to BIM process. Following are the critical issues which need to be addressed while implementing BIM.

i. Education and training in BIM, not just model developing but also its usage, extraction of information and processing it.
ii. Selection of hardware and software within the organization including compatibility issues.
iii. BIM project versus non-BIM projects happening within the firm.

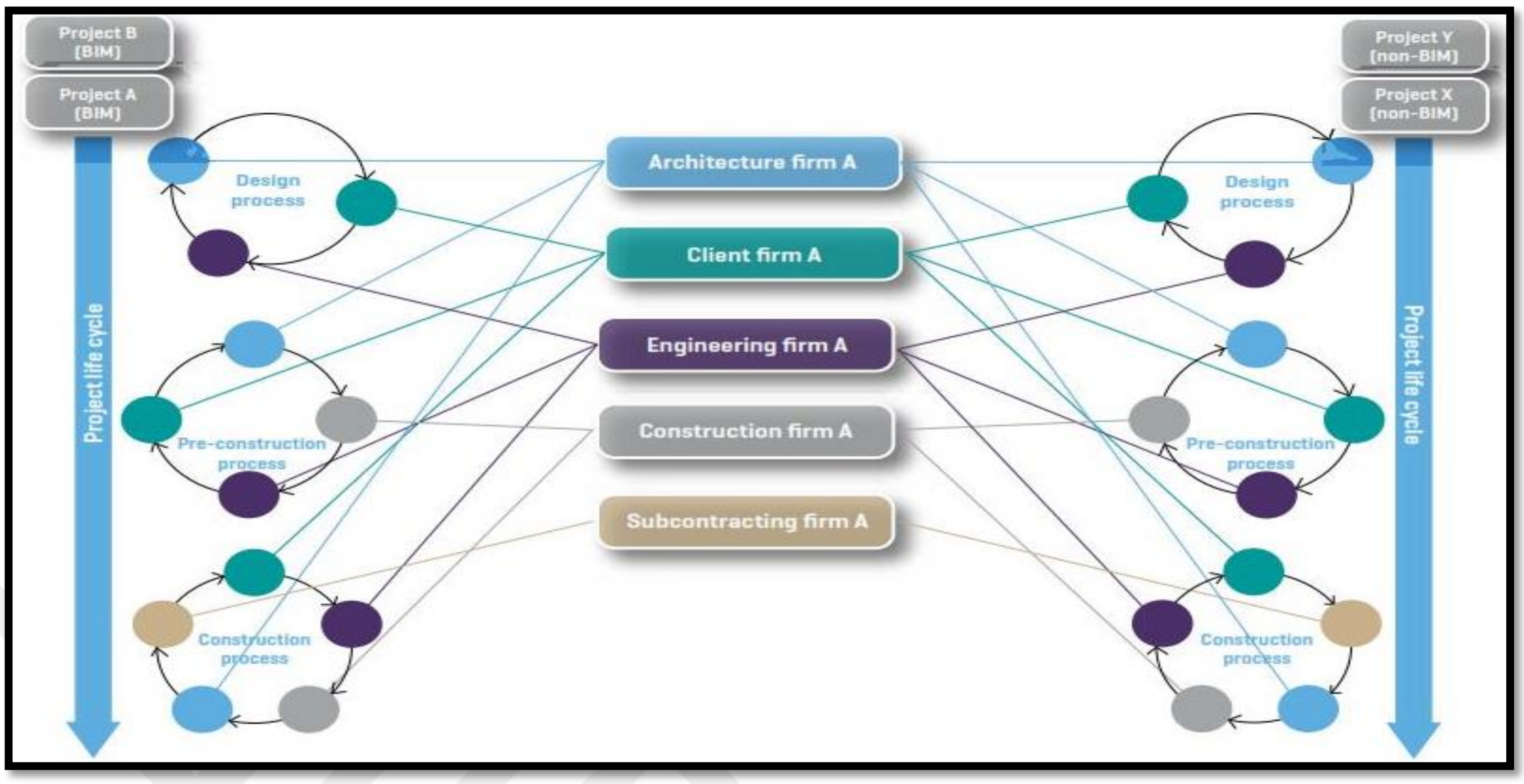
iv. BIM experience and capabilities of organization employees (inter-organizational issues).
v. Identifying human resources issues including whether or not there are experienced BIM professionals.
vi. Model ownership and data embedded in it.
vii. Procurement of the services so that BIM implementation services would be available at the organizational level.
viii. Understanding level of risks by sharing model and other risks as allocation risk and mitigation risk.
ix. Copy Rights issues based on content development and their use.
x. Contractual issues related to BIM services.
xi. Commercial terms for BIM services and selection of service providers (constructors and consultants).
xii. Insurance with liability issues on BIM project delivery.

Figure 2.4: The unique nature of the project-delivery network in construction



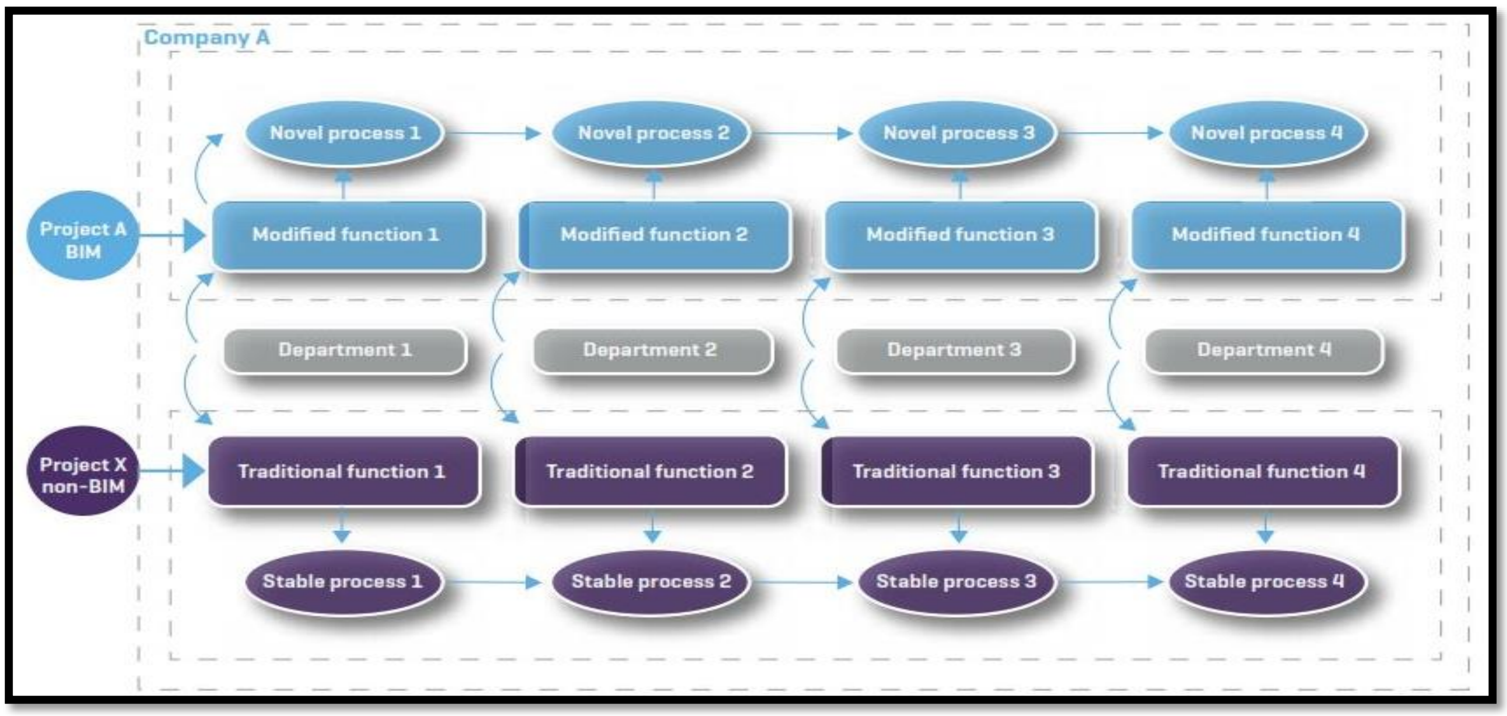
Source: (Sawhney, 2014)

Figure 2.5: BIM and non-BIM projects in the project-delivery network



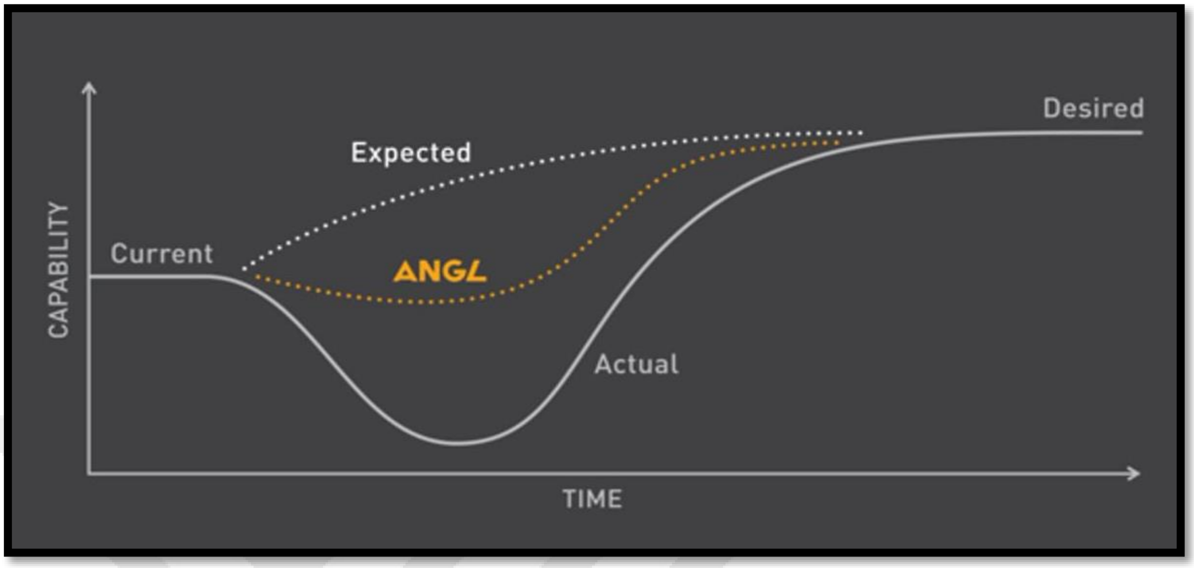
Source: (Sawhney, 2014)

Figure 2.6: BIM and non-BIM projects in the organization



Source: (Sawhney, 2014)

Figure 2.7: The J-curve of BIM adoption



Source: (ANGL Consulting)

Therefore, a strategy document, which addresses the critical issues above, needs to be introduced to achieve IM implementation. Most guidelines, such as National BIM Standard – 2006 (US), NATSPEC BIM Portal 2011 (Australia) and National Guidelines for Digital Modelling – 2011 (Australia) and etc, are available they mostly focus on project delivery rather than organizational management for BIM adoption. Although Organizational level strategies especially Small Medium Enterprises (SME) have been ignored (Sawhney, 2014).

BIM is a technology-driven process; hence its adoption also carries same issues that are common with any other technology adoption. Organizations which are seeking to adopt BIM need to train their employees in the office and on-site both ways. They also need to keep themselves updated on latest technology and its software and hardware requirements. Among various software, the most appropriate one shall pass on a number of criteria's such as price, availability of tools, plugins and updates, interoperability of files, user-friendly environment, files integration systems, customer service etc. Software vendors mostly provide hardware specifications which could help organizations to understand the level of hardware upgrade they need. Computability of hardware and software can also be evaluated with open standards of IFC and COBie before investing over.

To acquire any change within an organization, there is a transition period which needs to be planned properly. During this period some projects will go through BIM process and some projects will not. During this transition, any change of policies, procedures or practices in the organization should be done side by side, so that emerging problems and their solutions can be comprehended within the practicality of the ongoing projects.

Another common issue that organizations face is the different experience levels of partners and stakeholders in a BIM process. Trouble is mostly caused by those members, which are less experienced with BIM. Therefore, selecting the network of specialist organizations is always essential, who have already shifted to BIM process and are able to deliver successful AEC projects.

Points 1 to 6 in the above list need to be addressed through guidance and advice from professionals. If not addressed properly then many of issues can cause failure for BIM implementations. Point 6 to 10, which are about contractual arrangements and related legal issues such as copyright issues are interconnected with each other and are discussed below.

2.3.1 Variation in Contractual Arrangements and Related Legal Issues

To adopt BIM, some adjustments need to be done on contractual arrangements between project stakeholders. The most acknowledged procedure to incorporate BIM implementation is binding the organizations in the contract. The well accepted BIM addenda's currently available are:

i. Consensus Docs 301 Building Information Modelling (BIM) Addendum (Oberoi, S. and Holzer, D., 2016)
ii. CIC BIM protocol (Council, C.I., 2013)
iii. AIA Digital Practice Documents consisting of:
  a. AIA G201–2013 Project Digital Data Protocol Form
  b. AIA G202–2013 Project Building Information Modelling Protocol Form

c. AIA E203–2013 Building Information Modelling and Digital Data Exhibit
d. AIA C106–2013 Digital Data Licensing Agreement. (Bargstädt, H.J. and Tarigan, R.S., 2015)

In most of the projects, the addendum is merged in the standard form of contract. The Addendum can be changed depending on the level of BIM implementation without affecting the standard contract done between the firms. BIM implementation delivers new roles and responsibility within team members. The procurement of roles and responsibilities need to be modified and incorporate additional services accordingly depending on the project. The precise definition of BIM manager role needs to be addressed to identify responsibilities. Generally, Intellect Property Right (IPR) or copyright issues don't act as a roadblock for BIM adoption. The major issues are in this context are as follows (B.C.A, Authority2013):

i. Team members for the project need to assure that they do have rights for all their contribution to the model.
ii. Copyright and IPR issues should be evident between contractors and sub-contractors.
iii. Use of the model for facility management purpose after project delivery should also be addressed.

Issues of insurance and professional liability also need to be addressed in BIM addendum. Many feel that insurance issues can be a limitation to BIM implementation if not handled properly. As project activities shift from 2D drawing to 3D model-centric information sharing and collaboration, new challenges appear. The challenging questions which arise in mind are as following (Anil Sawhney, 2014).

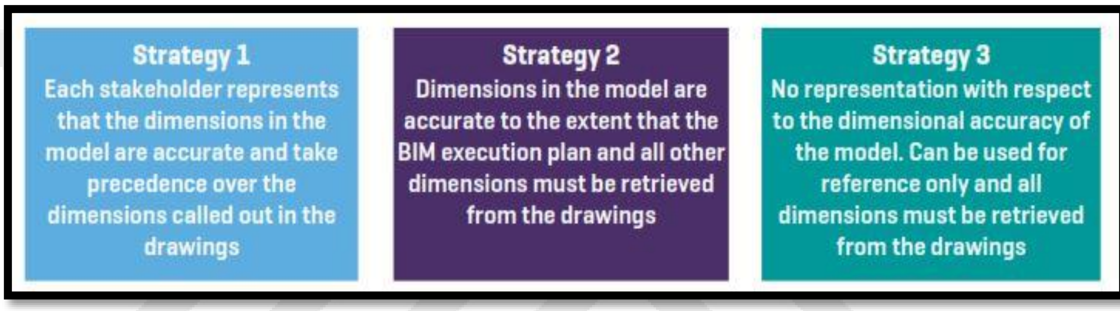
i. What risks can happen after sharing model among team members?
ii. Does BIM manager have addition liability over model?
iii. Is there any change in responsibility and liability exposure between team members?
iv. How to address IPR and copyrights issues?
v. What kind of amendments needed to be done in contracts?

Besides all these contractual and legal issues addressed above, contractual issues regarding to Information sharing and collaboration between different stakeholders is also significant for implementing BIM which is discussed below.

2.3.2 Information Sharing and Collaboration Using BIM

The most important issue of information sharing in BIM process is the use and delivery of information from the model. This phase carries a risk of providing false information or using information for other purposes. However, this issue can be easily handled through contracts, for example, the Consensus Docs 301. BIM Addendum, which provides three options (Figure. 2.8) in the case of model sharing (Council, C.I., 2013).

Figure 2.8: Information sharing as per Consensus Docs

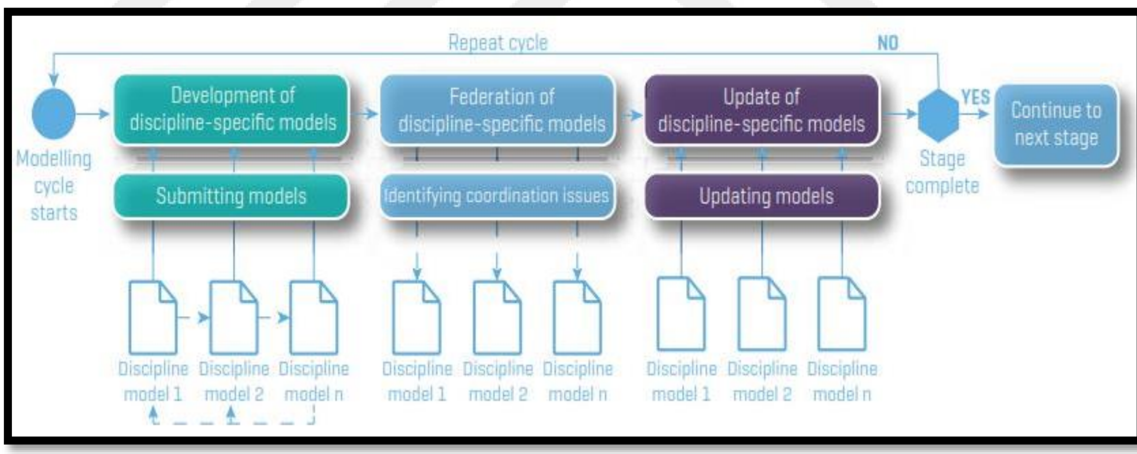


Variation in the workflow

Information management and its flow are central to an organization for BIM implementation. Workflow pattern within members, changes if information flow is changed in this process. There are two major mechanisms for information flow and information management in BIM process. In the first mechanism, every responsible member develops and authors his model independently with no centrally stored model and this process works in linear flow (Figure 2.9).

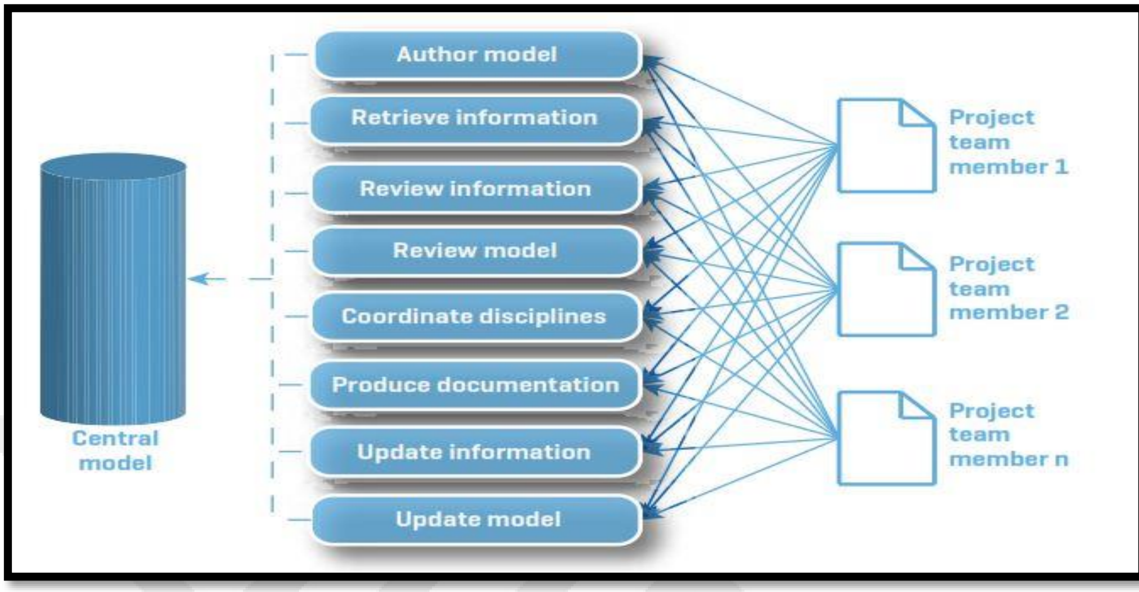
Information stored in these models are shared among team members by file sharing system and other similar systems. Every discipline member develops his model separately and draws information from others model which are authored by team members. After collecting all the information, a responsible BIM manager combines all discipline specific model, for coordinating. Issues after combing the models are coordinated with all team members in the form of snapshots on the basis of which model get enhanced and update accordingly. The process of model authoring, revision, coordination, and federation continues until a predetermined level of coordination is accomplished. In other words, information sharing is not happening in a true sense. Most information in this scenario is shared inform of 2D drawings. A protocol for such sharing is needed in this type of file-based sharing process. In the second approach, an integrated environment for BIM implementation becomes the centerpiece, rather than maintaining data by separate disciplines models a single central model is developed and used for project delivery. Figure 2.10 shows model information management, sharing, and workflow within the team. Modeling authoring, reviewing and coordination tasks are performed by team members in an integrated fashion. The central model is a single source of information and is used to collect, store, manage and disseminate project information, the graphical model and non-graphical data for the whole project team in Common Data Environment (CDE). Creating this information repository facilitates collaboration between team members and avoids mistakes and duplication. This central data environment is a true sense of model-driven collaborative system (Richards, M., 2010).

Figure 2.9: Asynchronous and linear modeling



S*ource:* (Sawhney, 2014)

Figure. 2.10: Central model-driven modelling



S*ource:* Sawhney, 2014

By studying both of the model systems positioning an architect and ensuring its values is very important to understand. The architect's responsibilities are to emerge client's requirements into design specification. As the architects holds the errands as stakeholder interest facilitator, defender of design and custodian client values (Sebastian et al, 2009a).

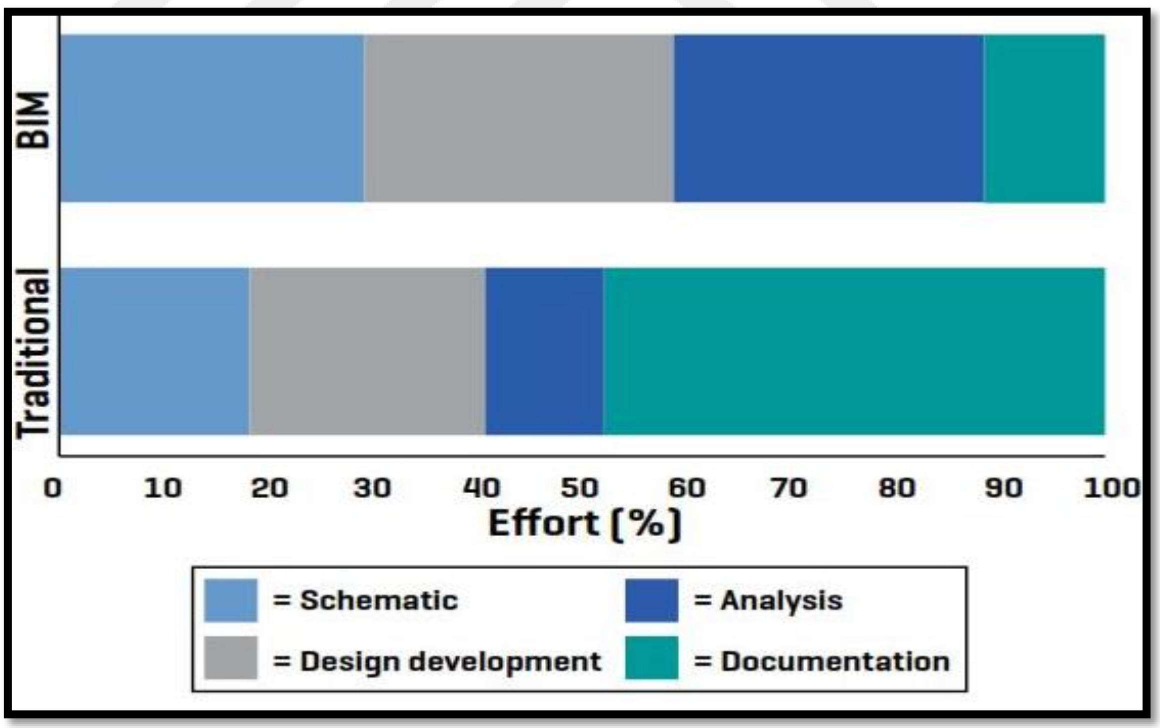
2.3.3 BIM For Architects and Designers

Recalling the roles of several stakeholders and consultants in BIM workflow such as; constructors, developers/owners/sponsors, project management consultants, quantity surveyors, facility managers, product manufacturers, this thesis aims to focus specifically on the role of architects. Hence, the following chapters will be on BIM implementation issues concerning architectural design firms.

So far, CAD has allowed architects and designers to develop, design and documents through computers. Where BIM effects, the way design data is generated, integrated and shared with all members. In another way, this impact is an "epochal" transformation of architects practice. Perhaps architects have become the stakeholders in both internal and external transformation caused by BIM (Eastman, Teicholz and Sacks, 2011). Internally design culture and design practice are affected by BIM which eventually effects the external traditionally CAD based interactions with the rest of the members of the project. Following are the three major shifts taking place:

i. Impact over design processes: BIM changes the realm of linear step by step process to a more collaborative and integrated process. This changes the process of design itself.
ii. Changing of design culture: BIM is shifting the thinking process of designers from 2D to 3D worldwide.
iii. BIM process is significantly shifting the scenario: In BIM process designers are required to focus on the generation of design options with available data, enriching early-stage designs with more information rather than just drafting and documenting as in traditional ways. This is restructuring, indicative redistributing and shifting the design effort as explained in Figure 11.

Figure 2.11: Indicative redistribution of effort in the design process



S*ource:* (Sawhney, 2014)

As outcomes of these implications, nowadays architects and designers can access the model to conduct a more detailed analysis. This enriches the design process and leads to a more complex design by making sustainability analysis, engineering analysis, and constructability analysis possible in the much more robust way than traditional ways.

These effects due to BIM adoption require the consideration of the fee structure for architects. As by BIM process architects can now deliver more than what they used to deliver by traditional CAD. This would lead to identifying new roles and responsibilities for BIM process in an architect's office depending on the size of the firm. To be a leading architectural firm in the market, an organization needs to spend more resources on hardware, software and training and development of BIM professionals to have a BIM model and workflow in the office. BIM implementation is more rooted in large architectural firms as compared to small and medium-sized firms which are further discussed below.

2.3.4 BIM Implementation Small and Medium Organization

Due to of BIM benefits, it is considered as the vanguard standard of practice in architectural firms of all sizes. Small firm holders may not think that time saving and error reduction can make up for the learning curve and adoption cost. Sole proprietor should also consider the long-term business values of BIM. As BIM process helps to bring more satisfying results for clients, this directly affects more business and recommendations. BIM can enhance margins as it helps in better and quick collaboration with consultants. Proficiencies that BIM offer let small firms to expand the number of billable services. In short small firms which use BIM will never face a disadvantage when they are competing for the business against the firms who didn't adopt BIM (Autodesk, 2016). According to survey report of AIA done in 2013 37percent of firms with less than 9 employees use BIM, at the other hand 60 percent of the firms with between 10 and 49 employees adopted BIM and 80 percent of firms with more than 50 employees are turned to BIM (AIA, 2014). The shift from traditional method to BIM process does required investment in time and resources, but they get the BIM adoption payoff in just three projects. BIM report from the Construction Industry Council mentions that: "Firms typically need three BIM-based projects under their belt before they can outperform previous practice." (Saxon, R.G., 2013). According to a case study done in the Netherlands over “BIM application for integrated design and engineering in small-scale housing development” a recommendation is concluded that client and project participants should establish a productive strategy to implement BIM. This strategy should be transparent and followed by all team members. Other than this in-house BIM object libraries are needed, as they will save time and efforts to establish management and Information communication technology (ICT) protocol at the beginning of each new projects. (Sebastian, Haak, Vos, 2009). Besides this, a table is derived to understand the problems and their solutions in terms of the relationship between all team members of the project (Table 2.3). To understand the BIM significance, we need to know about the adoption ratio around the globe which is discussed further.

Table 2.3: Summary of the problems and main results of Case Study

No	SME initiator	Problem / learning question	Result
1	Client (project developer and main contractor)	How to set up BIM and associate the 3D model to cost calculation application	A prototype of BIM linked with the currently used cost calculation application
2	Architect	How to get an immediate insight in the cost implications of the design alternatives	A method to get an immediate and more accurate cost estimate during modification of the building model
3	Prefab concrete manufacturer	How to accelerate the design process of prefab concrete floors through effective communication	A protocol for integrated decision-making by all disciplines using the support of 3D model
4	Prefab roof manufacturer	How to agree on the accountability of the structural design between the engineer and manufacturer when a prefab solution is used	A 3D model integrating the prefab solution to the main building model, and indicating the limit of the accountability of each party
5	Electrical contractor	How to agree on the format of drawings for information exchange between main contractor and electrical subcontractor	An agreement on an efficient layer structure to accommodate the integration of 2D electrical elements within the 3D building model
6	Plumbing contractor	How to import and export 3D information between StabiCAD and AllPlan	Several techniques to utilize 3D import and export functions in StabiCAD and AllPlan
7	HVAC contractor	How to detect the possible clashes of HVAC installations using 3D visualizations	The discovery of 5 clashes in the pilot project which were then solved during the experiment
8	Structural engineer	How to use BIM resulted from the design stage to check and approve the quality of the structural elements during the construction stage	A technique to obtain visual information from the building site to compare as-built elements with the structural design in 3D, e.g. the position of reinforcement in concrete
9	Component supplier (kitchen and bathroom furniture)	How to improve the communication and decision-making processes in case of modifications of building elements and installations based on the customer's requirements	A proposal containing new functional requirements for ICT infrastructure within the international holding of building component supplier to solve the current limitations

Source: (Sebastian, Haak, Vos, 2009)

2.4. BIM ADOPTION AROUND THE GLOBE

BIM adoption is accelerating around the globe, looking at the adoption ratios from 2007 to 2015, it can be observed that major private and government sector organizations are transferred to BIM process because of its faster delivery, reliable quality and cost-efficient benefits (McGraw Hill, 2014). According to Lee et, al BIM method was mandatory in the US and UK to empower the AEC industry and to meet and exceed owner targets (Lee, Kim, and Yu, 2014). Since 2006 in US General Services Administration (GSA) approved BIM as a minimum requirement of submitting a drawing in Chief Architects office for final drawing approval. This is the reason that the country has one of the most leading BIM market and has grown from 28percent to71percent between the times of 2007 to 2012. In recent studies about South America, the ratio of architects exceeded to 70percent and contracts exceeded to 74percent. In the same way, the UK and other regions also showed a high ratio of adoption (McGraw Hill, 2014).

In 2016 and onwards government of UK mandate the use of BIM for public sector projects due of which UK is considered as the leading country for BIM adoption in Europe (McGraw Hill, 2014). BIM adoption is increasing rapidly in European countries such as Sweden, Denmark, Norway, Finland, Austria, Brazil, France, and Germany. These countries are gaining broad AEC industry interest towards BIM process. One third (36percent) of Western European industry adopted BIM. Moreover, BIM is expanding in other continents especially in developed countries like Japan, New Zeeland, Australia Finland, etc. In Table 2.4 and Table.2.6 countries are discussed on the basis of BIM adoption in terms of target and promises, implementation standards and guidelines. Whereas in Table 2.14 same counties are discussed in terms of organization developed for BIM, BIM drivers, regulatory bodies, education, training, funding agencies, and research database systems. A summarized discussion of BIM adoption of other countries as Lithuania, Canada, Germany, Iceland, India, Iran, South Korea, and Brazil is given in Table 2.6.

Table 2.4: BIM adoption worldwide

			BIM Adoption		
Region	**Country, City or Organization**		**Targets and Promises**	**BIM Implementation**	**BIM Standards and Guidelines**
The United States	Nation-wide	NIBS, USACE, GSA, VA, AIA, NIST, AGC	Require BIM on projects	BIM programs, committees, BIM workshops and training courses, fund BIM and R&D projects, USACE - BIM roadmaps	e.g. NBIMS-USTM V1, V2, BIM Guide Series 01 to 08
	State-wide	Wisconsin, Ohio, Tennessee	Require BIM on projects	BIM projects	e.g. State of Ohio BIM Protocol
	City-wide	New York, Seattle	Require BIM on projects	BIM projects	e.g. NYC BIM Guidelines
	University-wide	PSU, LACCD, IU, etc.	Require BIM on projects	BIM projects	e.g. BIM PEP Guide V1, 2, IU BIM Guidelines and Standards
Europe	the United Kingdom	BSI, CIC, AEC-UK	Adopt Level 2 BIM by 2016	BIM Task Group, BIM sessions, BIM training programs	e.g. BS series, AEC-UK-BIM Standard v1.0
	Norway	Statsbygg, etc.	2010, Gov. commitment to BIM 2010, Statsbygg – require BIM for new buildings	BIM programs, pilot and R&D projects	e.g. Statsbygg - SBM, BIM Manual v1.2.1
	Finland	Senate Properties	2007, require the use of IFC/BIM for its projects	BIM projects	e.g. Senate Properties' BIM Requirements for Architectural Design, COBIM
	Denmark	Palaces & Properties Agency, etc.	Danish state clients such as the Palaces & Properties Agency require BIM	Digital Construction project	e.g. 3D CAD Manual 2006, 3D Working Method 2006
	Sweden	Transportation Administration, etc.	2015, all investment projects use BIM	BIM implementation project, pilot projects to demonstrate BIM	No National BIM standard, BH90 Series 8 - CAD guide
	Netherlands	Rijkswaterstaat, Rijksgebouwendienst	2011, mandate BIM in building projects with 7,000,000 m2	BIM 2012-2014 program, pilot projects, BIM database	e.g. Rijksgebouwendienst BIM Standard
Asia	Singapore	BCA	2015, 80% of the industry using BIM and BIM e-submission	BIM center, pilot projects, BIM training programs, training framework, conference, BIM steering committee, BIM fund, nation-wide BIM competitions, BIM roadmap	e.g. BIM e-Submission Guideline for Architectural Discipline, Singapore BIM Guide
	Korea	MLTM, PPS, KICT, KICTEP	MLTM, PPS mandate BIM before 2016	MLTM - BIM implementation roadmap, BIM program, BIM R&D projects, PPS - BIM fund	e.g. National Architectural BIM Guide, PPS Guidelines
	Japan	MLIT, JFCC, JIA	2010, MLIT mandate BIM in government projects	MLIT-BIM pilot projects, JFCC - BIM special section, BIM seminar	No National BIM standard, JIA - BIM guidelines
	Mainland China	the Ministry of Housing and Rural Urban Development	2012, release the National 12th Five Year Plan (2011-2015)	BIM-related national standards program	e.g. Two national BIM standards draft versions, Beijing and Shanghai BIM standard
	Taiwan	NTU, etc.	No Gov. commitment to BIM	Fund BIM projects, centers, NTU - BIM conferences, forums, training workshops, publications and research projects	LOD Specification, Owner's Guide for preparing BIM Guidelines
	Hong Kong	HA, ArchSD, MTRC, HKIBIM, HKCIC, etc.	HA - BIM in all new projects by 2014	BIM projects, conferences, ArchSD - BIM development unit, training courses, pilot projects, Lands Department - 3D spatial database, BM seminar, HKIBIM - BIM committees	e.g. HA - BIM Standards Manual v1, BIM Project Specification Rev 3
Australasia	Australia	BEIIC, AMCA, NATSPEC	Require 3D BIM for Gov. projects by 2016	BEIIC - BIM plan, pilot projects, AMCA - BIM initiative, forums, training plans	e.g. The NATSPEC National BIM Guide, ANZRS

Source: (Cheng, and Lu, 2015)

Table 2.5: Roles of the public sector worldwide for BIM adoption

			Roles of the Public Sector for BIM Adoption					
Region	Country, City or Organization		Initiator and Driver	Regulator	Educator	Funding Agency	Demonstrator	Researcher
The United States	Nation-wide	NIBS, USACE, GSA, VA, AIA, NIST, AGC	Require BIM on projects, BIM roadmaps, programs, committees	BIM standards, e.g. NBIMS-USTM V1, V2	BIM training courses, Education Symposium	Fund BIM	BIM pilot projects	R&D projects
	State-wide	Wisconsin, Ohio, Tennessee	Require BIM on projects, BIM projects	BIM standards, e.g. State of Ohio BIM Protocol				
	City-wide	New York, Seattle	Require BIM on projects, BIM projects	BIM guidelines, e.g. NYC BIM Guidelines				
	University-wide	PSU, LACCD, IU, etc.	Require BIM on projects, BIM projects	BIM guides, e.g. BIM PEP Guide V1, 2, IU BIM Guidelines and Standards				
Europe	the United Kingdom	BSI, CIC, AEC-UK, etc.	Level 2 BIM by 2016, BIM Task Group, sessions	BIM standards, e.g. BS series	BIM training Framework			
	Norway	Statsbygg, etc.	Gov. commitment to BIM, BIM programs	BIM standards, e.g. Statsbygg - SBM			BIM pilot projects	BIM R&D projects
	Finland	Senate Properties	Require BIM on projects, BIM projects	BIM standards, e.g. COBIM				
	Denmark	Palaces & Properties Agency, etc.	Require BIM, BIM projects	BIM standards, e.g. 3D CAD Manual 2006			Digital Construction project	Digital Construction project
	Sweden	Transportation Administration, etc.	Require BIM, BIM projects	BH90 Series 8 - CAD guide			BIM pilot projects	
	Netherlands	Rijkswaterstaat, Rijksgebouwendienst	Mandate BIM on projects, BIM 2012-2014 program	BIM standards, e.g. Rijksgebouwendienst BIM Standard			BIM pilot projects	BIM database
Asia	Singapore	BCA	BIM goals, BIM center, steering committee, Nation-wide BIM competitions, roadmap	BIM guidelines, e.g. Singapore BIM Guide	BIM training programs, training framework	BIM fund	BIM pilot projects	BIM center
	Korea	MLTM, PPS, KICT, KICTEP	Mandate BIM before 2016, BIM roadmap, program	BIM guidelines, e.g. PPS Guidelines		PPS - BIM fund		BIM R&D projects
	Japan	MLIT, JFCC, JIA	Mandate BIM in government projects, BIM special section, BIM seminar	JIA - BIM guidelines			MLIT-BIM pilot projects	BIM research seminar
	Mainland China	the Ministry of Housing and Rural Urban Development	Encourage enterprises to use BIM, BIM-related national standards program	Beijing – BIM Standard for Civil Engineering (draft)				
	Taiwan	NTU, etc.	NTU - BIM conferences, forums	BIM standard translations	Training workshops	Fund BIM projects		Research projects
	Hong Kong	HA, ArchSD, MTRC, HKIBIM, HKCIC, etc.	HA - BIM in all new projects by 2014	BIM standards, e.g. HA - BIM Standards Manual v1 , BIM projects, conferences, BIM unit, committees	Training courses		BIM pilot projects	3D spatial database
Australasia	Australia	BEIIC, AMCA, NATSPEC	Require 3D BIM for Gov. projects by 2016	BIM guidelines, e.g. ANZRS	BIM training plans		BIM pilot projects	

Source: (Cheng, and Lu, 2015)

Table 2.6: BIM adoption in other countries

Canada	Founded by the end of 2008, the Canada BIM Council for supports the adoption of standardized models in architecture, engineering, and construction, to manage nation-wide implementation and to introduce good practices and standards. The country requires the use of BIM in public construction projects.
Germany	Following the examples of some neighboring countries, where the use of BIM is already mandatory, Germany is trying to spread the use of BIM. It was previewed for 2014 in the publication of a BIM-Guide, that offers recommendations and knowledge for all in Germany that are interested in using the BIM. The BIM guide is a non-binding recommendation; it is no mandatory directive to execute construction projects using BIM.
Iceland:	The Implementation of BIM in Iceland is led by Framkvæmdarsýslu Ríkisins (FSR) a governmental organization. There are already some relevant documents related with BIM implementation. The Icelandic industry is on information Level 1 heading for information Level 2
Lithuania	Is moving towards adoption of BIM infrastructure by establishing a public body "Skaitmenine statyba". BIM (Building Information Modelling), Industry Foundation Classes (IFC) and National Construction Classification will shortly be adopted as standards.
India	In India BIM is also known as VDC: Virtual Design and Construction. It has many qualified, trained and experienced BIM professionals who are implementing this technology in Indian construction projects and assisting teams in the USA, Australia, UK, Middle East, Singapore, and North Africa to design and deliver construction projects using BIM.
Iran	The Iran Building Information Modeling Association (IBIMA), founded in 2012, shares knowledge resources to support construction engineering management decision-making.
South Korea	In the late 2000s, the Korean industry paid attention to BIM. It has been spread very rapidly. Since 2010, the Korean government has been gradually increasing the scope of BIM-mandated projects. In 2012 was published a detailed report on the status of BIM adoption and implementation.
Brazil	Began to be implemented in 2006 in some private initiatives. In 2010 ABNT/134 EEC Special Commission to Study the implementation was created. In 2011 BIM was widespread to public initiatives.
Other Countries	Some European countries (France, Switzerland…) require the use of BIM in public construction projects, and, some of them set up agencies to manage national-wide implementation and introduced good practices and standards.

Source: (Silva, 2016)

The research by Jung and Lee (2015) surveyed six continents (North America, Asia, Europe, Oceania, Middle East/Africa, and South America) to find BIM Implementation around the globe. It implemented three different sets of indexes, which were Engagement level, Hype Cycle model, BIM services, each method determined different issues (percentage of BIM projects, expertise, years of using BIM, technology phase, primary user, and use) eventually the purpose was the same. As a result, among the six continents, North America ranked as the most advanced continent for BIM implementation. Following it, Oceania and Europe were advance and robust in the design phase. Middle East/Africa 4th in implementation status, Asia ranked 5th, and South America was the last as shown in Figure 2.7, Figure 2.8 and Figure 2.9. Countries in North America and Europe were gaining the progress of BIM implementation due to non-profitable organizations. These NGOs were helping to develop and maintain BIM implementation policies and BIM optimization technologies in AEC sector.

Table 2.7: Perceived status of BIM adoption

	Overall	North America	Europe	Oceania	Asia	Middle East & Africa	South America
Technology Trigger	11.4%	0.0%	11.1%	10.0%	9.5%	28.6%	50.0%
Peak of Inflated Expectations	2.6%	3.7%	6.7%	0.0%	6.3%	20.0%	0.0%
Trough of Disillusionment	20.0%	7.4%	22.2%	20.0%	28.6%	0.0%	33.3%
Slope of Enlightenment	38.6%	48.1%	33.3%	40.0%	42.9%	28.6%	16.7%
Plateau of Productivity	21.4%	40.7%	22.2%	30.0%	4.8%	35.7%	0.0%

Table 2.8: Use frequencies of BIM services used in each continent

	Overall	North America	Europe	Oceania	Asia	Middle East and Africa	South America
3D Coordination	85.0%	95.5%	92.9%	100.0%	70.3%	91.7%	60.0%
Cost Estimation	75.0%	95.5%	92.9%	66.7%	56.8%	58.3%	80.0%
Existing Conditions Modeling	74.3%	81.8%	60.7%	88.9%	67.6%	66.7%	80.0%
Design Authoring	63.4%	63.6%	71.4%	88.9%	73.0%	83.3%	0.0%
Structural Analysis	60.0%	90.9%	78.6%	88.9%	51.4%	50.0%	0.0%
Maintenance Scheduling	30.1%	54.5%	57.1%	33.3%	18.9%	16.7%	0.0%
Building System Analysis	33.4%	72.7%	53.6%	11.1%	37.8%	25.0%	0.0%

Table 2.9: Each continent's most developed phase

	North America	Europe	Oceania	Asia	Middle East & Africa	South America
The most developed phase	Construction	Design	Design	Construction	Design	Construction
Technology Trigger	5.0%	13.6%	14.3%	12.1%	30.0%	33.3%
Peak of Inflated Expectations	10.0%	13.6%	0.0%	24.2%	10.0%	33.3%
Trough of Disillusionment	10.0%	13.6%	0.0%	12.1%	10.0%	0.0%
Slope of Enlightenment	40.0%	22.7%	42.9%	45.5%	30.0%	0.0%
Plateau of Productivity	35.0%	36.4%	42.9%	6.1%	20.0%	33.3%

Source: (Jung and Lee, 2015)

2.4.1. International BIM Supporting Organizations

Countries that are leading the implementation of BIM have public organizations that underline the successful implementation of BIM. They have a long-term vision and focus on how to optimize the implementation of BIM by improving the overall building process (Aðalsteinsson, 2014). The most well-known organizations are g iven below:

Building Smart Alliance (UK)

The Building Smart alliance is a neutral, non-profit organization which supports the use of open BIM. The focus of this organization is to improve cost, value and environmental performance of buildings through the use of open sharable asset information. Building Smart develops and maintains the Industry Foundation Classes (IFC) platform which makes it possible for interoperability between different native CAD software. The Scandinavian countries and the UK are a part of the Building Smart alliance using the non-proprietary format IFC as a tool for interoperability of native BIM models.

National Institute Of BIM Services (USA)

NIBS is a nongovernmental, non-profit organization that brings together representatives of industry, government, professions, regulatory agencies, consumer, and labor interests to focus on the identification and solutions of problems. As NGO they solve problems throughout the United States that hinder the construction of safe and affordable structures for housing, commerce, and industry. The institute's mission is to serve the public interest by supporting and developing the building sciences and technologies. The NIBS supports to develop North American BIM standard, National BIM Standard-United States (NBIM-US) and Construction-Operations Building Information exchange (COBie).

Building Information Modelling Task Group (BIM-UK)

BIM-UK is a group which supports and helps to deliver the objectives of government construction strategy. On the other hand, this group also strengthens the public sector capability in BIM implementation. They aim to adopt level 2 BIM in both government and the public sector.

Statsbygg (Norway)

Statsbygg is the Norwegian construction and property affairs adviser for government in property development, management and building commission. It released a BIM manual in 2011 defining what should be the general requirements and specific requirements for BIM projects and facilities, in the open IFC.

Framkvæmdasýsla Ríkisins (Frs-Iceland)

FRS is an organization working in government that has the aim to collect knowledge on construction processes and to standardize information technology in the construction industry.

Det Digital Byggeri (Bips-Denmark)

“Det Digital Biggeri” (The digital construction) is the Danish organization that implements and endure the BIM method in Denmark. They are developing, digital infrastructure and standardize information use in Denmark to cooperate the productivity in AECO industry. Adopting BIM With BIPS having a strong influence on legislation.

3. CASE STUDY

In this chapter research case area "Pakistan" is discussed regarding BIM implementation. This part will identify the role of BIM in Pakistan's architectural professional practice. Implementation of BIM, benefits of BIM adoption, limitations to implement BIM and other issues will be discussed to understand BIM current situation. After analysis, future measures for BIM implementation will be discussed.

3.1 BIM ADOPTION IN PAKISTAN

According to a previous research the current state of BIM implementation levels in AEC industry are not satisfying in Pakistan (Masood, Kharal and Nasir, 2014). The idea of BIM is insufficient and unclear, and there is a need for technology transfer. In Pakistan, BIM implementation is popular with architectural professionals rather than engineers and construction professionals. Especially in Karachi, BIM adoption rate is higher than rest of Pakistan. A couple of firms shifted to BIM technology and utilizing and are applications (3D coordination, lightning analysis, design review and 4D scheduling). (Masood, Kharal and Nasir, 2014). Mostly the firms which are found to be adopting BIM are indeed doing their projects with international firms. Hence BIM contractual issues aren't clear to them and change of roles in architectural offices is yet in a premature stage. Local firms are only using BIM for coordination with international firms, who are providing designs to local executers and local firms acting as middle bodies in between. Therefore, most BIM users in Pakistan are keeping traditional (CAD method) and BIM process together (Figure 2.5). Table 3.1, shows BIM implemented projects in Pakistan arranged according to scale (S, M, L, XL). The chart shows that in S and M size projects, conventional methods have been preferred to BIM. It is only L and XL scales, where BIM has been implemented. However, a common practice in developing countries requires BIM as an inseparable process for building life cycle and governmental policies, regardless of scale. Therefore, a case study, a survey will be handled to professionals of architecture industry of Pakistan. In order to recognize the current role of BIM in AEC industry, initially, the BIM awareness and implementation in architecture design sector needs to be clarified. Since preliminary the 3D information modeling is done in architects office, then professionals from different disciplines enhance the information model by giving their input in it (Eastman, Teicholz and Sacks, 2011). To collect data from Architecture professionals of Pakistan, Research Survey is not only sent to architects via email but also visits to their firms are conducted to gather more knowledge regarding research topic.

3.2 SURVEYING BIM AWARENESS AND IMPLEMENTATION LEVEL

To gratify the research surveys, interviews were conducted with architectural firms across Pakistan. The surveys were distributed in different sizes and age of firms to gather the review of respondents with different experiences. Collected data was converted into graphs and tables in order to find out respondents profile, awareness of BIM, professional practice limitations, the compliance of projects scales for BIM implementation, application benefits of BIM for BIM users and non-BIM users, BIM in professional practice, limitations for BIM implementation, future of BIM adoption. The survey was designed from three questionnaires (Appendix -1 Common Questionnaire, Appendix -3 - NON-BIM User Questionaire, Appendix -3 BIM User Questionnaire) which are briefly discussed below.

3.2.1 Standard Questionnaire

This questionnaire was a mandatory part of the survey; all the respondents need to fill this part to clarify their position in the market as professionals. Questions regarding name of the firm, headquarter location, specialization in design, the scale of projects they did, number of employees, the age of firm, concept and implementation of sustainability in projects, and BIM implementation in projects are asked. All this information assists in defining the role of the respondent in professional practice. This common questionnaire was divided into two parts (BIM user questionnaire and non-BIM user questionnaire). Respondents who are implementing BIM will follow BIM user questionnaire and the one who never implemented BIM will follow the non-BIM user questionnaire as shown in Figure 3.1.

Table 3.1: BIM-implemented projects in Pakistan according to scale

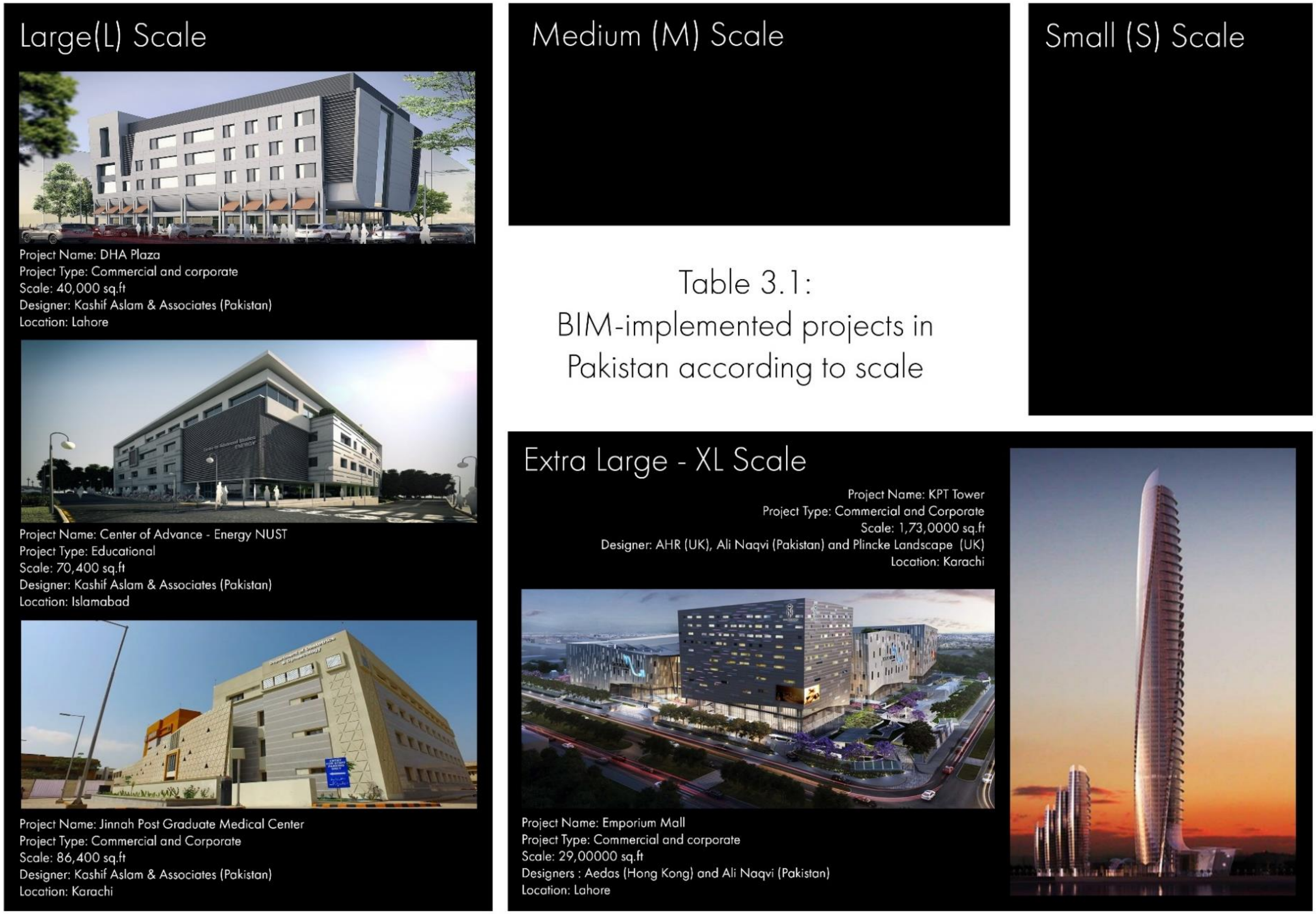
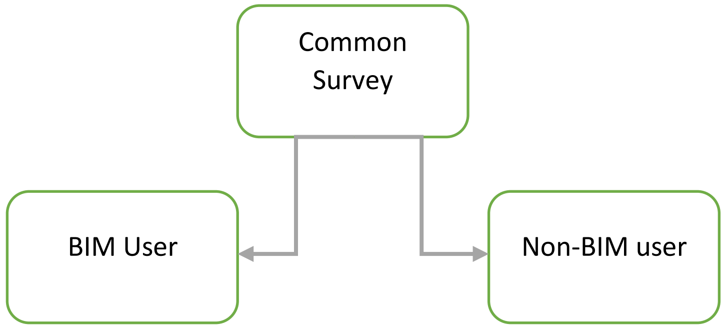


Figure 3.1. Survey Methodology



3.2.1. BIM User Questionnaire

This questionnaire is designed for BIM implementing firms in Pakistan's professional practice. This will define an understanding of the benefits they achieved and limitations they overcome after shifting to BIM process from traditional method. Questionnaire starts from definition of BIM according to respondent, further it leads to usgae of software using for implementing BIM, reasons for using that software, limitation respondents overcame after implementing BIM, scale of projects for which BIM is more useful in practice, advantages of BIM in terms of cost, time and quality and importance of BIM culture for Pakistan.

3.2.2. Non-BIM User Questionnaire

This part of the survey gathers the data from the non-BIM users who never implemented BIM in their projects. This questionnaire assists to identify the limitations and issues respondents face while using traditional methods of working. Questionnaire starts from limitations respondents face in professional practice, the scale of projects face more limitations, reasons for not using BIM, aspects of BIM they would utilize and vision of implementing BIM shortly. This opinion plot will also succor to recognize the lack of awareness of BIM and how to overcome it in professionalism and education sector.

3.3. SURVEYS OUTCOMES

Results of surveys are explained and discussed as

i. Respondents Profile
ii. Awareness of BIM
iii. Professional practice limitations:
iv. BIM implementation scale
v. BIM in professional practice
vi. Limitations for implementation of BIM
vii. Future of BIM adoption

3.3.1. Respondents Profile

Out of 100 surveys sent only 40 are replied in which 30 are valid to be analyzed. Table 3.2 shows the summary of respondent's profile according to their firms' ages, headquarters' locations, and qualifications of principal architects and type of projects they are specialized in.

Age of firm**:** According to the survey, 36.67percent were within the category of 15 to 30 years of experience, followed by 23.33percent were within 1 to 3 years, 10.00percent were more than 30+ years, 16.67percent were between 3 to 7 years and the least 3.33percent were 7 years to 15 years of experience.

Location of Firms: The survey was distributed to architectural design firms all over Pakistan, especially to those states where considerable investments in AEC sector had been taking place. 26.66percent of firms were located in capital city Islamabad, 40.00percent were located in Punjab state which hosts big commercial city Lahore, 23.33percent were located in KPK which hosted Peshawar as a commercial city, and 10.00percent were located in Sindh where Karachi is a commercial city.

Size of firms: The same way survey was distributed between small (1 to 5 employees), medium (5 to 20 employees), large (20 to 50 employees) and extra large (50+ employees) size of firms. Table 3.2 shows that 26.67percent of firms had 5 - 10 number of employees, 20.00percent had 1 - 5 number of employees, 13.33percent had 10 - 20 number of employees, 23.33percent had 20 - 50, and 10.00percent of firms had 50+ employees.

Qualification of Firms bearers: Regarding to qualification, 53.33percent of firm bearers are Masters / Graduate in Architecture, followed up by 43.33percent were Bachelor degree holders, and 3.33percent were Diploma holders with 45+ year of experience. None of the firm bearers held Ph.D. degree, whereas 33.33percent held a graduate degree from abroad, and 66.66percent opted an undergraduate degree from Pakistan.

Firms specialization: On the specialization of firms, 93.33percent were specialized in commercial projects, 90.00 are specialized in residential projects, 83.33percent are specialized in interior design projects, following up by 60.00percent firms are specialized in landscape designs, 36.67percent are specialized in urban design, 30.00percent are specialized in green and sustainable design, 20.00percent are specialized in industrial design, and 26.67percent are specialized in other project types such as institutional, academic and hospitality designs.

According to Table 3.2, it is evident that the data sampling is used in the survey where respondents are equal in all age, size and types of firms in different locations of Pakistan. Within this survey “BIM User” respondents are 33.33percent and Non-BIM User Respondents are 66.66percent.

Table: 3.2: Profile of respondents

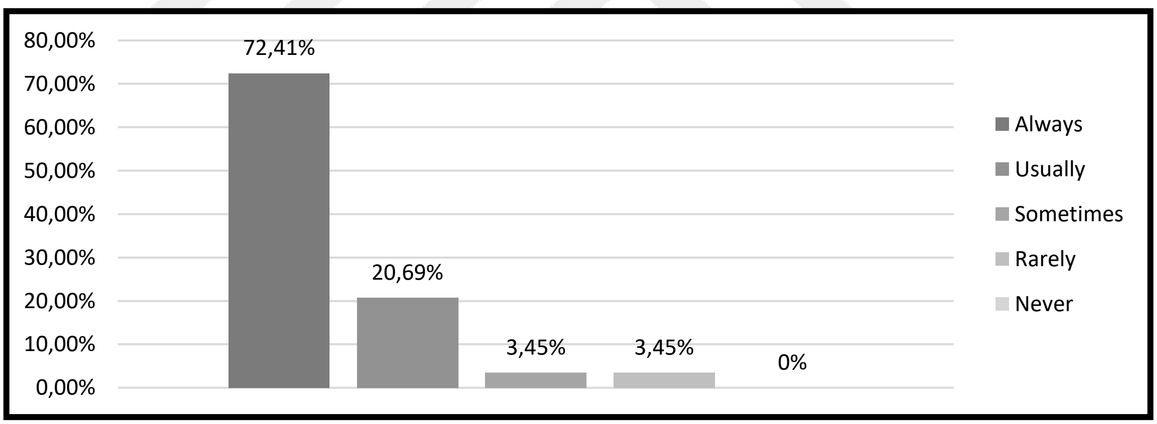
RESPONDENTS INFORMATION	CATEGORIES	PERCENTAGE
AGE OF FIRM	1 year - 3 year	23.33%
	3 years - 7 year	16.67%
	7 years - 15 year	3.33%
	15 years - 30 year	36.67%
	30 years +	10.00%
EDUCATION LEVEL	Diploma	3.33%
	Bachelors	43.33%
	Masters	53.33%
	PhD	0.00%
	Abroad Degree	33.33%
	Local (Pakistan) Degree	66.66%
FIRM SIZE BY NUMBER OF EMPLOYEES	1 to 5	20.00%
	5 to 10	26.67%
	10 to 20	13.33%
	20 to 50	23.33%
	50 +	16.67%
COMPANY HEADQUARTER	Islamabad	26.66
	Punjab	40.00%
	KPK	23.33%
	Sindh	10.00%
FIRM IS SPECIALIZED IN	Residential	90.00%
	Commercial	93.33%
	Urban Design	36.67%
	Interior Design	83.33%
	Landscape Design	60.00%
	Industrial Design	20.00%
	Green & Sustainable Design	30.00%
	Other	26.67%

3.3.2. Awareness of BIM

In this part of the survey, awareness of BIM is discussed in order to understand the scope of BIM implementation in the architectural design process for sustainable professional practice in Pakistan. Appling pre-construction in professional practice, use of pre-construction methods, importance and implementation of sustainability as a design concept and implementation of BIM in projects are being measured.

Appling pre-construction in professional practice: According to Figure 3.2, 72.41percent of the firms always apply pre-construction methods; following it 20.63percent usually apply the pre-construction methods and 3.45percent rarely and sometimes apply preconstruction methods.

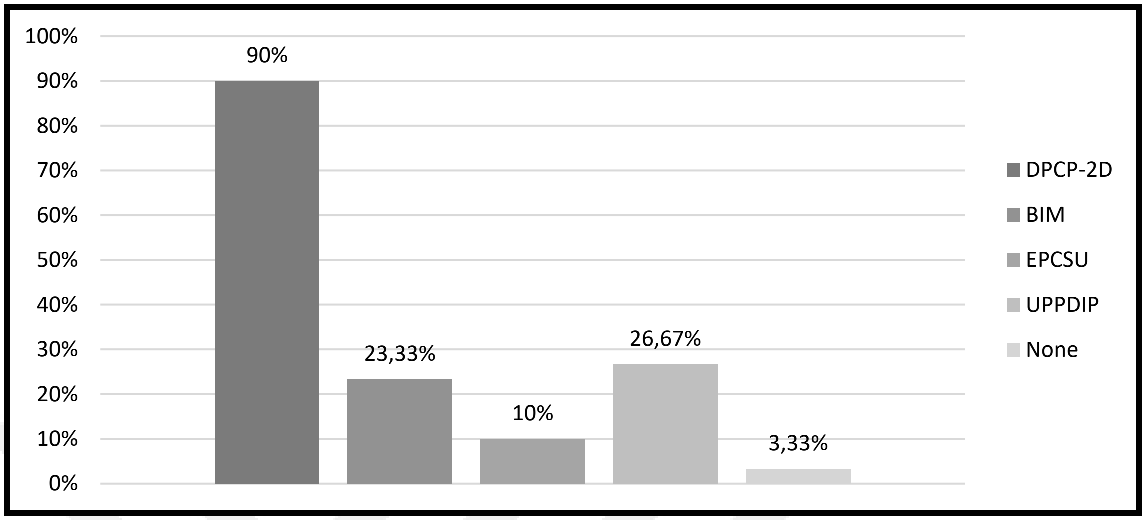
Figure 3.2: Appling pre-construction in professional practice



Use of Pre-construction Methods: As shown in Figure 3.3, out of that dominant 70 percent which apply pre-construction methods are as follows:

i. 90.00percent prefer Design Phase Construction Planning (2D Detail Planning, DPCP-2D)
ii. 26.67percent Using Past Project Data (UPPDIP)
iii. 23.33percent Building Information Modeling (BIM)
iv. 3.33percent use none of the mentioned techniques for pre-construction method
v. 10.00percent use Establishing Project Control System Unit method (EPCSU)

Figure 3.3: Pre-construction method



Importance of sustainability: According to Figure 3.4, 66.67percent think that the concept of sustainability is very important and 26.67percent consider it important, whereas 3.33percent think it is neutral.

Implementation of sustainability: According to Figure 3.5, 83.33percent implement sustainability in AEC projects and 16.67percent do not implement the concept of sustainability in their projects.

Figure 3.4: Importance of the sustainability concept in building construction

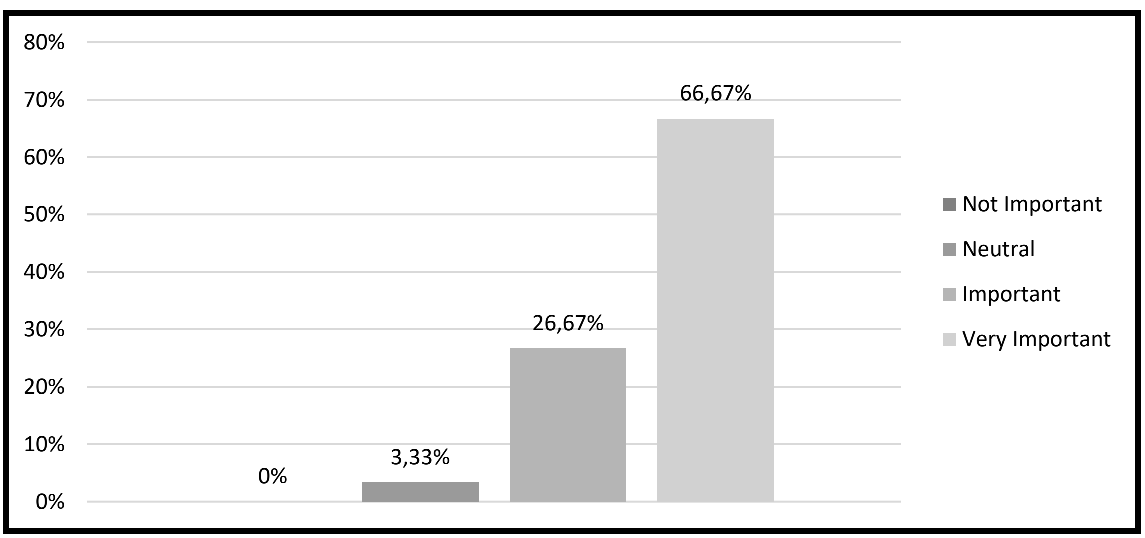
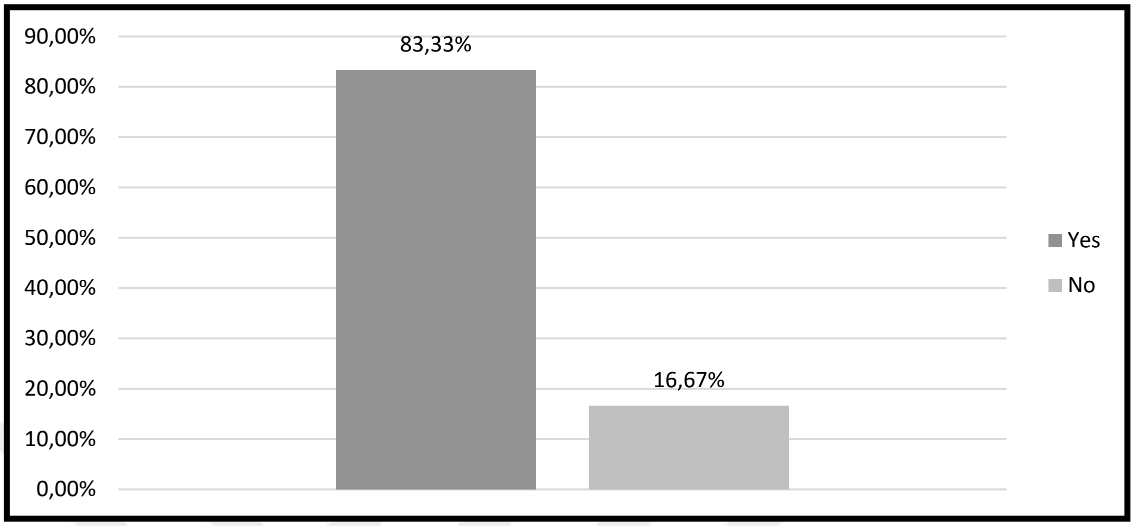
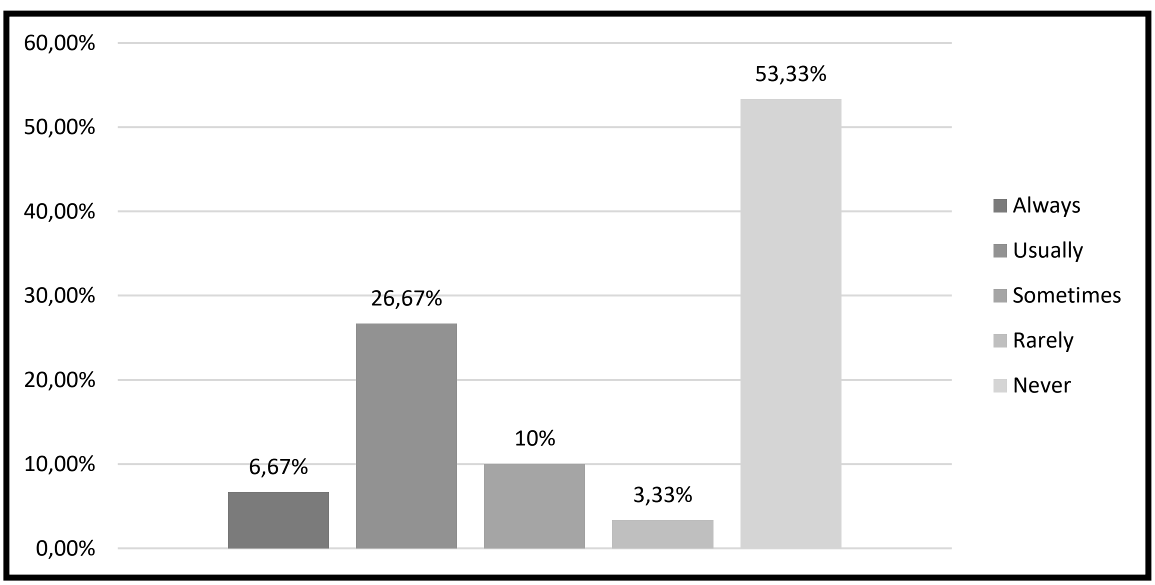


Figure 3.5: Implementation of sustainability in projects



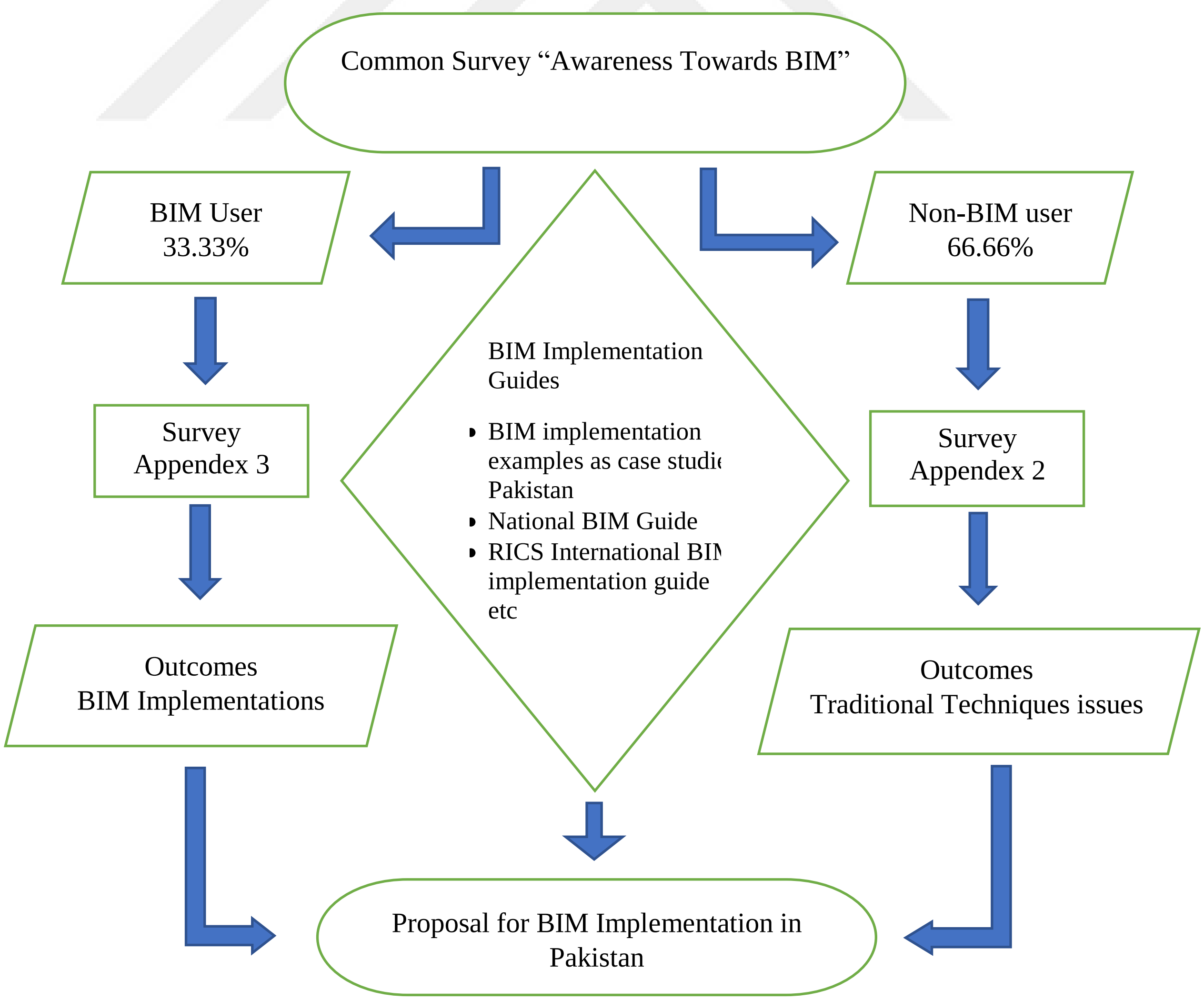
Implementation of BIM in projects: Figure 3.6, shows the implementation of BIM in projects by the respondent firms. 53.33percent have never implemented BIM in their projects, 26.67percent usually implement BIM, 10.00percent usually implement BIM, 6.67percent always implement BIM and rest 3.33percent rarely implement BIM.

Figure 3.6: Implementation of BIM in projects



The results of survey on "Awareness Towards BIM" reveals respondents' profile and their perception towards pre-construction and its method of implementation. It also leads to the concept and enactment of sustainability and ends over with the choice of BIM process or traditional methods. As an outcome, all respondents do implement pre-construction and do consider sustainability as one of the major factors in their projects. Whereas non-BIM users (66.66percent of respondents) still consider traditional methods for project delivery whether it may be sometimes (10percent), never (53.33percent), and rarely implement BIM (3.33percent). The rest 33.33percent, who are BIM users, always (6.67percent), and usually (26.67percent), implement BIM in their projects as given in survey methodology (Figure 3.7)

Figure 3.7: Survey methodology and flowchart



3.3.3. Professional Practice Limitations

This part of the survey is related to information regarding limitations in professional practice, due to the implementation of traditional techniques or implementation of BIM. Limitations are discussed as a matter of comparison between BIM user and non-BIM user experience.

BIM USER

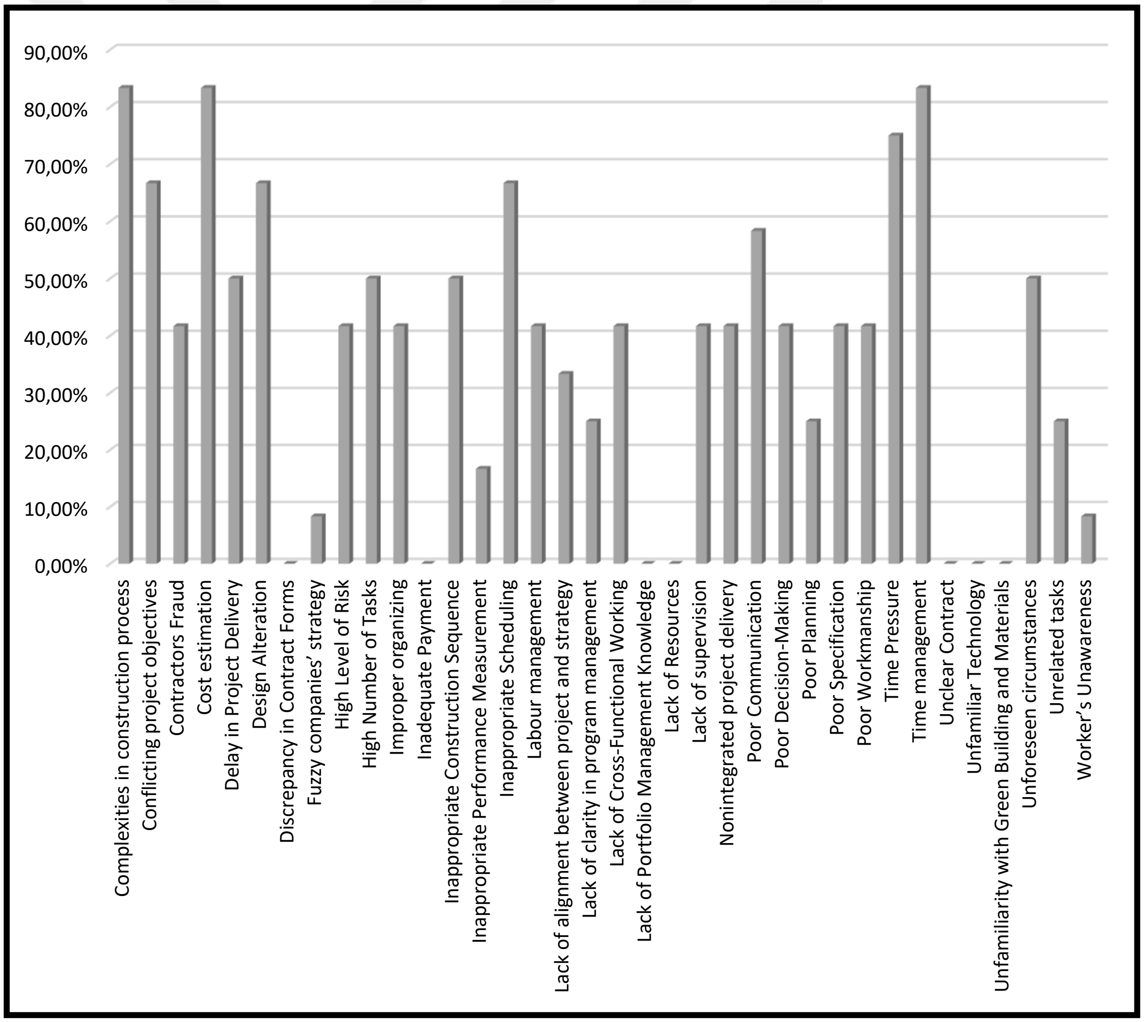
According to Figure 3.8, BIM user respondents who were asked about "the type of limitations they overcame after implementing BIM" were as follows:

i. 83.33percent overcame the limitations of complexities in projects, time management, and cost management.
ii. 75.00percent overcame the limitation of time pressure.
iii. 66.67percent overcame the limitations of conflicting project objectives, design altercations, and inappropriate scheduling.
iv. 58.33percent overcame the limitation of poor communication.
v. 50.00percent overcame the limitation of delay in project delivery, high number of tasks, inappropriate construction sequence and unforeseen circumstances.
vi. 41.67percent overcame the limitation of contractors' fraud, high level of risk, labor management, lack of supervision, nonintegrated project delivery, poor decision-making, poor specification, and poor workmanship.
vii. 33.33percent overcame the limitation of lack of alignment between project and strategy.
viii. 25.00percent overcame the limitation of lack of clarity in program management, poor planning, and unrelated tasks.
ix. 28.57percent overcame the limitation of contractor's fraud, delay in project delivery, improper organizing, inappropriate construction sequence, nonintegrated project delivery, communication errors, specification, and unforeseen circumstances.
x. 16.67percent overcame the limitation of inappropriate performance measurement.

xi. 0.83percent overcame the limitation of fuzzy companies' strategy and worker's unawareness.

Whereas BIM did not help to overcome the limitations of discrepancy in contract forms, inadequate payments, lack of portfolio management knowledge, lack of resources, unclear contract, unfamiliar technology, unfamiliarity with green building and materials performance measures.

Figure 3.8: Professional practice limitations overcome by BIM users

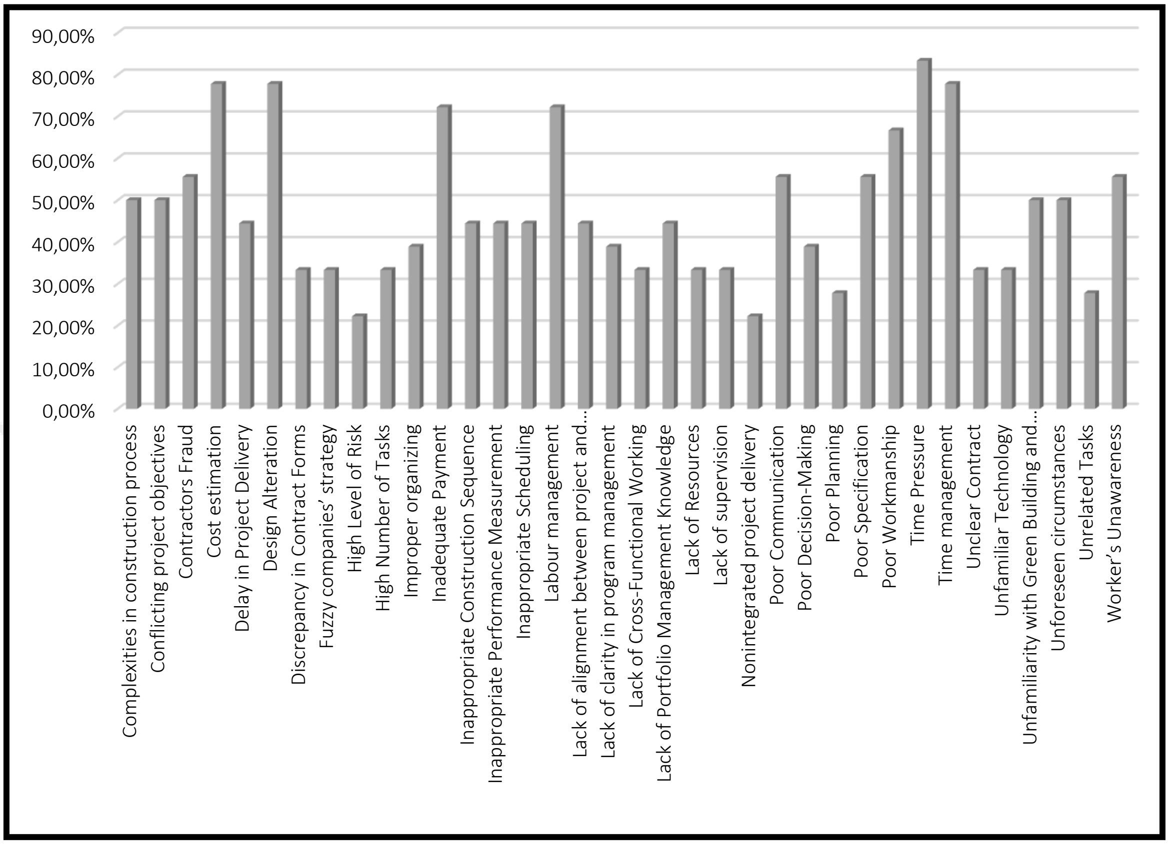


Non-BIM user

According to figure 3.9, Non-BIM user respondents who were asked about "the type of limitations they faced in professional practice due to of traditional methods" were as follow:

i. 83.33percent faced limitations of time pressure.
ii. 77.78percent faced limitation of cost estimation, design alteration and time management.
iii. 72.22percent faced limitation of inadequate payment and labor management.
iv. 66.67percent faced limitation of poor workmanship.
v. 55.56percent faced limitation of contractor's fraud, poor communication, poor specification, and workers unawareness.
vi. 50.00percent faced limitation of complexities in construction, conflicting project objectives, unfamiliarity with green building and materials and unforeseen circumstances.
vii. 44.44percent faced limitations of delay in project delivery, inappropriate construction sequence, inappropriate performance measurement, inappropriate scheduling and lack of alignment between project and strategy.
viii. 38.89percent faced the limitation of Improper organizing, Lack of clarity in program management and Poor Decision-Making.
ix. 33.33percent faced the limitation of discrepancy in contract forms, fuzzy company's strategy, high number of tasks, lack of cross-functional working, lack of resources, lack of supervision, unclear contract and unfamiliar technology.
x. 27.78percent faced the limitation of poor planning and unrelated tasks.
xi. 22.22percent faced the limitation of high-level risks and non-intergraded project delivery.

Figure 3.9: Professional practice limitations faced by non-BIM users



By the comparison of both groups BIM user and Non-BIM user, an average line is stretched to recognize those limitations which are prioritized by both the set of groups. According to Figure 3.10:

i. Average of Cost Estimation and Time Management is 80.56percent.
ii. Average of Time Pressure is 79.17percent.
iii. Average of Design Alteration 72.23percent.
iv. Average of Complexities in Construction Process 66.67percent.
v. Average of Conflicting Project Objectives 58.34percent.
vi. Average of Labor-Management and Poor Communication 56.95percent.
vii. Average of Inappropriate Scheduling 55.56percent.
viii. Average of Poor Workmanship 54.17percent.
ix. Average of Unforeseen Circumstances 50.00percent.

x. Average of Contractors Fraud and Poor Specification 48.62percent.

xi. Average of Inappropriate Construction Sequence and Delay in Project Delivery is 47.22percent.

xii. Average of High Number of Tasks 41.67percent.

xiii. Average of Improper Organizing and Poor Decision-Making is 40.28percent.

xiv. Average of Lack of Alignment between Project and Strategy 38.89percent.

xv. Average of Lack of Cross-Functional Working and Lack of Supervision is 37.50percent.

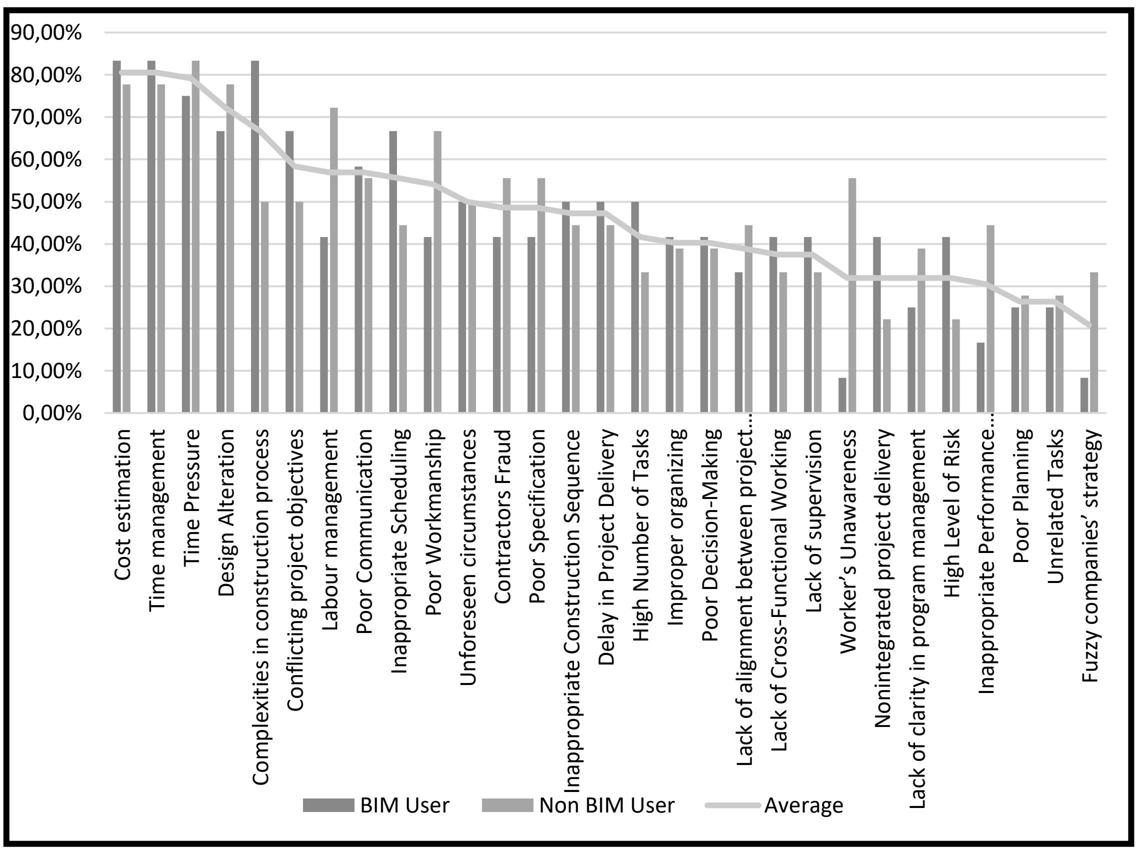
xvi. Average of Worker's Unawareness, Nonintegrated Project Delivery, Lack of Clarity in Program Management and High Level of Risk is 31.95percent.

xvii. Average of Inappropriate Performance Measurement is 30.56percent.

xviii. Average of Poor Planning and Unrelated Tasks is 26.39percent.

xix. Average of Fuzzy companies' strategy is 20.83percent.

Figure 3.10: Average line reckoned by non-BIM user and BIM user



Benefits of BIM implementation

After displaying professional practice limitations of BIM Users and Non-BIM Users, both graphs are compared to identify benefits of BIM implementation in two different forms (Figure 3.10 and Figure 3.11). A table is concluded from figure 3.9 which indicates the gap between both positive (BIM user) and negative (non-BIM user) limitations. According to both tables (Table 3.5 and Table 3.6) and Figures (Figure 3.11 and Figure 3.12), BIM does benefit 29 limitations out of total 36 limitations set by conventional methods. Figure 3.8 and Table 3.3; prove that BIM Implementation in professional practice can indeed provide a high level of benefit to architects practicing in Pakistan. On the other hand, remaining 7 limitations Discrepancy in Contract Forms, Inadequate Payment, Lack of Portfolio, Management Knowledge, Lack of Resources, Unclear Contract, Unfamiliar Technology and Unfamiliarity with Green Building and Materials were unable to get a positive impact through BIM adoption in Pakistan (Table 3.4).

Table 3.3: Professional practice limitations not overcome by BIM implementation

	LIMITATIONS NOT OVERCOME BY BIM IMPLEMENTATION	BIM USER	NON-BIM USER
1.	Discrepancy in Contract Forms	0%	35.29%
2.	Inadequate Payment	0%	35.29%
3.	Lack of Portfolio Management Knowledge	0%	70.59%
4.	Lack of Resources	0%	47.06%
5.	Unclear Contract	0%	47.06%
6.	Unfamiliar Technology	0%	35.29%
7.	Unfamiliarity with Green Building and Materials	0%	47.06%

Figure 3.11: Gap between BIM user and non-BIM user in professional practice

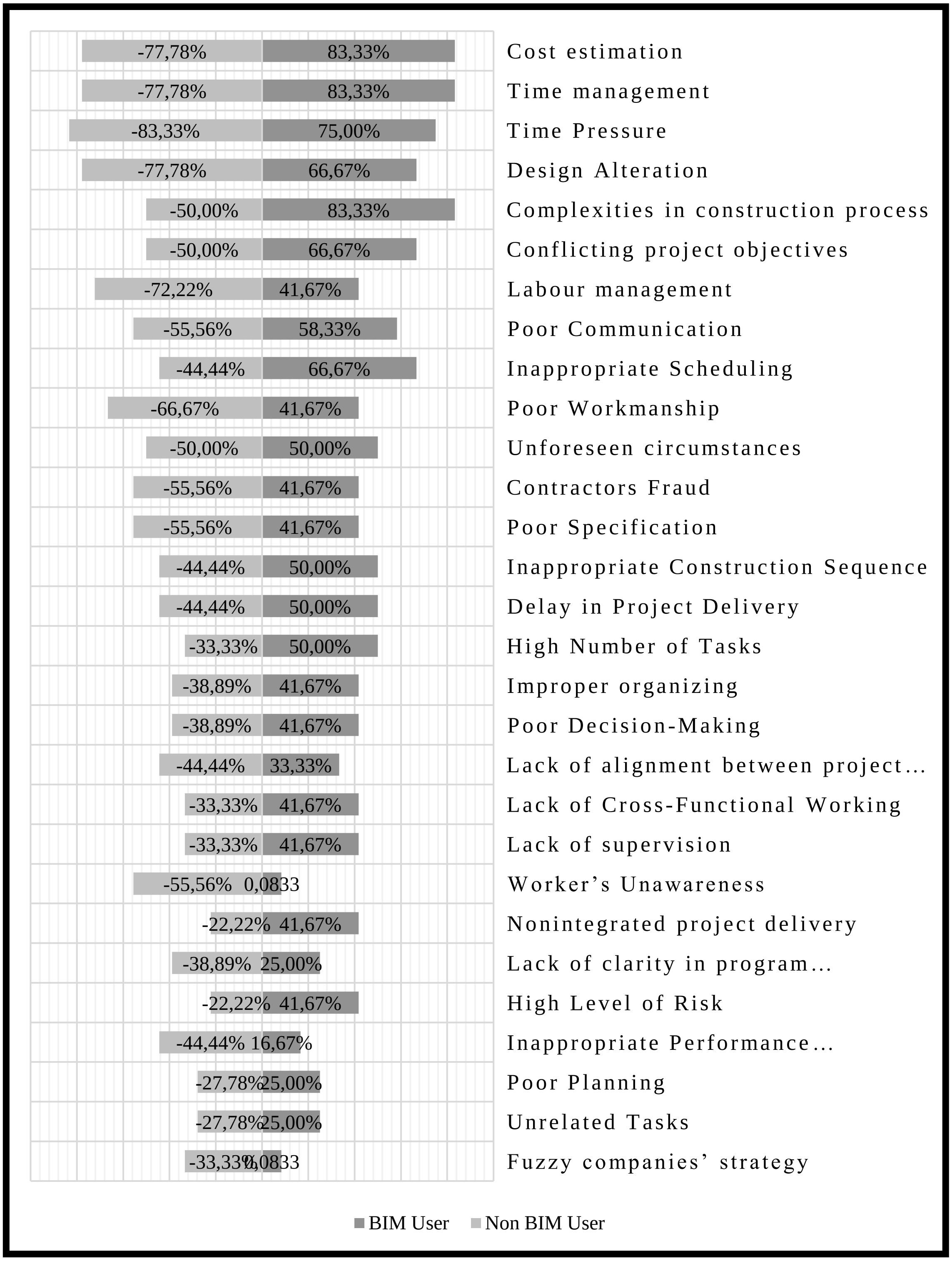


Table 3.4: List of limitations which can be overcome by implementing BIM

NO	LIMITATIONS	BIM USER	NON-BIM USER	GAP %
1.	Cost Estimation	83.33%	77.78%	161.11%
2.	Time Management	83.33%	77.78%	161.11%
3.	Time Pressure	75.00%	83.33%	158.33%
4.	Design Alteration	66.67%	77.78%	144.45%
5.	Complexities in Construction Process	83.33%	50.00%	133.33%
6.	Conflicting Project Objectives	66.67%	50.00%	116.67%
7.	Labor Management	41.67%	72.22%	113.89%
8.	Poor Communication	58.33%	55.56%	113.89%
9.	Inappropriate Scheduling	66.67%	44.44%	111.11%
10.	Poor Workmanship	41.67%	66.67%	108.34%
11.	Unforeseen circumstances	50.00%	50.00%	100.00%
12.	Contractors Fraud	41.67%	55.56%	97.23%
13.	Poor Specification	41.67%	55.56%	97.23%
14.	Inappropriate Construction Sequence	50.00%	44.44%	94.44%
15.	Delay in Project Delivery	50.00%	44.44%	94.44%
16.	High Number of Tasks	50.00%	33.33%	83.33%
17.	Improper Organizing	41.67%	38.89%	80.56%
18.	Poor Decision-Making	41.67%	38.89%	80.56%
19.	Lack of Alignment between Project and Strategy	33.33%	44.44%	77.77%
20.	Lack of Cross-Functional Working	41.67%	33.33%	75.00%
21.	Lack of Supervision	41.67%	33.33%	75.00%
22.	Worker’s Unawareness	0.0833	55.56%	63.89%
23.	Nonintegrated Project Delivery	41.67%	22.22%	63.89%
24.	Lack of Clarity in Program Management	25.00%	38.89%	63.89%
25.	High Level of Risk	41.67%	22.22%	63.89%
26.	Inappropriate Performance Measurement	16.67%	44.44%	61.11%
27.	Poor Planning	25.00%	27.78%	52.78%
28.	Unrelated Tasks	25.00%	27.78%	52.78%
29.	Fuzzy Companies’ Strategy	08.33%	33.33%	41.66%

3.3.4. The Compliance of Projects Scales for BIM Implementation

This part of the survey, identifies the suitability of project scales for BIM implementation. To define the scale for BIM implementation, initially, the measure of scale will be discussed. Afterwards, BIM user scale, non-BIM user scale, and results will be concluded.

Scale

Surveys were distributed in a different size and age of firms, due to which scale was relative and varies for every firm. In surveys the scale of projects are classified as Small (S), Medium (M), Large (L) and Extra Large (XL) referring to the book "S, M, L, XL (Koolhaas, 1995)". Respondents define their project scales as S, M, L or XL out of which an average range are figured. Table 3.7 shows these measures of scales in Pakistan for S, M, L, XL projects.

Table 3.5: Project scale classification in Pakistan according to respondents

SCALE	FROM	TO
Small Scale Varies From	0 sq ft / 0 sq mt	3500 sq ft / 325 sq mt
Medium Scale Varies From	3500 sq ft / 325 sq mt	28500 sq ft / 2648 sq mt
Large Scale Varies From	28500 sq ft / 2648 sq mt	86000 sq ft / 79890 sq mt
Extra Large Scale Varies From	86000 sq ft / 79890 sq mt	3484000+ sq ft / 323675+ sq mt

BIM User Scale Identification

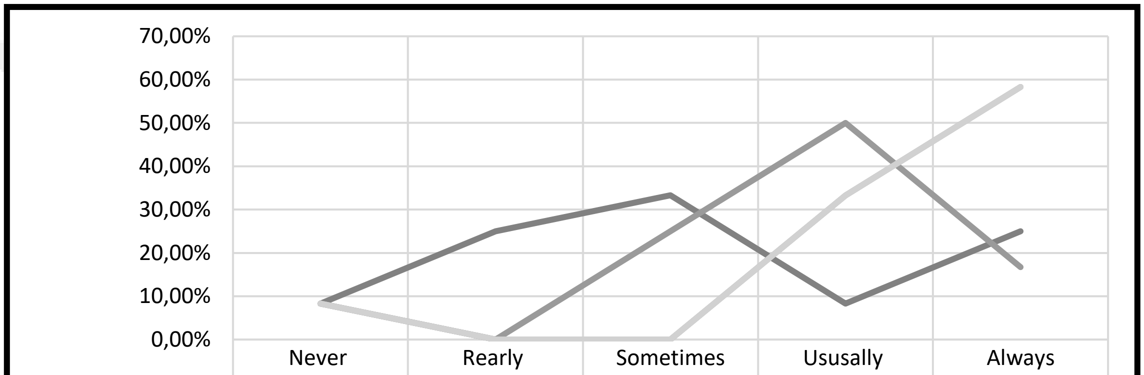
BIM users scale, indicates experience of BIM implementation in professional practice in Pakistan as never, rarely, sometimes, usually and always, as explained in Figure 3.12. According to respondents:

i. In S scale projects 33.30percent agree to implement BIM sometimes, 25.00percent agree over always and rarely, 5.90percent agrees over usually and never.
ii. In M scale project 50.00percent agrees to implement BIM usually, 25.00percent agrees over sometimes, 16.70percent agrees over always, 8.30percent agrees over never.

iii. In L scale of project 58.30percent agrees to implement BIM always, 33.30percent agrees over usually, 8.30percent agrees over never and 0percent agrees over sometimes and rarely.

iv. In XL scale of projects, 58.30percent agrees to implement BIM always, 33.30percent agrees over usually, 8.30percent agrees over never, and 0percent agrees over rarely and sometimes.

Figure 3.12: BIM user scale identification



	Never	Rearly	Sometimes	Ususally	Always
Small	8,30%	25,00%	33,30%	8,30%	25,00%
Medium	8,30%	0,00%	25,00%	50,00%	16,70%
Large	8,30%	0,00%	0,00%	33,30%	58,30%
Extra Large	8,30%	0,00%	0,00%	33,30%	58,30%

Non-BIM User Scale Identification

According to non-BIM users experience, the scale of projects in Pakistan, which faces more limitations in professional practice is explained in Figure 3.13. According to respondents:

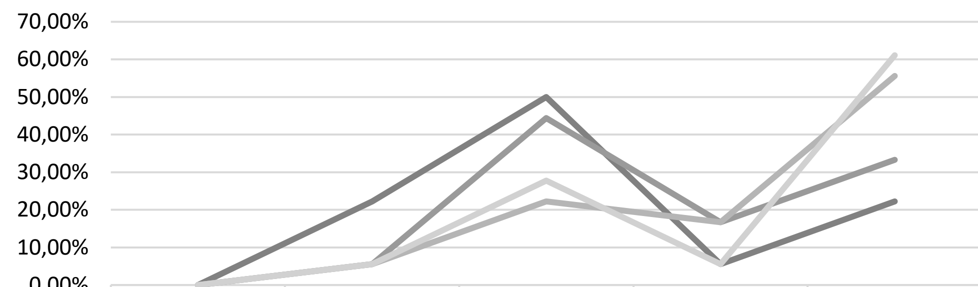
i. In S scale projects 50.00percent agree to implement BIM sometimes, 22.20percent agree over rarely and always, 5.60percent agrees over usually and never, whereas 0percent agrees over never.

ii. In M scale project 44.40percent agrees to implement BIM sometimes, 33.30percent agrees over always, 16.70percent agrees over usually, and 5.60percent agrees over rarely.

iii. In L scale of project 55.60percent agrees to implement BIM always, 22.20percent agrees over sometimes, 16.70percent agrees over usually, 5.60percent agrees over rarely and 0percent agrees never.

iv. In XL scale of projects 61.10percent agrees to implement BIM away and usually, 27.80percent agrees over sometimes, 5.60percent agrees over rarely and usually and 0percent agrees over never.

Figure 3.13: non-BIM user scale identification

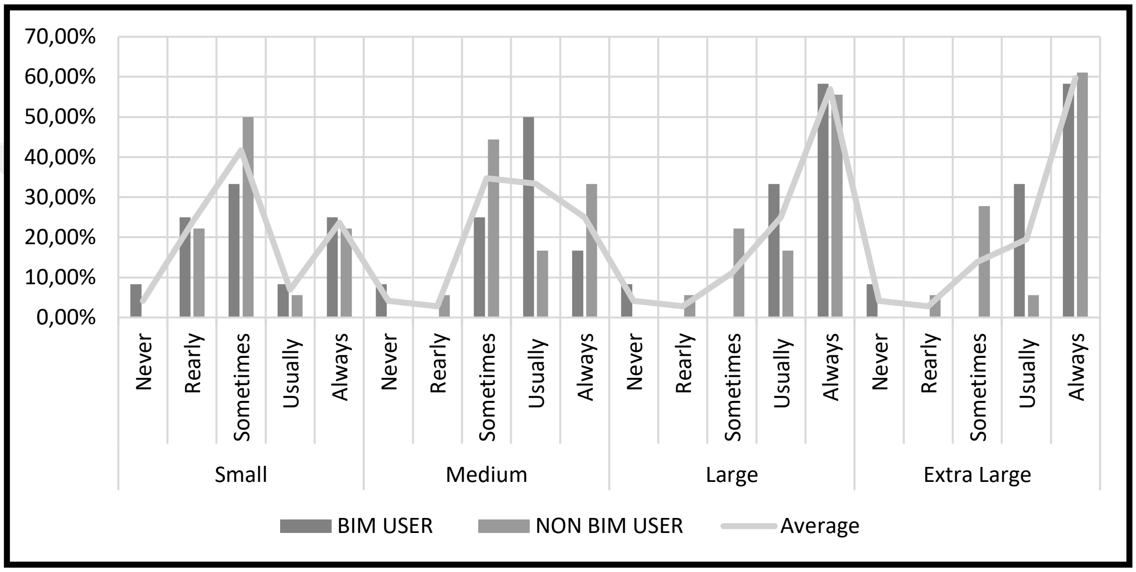


	Never	Rarely	Sometimes	Usually	Always
Small	0,00%	22,20%	50,00%	5,60%	22,20%
Medium	0,00%	5,60%	44,40%	16,70%	33,30%
Large	0,00%	5,60%	22,20%	16,70%	55,60%
Extra Large	0,00%	5,60%	27,80%	5,60%	61,10%

Comparison of BIM User Scale and Non-BIM User Scale

Figure 3.14 shows the comparison between BIM user scale and non-BIM user scale in order to ascertain the effective scale for BIM implementation. In the process, an average range is reckoned to perceive the different project scales XL, L, M, S. According to Figure 3.11, the highest point for average measured line in S scale is at “sometimes”, in M scale it lies at “sometimes”, in L scale it lies at “always” and in XL scale its highest growth is at “always”. This result reveals that BIM process needs to be implemented specifically on L scale and XL scale projects, for gaining more benefits and overcoming more limitations. Whereas M and S scale projects fall in second priority in current market situation of Pakistan. We can consider that in future, with more knowledge of BIM among professionals and demanding market trends such as sustainability, Assist Management, Labor shortage, and Language Barriers, S and M scale projects will need more BIM implementation. However, in current situation, L and XL scale of projects are given the priority.

Figure 3.14: Comparing BIM user scale and non-BIM user scale reveals



3.3.5. Application Benefits of BIM for BIM Users and Non-BIM Users

This part of the survey assesses application benefits of BIM to BIM users and future implementation of BIM applications by non-BIM users.

Application Benefits for BIM Users:

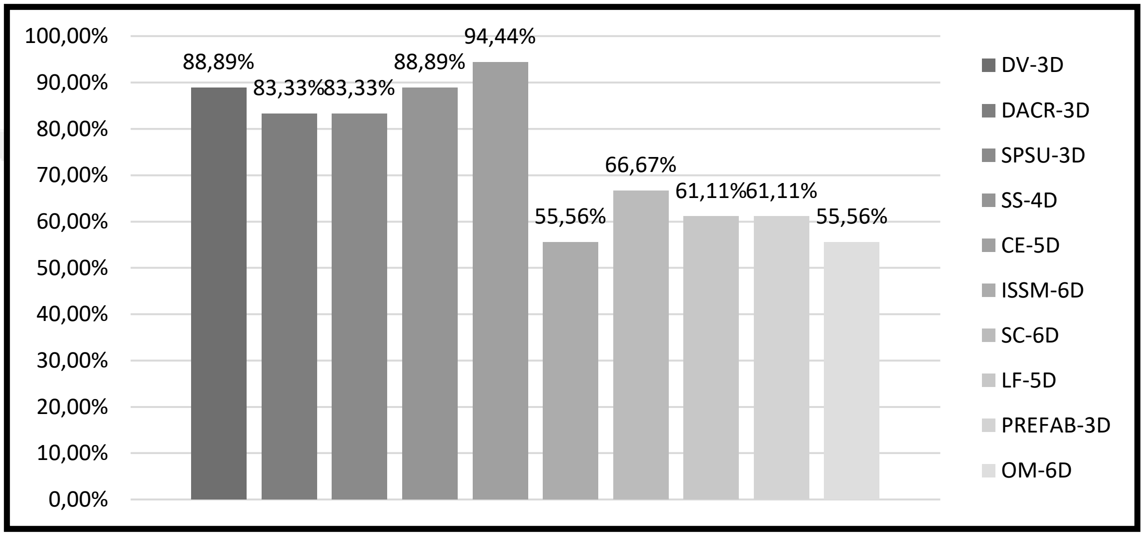
Figure 3.15 identifies the benefits of BIM in professional practice. According to respondents:

i. 94.44percent gain the benefits of Cost Estimation (CE-5D).
ii. 88.89percent gain the benefits of Design visualization and Scheduling and Sequencing - 4D (SS-4D)
iii. 83.33percent gain the benefits of Design Assistance and Construction Review (DACR-3D) and Site Planning and Site Utilization (SPSU-3D)
iv. 66.67percent gain the benefits of System Co-ordination (SC-6D).

v. 61.11percent gain the benefits of Prefabrications (PREFAB-3D) and Layout and Field Work (LF-5D).

vi. 55.56percent gain benefits of Operation and Maintenance (OM-6D) and Integration of Subcontractor and Suppliers Models (ISSM-6D).

Figure 3.15: Application benefits of BIM implementation



Future Implementation of BIM Applications by Non-BIM Users:

In this part of the survey, non-BIM users express their interests in BIM applications, in which they are likely to implement BIM in future. According to Figure 3.16:

i. 91.67percent are interested in Cost Estimation - 5D (CE-5D) and Design Visualization (DV-3D) applications.

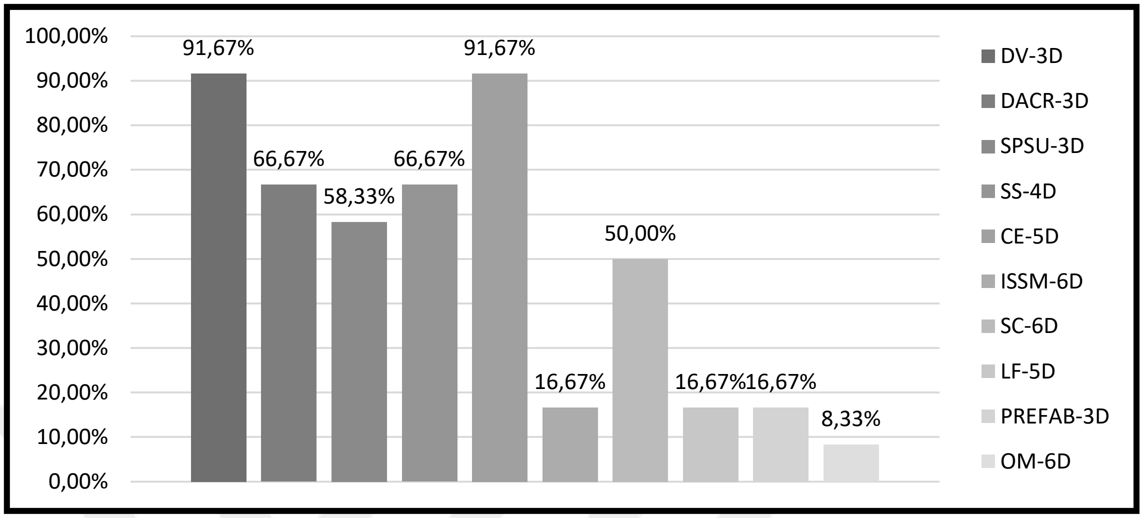
ii. 66.67percent intends to make use of and Scheduling and Sequencing - 4D (SS-4D) and Design Assistance and Constructability Review (DACR-3D) applications.

iii. 50.00percent hope to carry out Systems Coordination (SC-6D).

iv. 16.67percent claim to put in practice, Layout and Fieldwork (LF-5D), Prefabrication (PREFAB-3D) and Integration of Subcontractors and Supplier Models (ISSM-6D) applications.

v. 8.33percent demand Operations and Maintenance (including as-built records) (OM-6D) applications.

Figure 3.16: BIM applications to be implemented in future



Fist Comparison:

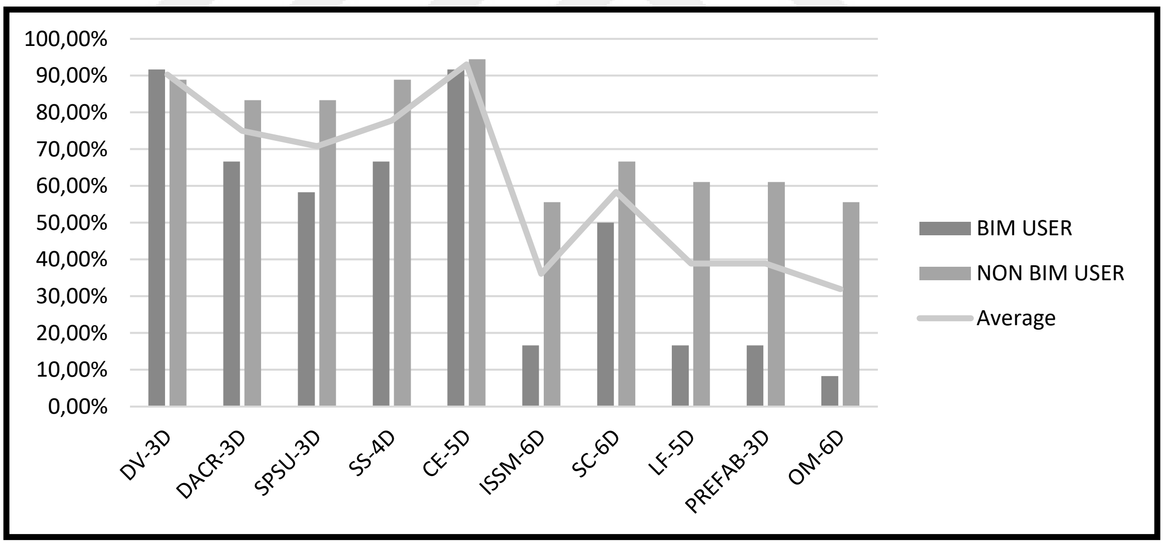
By comparing both BIM user and non-BIM user data, an average line is concluded which defines the priorities of both users, who demand specific applications in current market trends. As shown in Figure 3.17:

i. Cost Estimation CE-5D is at 1st priority with the highest average point of 93.06percent.
ii. Design Visualization DV-3D have 2nd highest peak with the average of 90.28percent.
iii. Scheduling and Sequencing SS-4D is at 3rd priority with average of 77.78percent.
iv. Design Assistance and Construction Review DACR-3D is at 4th priority with the average of 75.00percent.
v. Site Planning and Site Utilization SPSU-3D is at 5th priority with the average of 70.83percent.
vi. System Coordination SC-6D is at 6th priority with average of 58.34percent.
vii. Layout and Fieldwork LF-5D and Prefabrications PREFAB-3D is at 7th priority with average of 38.89percent.
viii. Integration of Subcontractor and Suppliers' Models ISSM-6D is at 8th priority with the average of 36.12percent.

ix. Operation and Maintenance OM-6D is the least 9th priority with the average of 31.95percent.

All these above-given priorities can be utilized while creating strategy of awareness and roadmap for BIM process. As these priorities are defined by both groups of respondents, who highlight the need of applications according to market trends. In future with the spreading knowledge for BIM process, the first three priorities are found to be Cost Estimation CE-5D, Design Visualization DV-3D, and Scheduling and Sequencing SS-4D, to get people trained in and utilize them in professional practice. As these priorities are showing the needs of market, which will require BIM professionals and provide BIM process through their architectural projects.

Figure 3.17: Average line of both scales

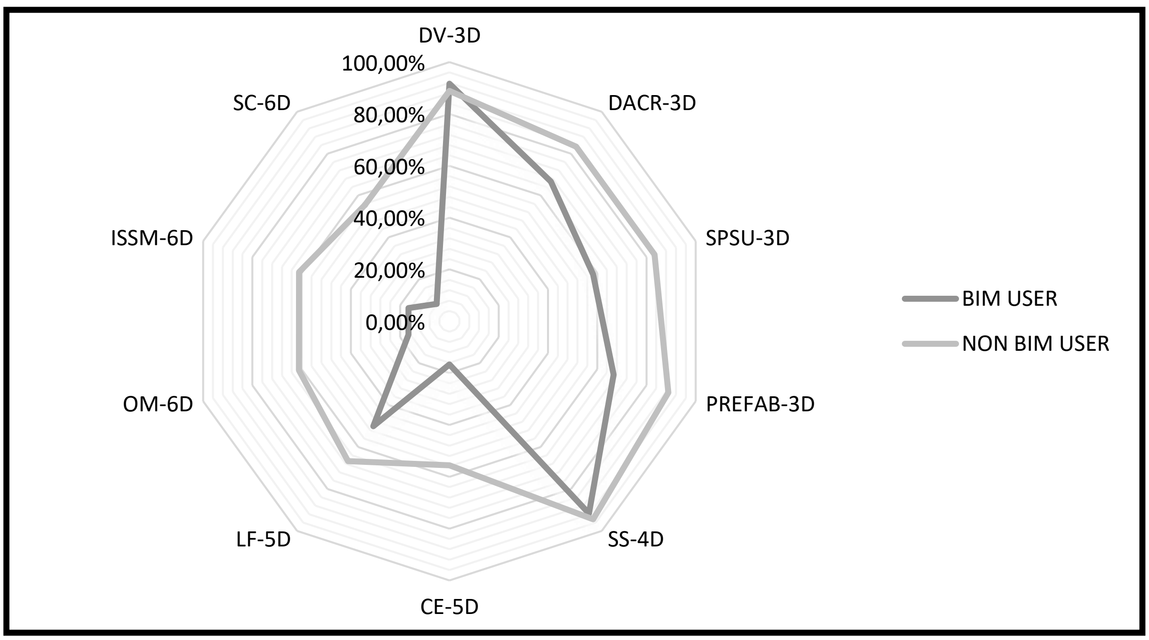


Second Comparison:

By the comparison of both non-BIM user and BIM user application benefits, following applications will get an increase in effect according to Figure 3.18. results show that architects do urge to adopt new applications of AEC sector to deliver a better product for clients and become a part of modern information-based design era. Radar graph (Figure 3.18) shows the gap between current BIM user application usage and interest of non-BIM users application usage in future. Radar Graph also gives an idea of where we are standing and what we can achieve in future. Following is the increase of gap in applications.

i. Operations and Maintenance OM-6D will increase 47.23percent.
ii. Prefabrications PREFAB-3D and Layout and Fieldwork LF-5D will increase 44.44percent in professional practice.
iii. Integration of Subcontractor and Suppliers' Models ISSM-6D will increase 38.89percent in professional practice.
iv. Site Planning and Site Utilization SPSU-3D will increase 25.00percent in professional practice.
v. Scheduling and Sequencing SS-4D will increase 22.22percent in professional practice.
vi. Design Assistance and Construction Review DACR-3D and System Coordination SC-6D will increase 16.67percent in professional practice.
vii. Cost Estimation CE-5D and Design Visualization DV-3D will increase 2.78percent in professional practice.

Figure 3.18: Increase of applications in professional practice



3.3.6. BIM in Professional Practice

This part of survey gives a comprehension of BIM Users in professional practice of Pakistan. The following information will be discussed in figures and tables

i. Description of BIM
ii. Most common BIM software
iii. Reviews for preference of BIM software
iv. The motivation for BIM implementation
v. Benefits of BIM implementation
vi. Effects of BIM implementation on project characteristics and phases

Description of BIM:

In the questionnaire with BIM Users, respondents were asked to give a brief explanation about BIM and define "what BIM means to them." The responses given in Table 3.7 reveals that respondents do know that BIM is not only for visualization. It is also essential for costing, scheduling, clash detection and it does help in coordinating data due to its parametric nature

Table 3.6: Definition of BIM according to respondents

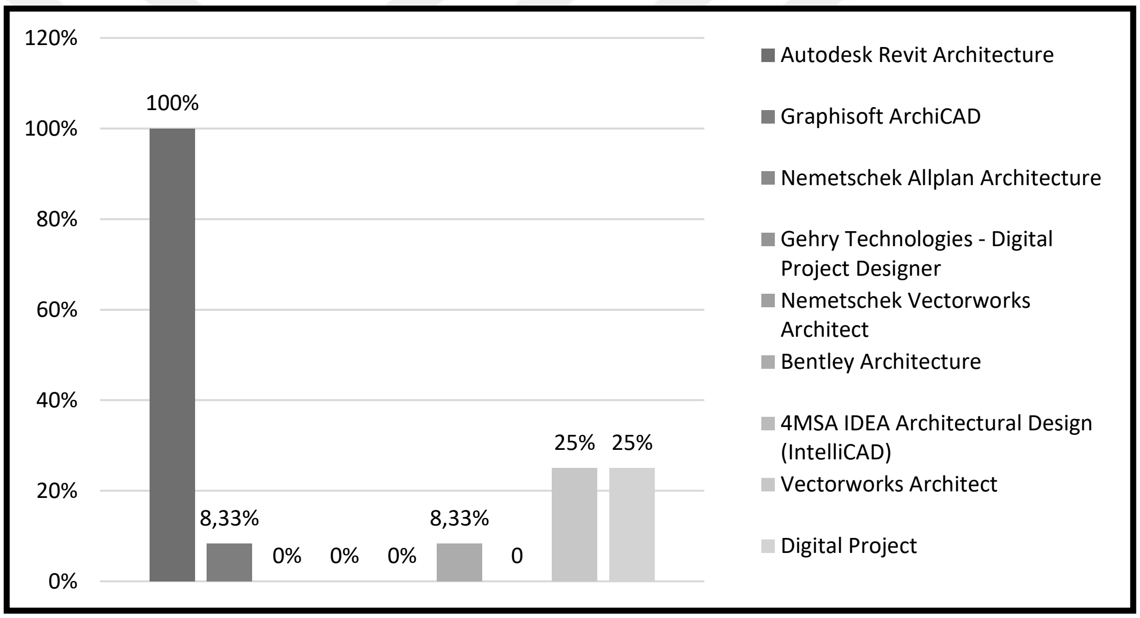
Respondent 1	*BIM is the digital representation of buildings regarding 3d modeling that gives a sense of the look and feel of that space. It is benefitable as it gives the full information of what a building will look like once it is constructed and so helps an architect to make design decisions.*
Respondent 2	*For us, as a firm BIM is about the most reliable tool for the accuracy of the project through parametric relations within the model, shadow studies, take offs, using for revisions and altering information in 2D and 3D.*
Respondent 3	*Integrated and coordinated set of data that keeps track of designer's decisions and assists team members to understand with minimum time lags. We are working on streamlining of construction cost estimates with BIM models. That will be the next massive advantage for us.*
Respondent 4	*BIM is integrated digital model which delivers Clash free designs, Accurate schedules, and precise cost estimation. These all are basic needs for every AEC investor.*

Most common BIM software:

Figure 3.19, shows the most common BIM software among BIM Users. According to respondents:

i. 100percent use Autodesk Revit.
ii. 25.00percent use Digital Project and Vector works Architects.
iii. 8.33percent use Bentley Architecture and Graph iSOFT. 28.57percent use.
   Other: some respondents use other software as Navis Works and VICO Office

Figure 3.19: Use of Software for BIM implementation



Reviews for preference of BIM software:

BIM users defined their reasons for preference. In Table 3.9, respondents explain that in Pakistan Autodesk was the very first company that became familiar through digitalization in professional practice, hence Autodesk is the primary choice for implementing BIM. Whereas one respondent was trained in Autodesk family from the USA. The second choice Navisworks is also a product of Autodesk, Whereas Vico office is from the family of Archicad. The last choices of Vectorworks and Design Project both are newly emerging tools in Pakistan market.

Table 3.7: Reviews of respondents for preference of BIM software

Respondent 1	*In Pakistan, we mostly use Autodesk family, whereas Revit helps me to save time because of its parametric design system and initial scheduling.*
Respondent 2	*Autodesk that is what I was trained in from the USA.*
Respondent 3	*Revit is ease to use.*
Respondent 4	*Autodesk is a conventional environment is our region.*
Respondent 5	*in Pakistan, we are driven by Autodesk software for decades, AUTOCAD has been our central platform, Revit as Autodesk software was naturally our prime preference*
Respondent 6	*Was already using Autodesk products*

Motivation factors for BIM implementation:

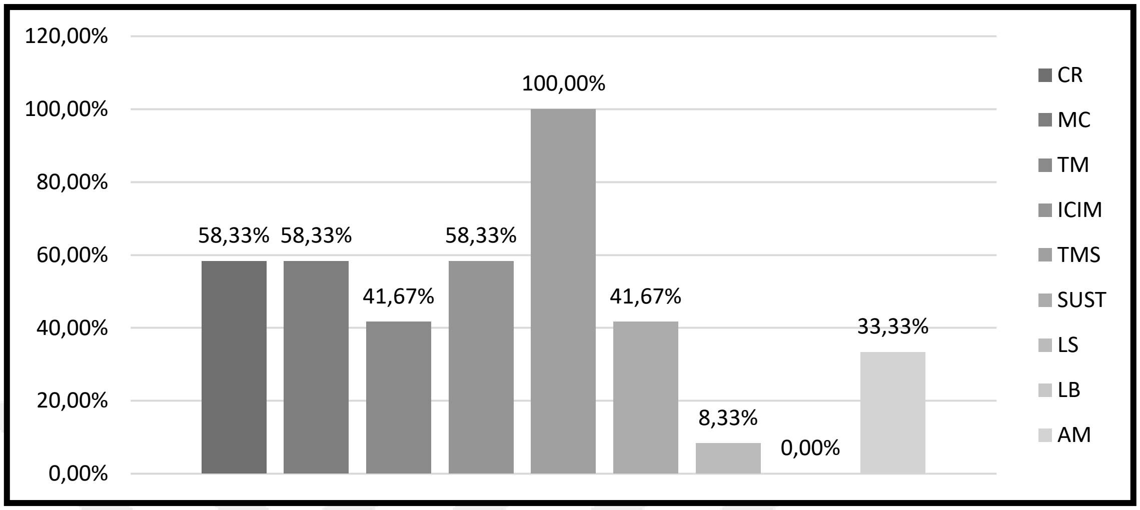
This part of survey explains the factors for which most BIM users feel motivated to shift from traditional methods into BIM process. According to Figure. 3.20:

i. 100percent were motivated by its Time Management and Saving (TMS) factor.
ii. 58.33percent were motivated by its Management in Construction (MC), Increase of Complexity in Infrastructure and Marketplace (ICIMP) and Cost Reliability (CR).
iii. 41.67percent were motivated by Sustainability (SUST) and Time to Market (TM).
iv. 33.33percent were motivated by Assist Management (AM).
v. 8.33percent were motivated by Labor shortage (LS).
vi. None of the respondents were motivated by language barriers (LB) factors.

One of the respondents expressed his review in "other" section, as follow:

> "*My use of BIM is unfortunately limited because of my clients and contractors in the market. I mostly use it for scheduling and estimation and visualizations. Payments of projects do not support BIM. The issue is, can architect hire BIM professionals?"*

Figure 3.20: Motivational factors for BIM implementation



Through the above results of “Motivational factors for BIM implementation”, the priorities of professionals in order to deliver a better product to the clients in current market situation of Pakistan are given. Time Management and Saving is the major issue and all BIM users are motivated towards BIM to overcome it.

The second most prioritized issues are found to be "Management in Construction (MC)", Increase of Complexity in Infrastructure and Marketplace (ICIMP) and Cost Reliability (CR). This shows that complex structures and their construction management are not easy to be handled anymore through traditional methods. Architects do need more precise numbers of cost estimation to handle their projects.

“Sustainability” and “Time to Market” come in 3rd place according to results, which show the awareness of sustainability that could be achieved by BIM process. Whereas motivation factor for “Time to Market” shows that professionals are also aware of the importance of BIM process and its benefits, which are highly valued in current market.

“Assist Management" and Labor Management” falls under 4th and 5th priorities. They are at last in the list of priorities in current market but in future will be considered in high levels, as more professionals will be trained in BIM process and bring it to more mature state.

None of the professional either considered Language barrier as issue or a reason to be motivated for. This defines that there is no communication gap due to language between professionals in AEC sector and other stakeholders.

Effects of BIM on project phases through characters:

This part of survey deals with the effectiveness of BIM implementation over traditional methods regarding characteristics of projects in different phases. Cost, quality and time are considered as characteristics of projects in different phases. According to Figure 3.21, in detail examination:

i. In the design phase, cost effect 23.10percent, quality effect 42.30percent and time effect 34.60percent as compared to traditional method.
ii. In documentation phase, cost effect 33.30percent, quality effect 41.70 and time effect 25.00percent as compared to traditional method.
iii. In construction phase, cost effect 30.40percent, quality and time effect 34.80percent as compared to traditional method.
iv. In operation and maintenance phase cost and time effect 40.00percent, quality effect 20.00percent as compared to traditional method.

In overall case of Figure 3.21: Above given results of "Effects of BIM on project phases through characteristics" provide evidence that in current market situation where BIM is not properly nourished but still affecting all the phases of project positively through time, quality and cost. According to the results in overall case of professionals transferred from traditional method to BIM process gained a positive effect in time 44.00percent, quality 32.00percent and cost 24.00percent.

3.3.7. Limitations for BIM Implementation

This part of the survey is about the identification of limitations for implementing BIM for non-BIM users. According to respondents (Figure 3.22):

i. 94.44percent consider lack of trained BIM professionals is the primary limitation.
ii. 83.33percent consider that education and training issues are major limitations.
iii. 44.44percent consider lack of demand in the market is a limitation.

iv. 38.89percent consider the limitation as the cost of set-up.

v. 33.33percent consider that other companies which are not employing BIM in coordination is a limitation.

Figure 3.21: BIM implementation effecting project characteristics in different phases

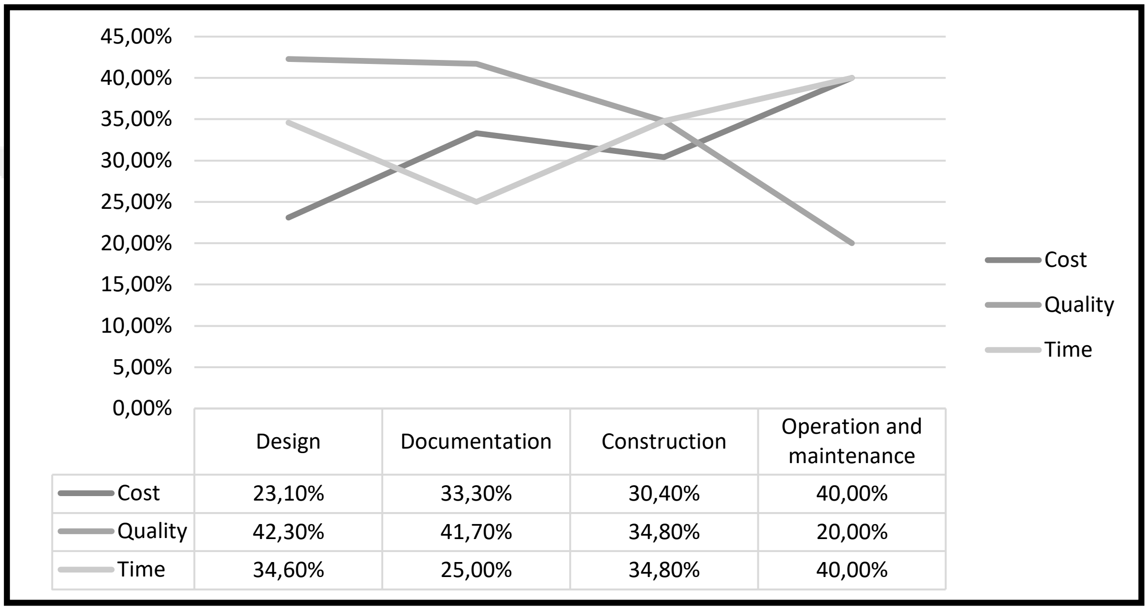
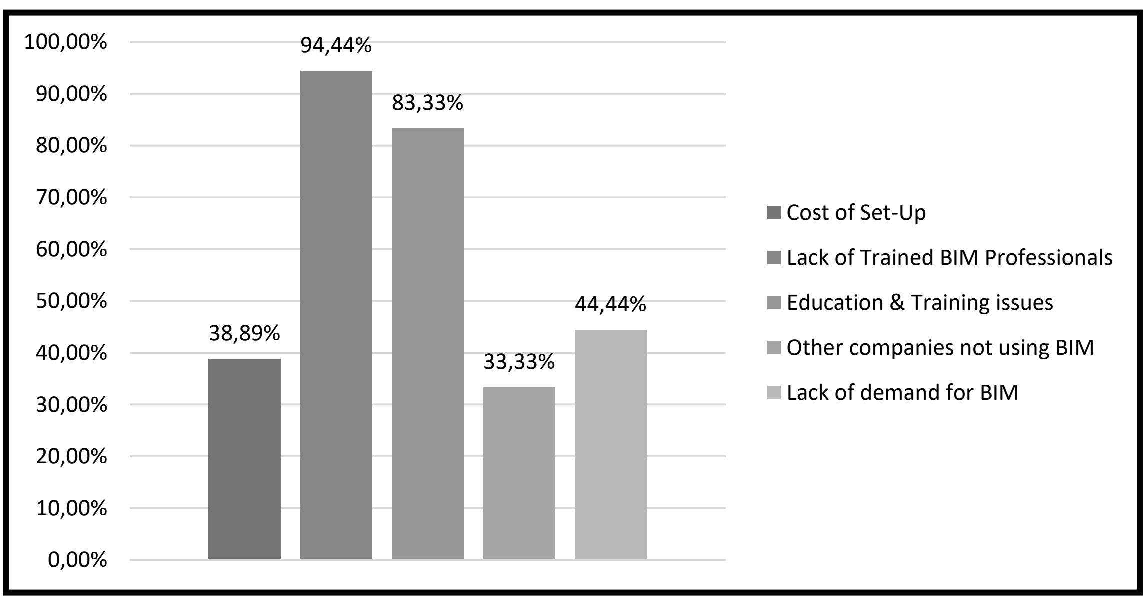


Figure 3.22: Limitations for implementation of BIM



Through the above-given results of "Limitations for implementation of BIM", it's clearly evident that the lack of trained BIM professionals is one of the major issues for not implementing BIM in Pakistan. This identifies that if number of BIM professionals will increase the implementation of BIM will directly be get positively affected. To increase the number of BIM professionals, education systems and training institutes should consider BIM seriously in their syllabus which also falls in 2nd prior issue according to survey. Initiative for both 1st and 2nd issue will indirectly increase BIM demand in market, which is 3rd mentioned issue of survey and further, it will increase the number of companies to work in BIM environment, that is the last (5th) considered limitations. Whereas cost of the setup is 4th most observed issue in survey, which clarifies that professionals are ready to invest huge capital for the setup of BIM process.

3.3.8. Future of BIM adoption:

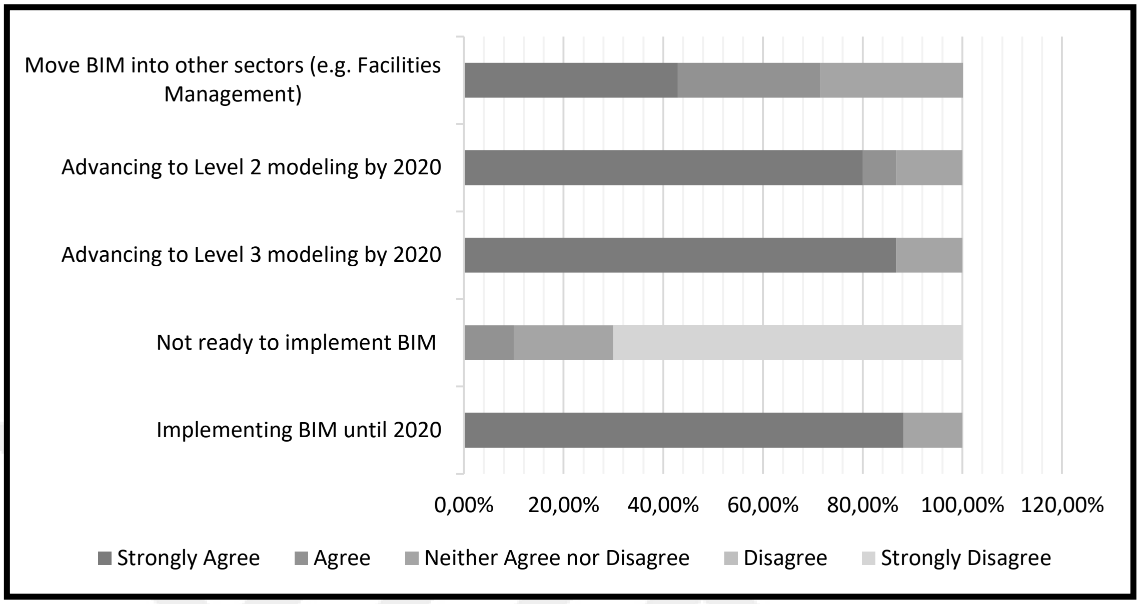
In this part of survey future considerations for BIM implementation are discussed based on the reviews of non-BIM user and BIM user groups.

Non-BIM users:

According to respondents of the non-BIM user group, 100percent agreed over that BIM culture will bring a positive impact not only in architecture but on the whole AEC industry of Pakistan. They prefer it over the conventional methods of professional architectural practice and like to adopt and implement it in future. Figure 3.23, displays consideration of future BIM implementation till 2020 by the non-BIM user. According to respondents:

i. 87.50percent of firms strongly agree to implement BIM in 2020.
ii. 86.70percent agreed to use BIM over level 3.
iii. 80.00percent agreed to use BIM on level 2.
iv. 42.90percent agreed to use its other functions as facility management.
v. 70percent strongly agree to implement BIM in future however not citing a specific time.

Figure 3.23: Future regarding BIM



BIM Users:

According to BIM User group, 100percent of respondents agreed that BIM needs to be adopted to bring a significant change in the AEC culture of Pakistan. Only a couple of gave their reviews as "others" section (table 3.10):

Table 3.8: BIM user reviews

Respondent 1	"*Yes, it should be introduced in the market. We are ten years behind from developed countries. We are lacking trained BIM professionals in market and education platforms".*
Respondent 2	"*I believe BIM is vital in 3D visualization and getting the sense of a building. It helps to experiment with and develop an architectural language. More than anything else it offers a realistic image as to what that space would feel like and drives the mechanics of design to make decisions.*

Through the results and responses of both groups (BIM user and Non-BIM user) the future and importance of BIM adoption and implementation is strong and evident. According to Figure 3.9, Non-BIM User strongly agrees to implement BIM and will deliver 2nd and 3rd Level of Development (LOD) till 2020. They also strongly disagree to the point where they were asked: “not yet ready to implement BIM”. 100percent of respondents agree over that BIM culture can bring a positive change in current market of Pakistan. Whereas BIM user respondents do feel that we are lacking behind in professional practice as compared to developed countries. BIM can easily solve our professional issues and limitations with more services, better quality, less time and precise number of costs. This readiness of BIM adoption in both groups demonstrates that architectural firms do want to transfer from traditional methods to BIM process.

4. CONCLUSION AND FUTURE SUGGESTIONS

BIM has proven to be useful for sustainable design and construction, revealed by the number of BIM implementing countries increasing every year (Jung, W. and Lee, G., 2015). This thesis clarifies that in case of Pakistan, current BIM implementation ratio is still not satisfying since the concept of BIM is still unclear in professional practice. In current status, only a minor number of firms are found to be implementing BIM professionally due to joint venture projects with international firms, such as Naqvi Associates and Kashif Aslam Associates. These projects are also found to be XL and L scale, which brings a new inquiry about "How BIM might become more effective for S and M size scale projects?" The answers to the questionnaires mainly address to technical skills of architects and coordination with other professions in BIM process.

4.2. CONCLUSION

According to the in-depth interview results, in Pakistan, the need to shift from traditional methods to BIM process is obvious but slow. Traditional methods are causing communication and coordination gaps between project stakeholders and organizations. As discussed in the survey, out of 32 limitations set by current traditional methods, almost 29 could be easily overcome by BIM implementation. Moreover, according to BIM user and Non-BIM user groups surveyed, L scale projects and XL scale projects do face these 29 limitations more than S and M scale projects. Therefore, implementation of BIM especially for L and XL scale projects is highly required than S and M scales, in order to provide a better working platform for AEC industry. With the requirements for more advanced technical specifications in future projects such as sustainability measures, building analysis, and facility management, BIM promises to become an inevitable tool even in M and S scales. However, there is need for more professional BIM users and demand from the market through building regulations, laws and other authorities etc.

This brings us to a point where BIM professionals are required hence BIM training and education is the most critical issue to be handled for further BIM implementation in developing countries, such as Pakistan. According to the interviews with professionals about academic syllabus of Pakistan universities, the most common BIM software is found to be Revit, which is mainly employed for 3D visualization. According to Autodesk website (2018), there is only one certified institute for Revit training in Lahore. This justifies the low levels of BIM awareness and implementation, as found out by the surveys in Chapter 3. Conferring to the in-depth interviews, most firm bearers with BIM awareness are those who studied abroad. However, they do not implement it in professional practice since there is lack of BIM skills among other AEC professionals. Rest of the respondents, who acquired their degrees from Pakistan do not have a clear idea of BIM and its potential benefits. This lack of awareness reveals the need for BIM lectures in the curricula, seminars, and workshops with BIM professionals in order to develop their interest for BIM implementation.

4.2.1. Construction of Conclusion

According to survey Figure 3.22 “Limitations for implementation of BIM”, an understanding towards the limitations for BIM implementation process can be seen. As explained before, major limitations are “lack of trained BIM professionals” and “education and training issues”. After that are “lack of demand in the market”, “cost of set-up” and “other companies not employing BIM”. These limitations are interlinked with each other. If education system starts training the students in BIM, then awareness towards BIM will increase and more BIM professionals will appear in the market, which will overcome the “lack of demand” and “other companies not using BIM”. Also “Cost of setup" will be a secondary issue if BIM becomes a mandatory part of professional practice till then. The interlinks of limitations in the Figure 3.22, considering “BIM in the education systems” is the most important factor to be dealt with. as a conclusion to this research, a strategy map for BIM implementation in education system is defined in Figure 4.1. Through implementation of this suggested strategies, rest of the limitations will directly be overcome with the duration of time.

4.2.2. Roadmap of BIM implementation in Pakistan

A roadmap of 10 years' timeline is concluded through the extracted data from surveys based on priorities of respondents. According to Figure 4.1, BIM implementation strategy is divided into two parts based on linear timelines "1st Level of Strategy (2019 – 2024)" and "2nd Level of Strategy (2024 - 2029)". As a Bachelor of Architectural Design Department is commenced in five years, both levels of strategies cover five years of estimated time.

4.2.3. Methodology of conclusion

Roadmap for BIM implementation in Pakistan (Figure 4.0) consists of three phases of development (application, scale, and software) depending on the priority of respondents in collecting data to achieve the concerned LOD. According to the methodology, applications (Figure 3.17) are taken as first phase of Roadmap, with which couple of correlation diagrams are constructed to understand the importance of applications according to priorities of the respondents. Correlations with applications are discussed below:

i. Figure 4.2 is a correlation chart that provides knowledge of achieving "limitations" (Figure 3.10) through implementing applications (Figure 3.17).

ii. Figure 4.3 chart defines the correlation between "applications" (Figure 3.17) and "motivation factors of BIM implementation" (Figure 3.20). As discussed above in Chapter 3.3.6 motivation factors explain the needs and priorities of professional architects to satisfy the requirement of their clients and sponsors for better product delivery.

Both correlation charts are providing the importance of applications suggested in the Strategy of BIM implementation. Furthermore, the reasons for selecting the three phases are discussed as follows:

i. Priorities of applications (Figure 3.17) provide the knowledge of demand by clients to the architectural firms and client needs.

ii. Priorities of Scales (Figure 3.14) provide the knowledge of scales (XL, L, M, S) in which professionals face more issues and limitations in current practice of Pakistan.

iii. Priorities of software (Figure 3.19) define the common use of them by professionals in architectural profession.

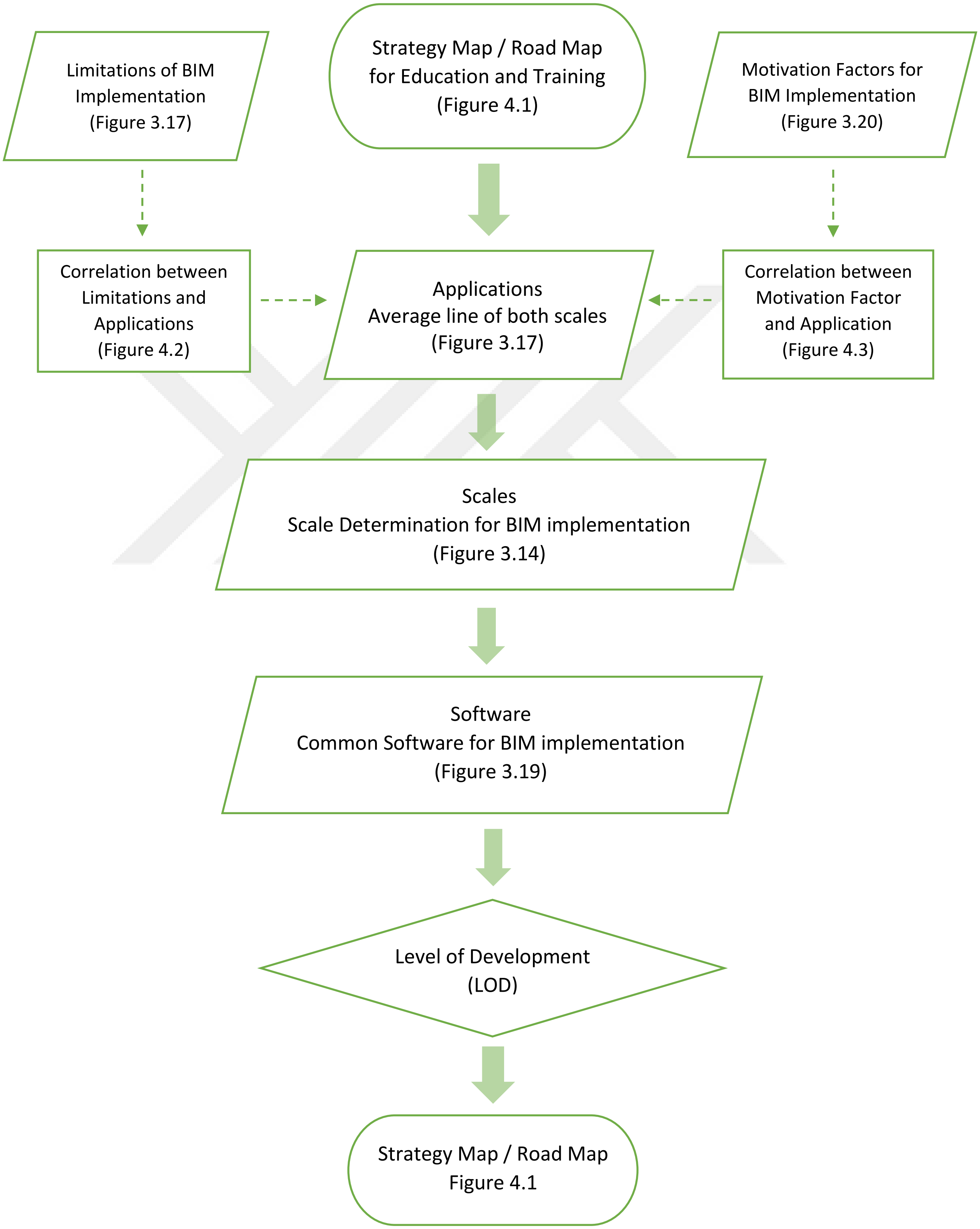
Moving through all above phases desired LOD (LOD 2 and LOD 3) is achieved for BIM adoption in Pakistan.

4.2.4. Explanation of Conclusion

1st Level: The 1st level of strategy will be aimed to achieve LOD – 2 in the first five years (2019 – 2024) of BIM implementation, considering the priorities defined by the survey respondents in three phases (applications, scale, and software). This part of strategy will be implemented as pilot projects for BIM in professional practice of Pakistan, considering the first five prior applications (Cost Estimation CE-5D, Design Visualization DV-3D, Scheduling and Sequencing SS-4D, Design Assistance and Construction Review DACR-3D, Site Planning and Site Utilization SPSU-3D), two recommended scales (L and XL), through two common software (Autodesk Revit and Digital Project). This level of strategy will work as foundation for 2nd level of strategy.

2nd Level: After achieving LOD – 2 market dimensions will expand and demand of further BIM adoption will develop in professional practice of Pakistan, which will lead it to LOD – 3 (2ndLevel of strategy). In 2ndlevel of strategy remaining applications (System Coordination SC-6D, Layout, and Fieldwork LF-5D, Prefabrications PREFAB-3D, Integration of ‘Subcontractors and Suppliers’ Models ISSM-6D, Operation and Maintenance OM-6D) will be considered to achieve S and M scales through the software (Vector works and Navis works). Software trends can be changed in the 2nd Level of strategy depending on their requirement by the professionals in market of that certain period (2024 – 2029).

Figure 4.1: Methodology of roadmap for BIM implementation



4.3. CURRENT SITUATION OF BIM PROFESSIONALS IN PAKISTAN

According to a survey, BIM user respondents are satisfied while shifting from traditional CAD methods to BIM process. They achieve much more than they expect, though they face different limitations which as follows:

i. While enhancing the scope of BIM, it is hard for them to find other organizations and professionals who can deliver more aspects of BIM such as sustainable tests, structure tests etc.
ii. Current fee structure of architects in Pakistan is not practically suitable for BIM process
iii. Clients mostly do not support the idea of BIM for their projects because of less awareness and hesitation to invest in something new, in the market.
iv. Other organizations and professionals don't want to participate in BIM process with architects; even in traditional methods, they aren't providing good professional services.
v. If architectural firm holders transfer to BIM process from traditional methods they won't be able to do government projects via BIM until and unless it won't become mandatory at government level too.
vi. Architects don't have intramural engineering facility due to which they are dependent on other engineering firms. They need to consider other team members of the project whenever they want to shift from traditional CAD methods to any other process in terms of systems and software. They are bound to use software of one family.

> *"We have fewer professionals here in Pakistan and our fee structure does not support BIM process. There might be people who are using Revit and other BIM application for their own use since the issues are mostly related with client's interest. If a client supports that and he wants that his building to be modeled in 3D information system, then it is possible. We, as an architectural firm, can hire a BIM professional. We give the option but still, they don't support the idea of BIM" (BIM user respondent).*

4.4. FUTURE SUGGESTIONS

All the respondents from both the groups do agree that BIM implementation can benefit and optimize the standards of AEC industry. To make BIM more popular in Pakistan BIM supporting organizations and institutes should be established at the government and private level. The role of these institutes can be seen in "Organizations for BIM development and implementation in Pakistan" (Table 4.1), this figure is inspired and developed from the Figure 2.4 and Figure 2.5 of Global awareness of BIM. These institutes will be developing policies, roadmaps, strategies and guidelines for BIM implementation in Pakistan. Detailed role of these institutes is discussed underneath:

i. These organizations will help in training BIM professionals, guide them to implement BIM as beginners, and most importantly spreading the knowledge about BIM in AEC sector.
ii. Such organizations will be needed to set targets for achieving Level of Developments (LOD).
iii. They will help to create roadmap and strategies for all the sectors of AEC industries who are directly or indirectly connected with BIM process.
iv. These organizations will research and develop guidelines and standards in co-operation with international organizations with respect to BIM implementation in Pakistan.
v. Extensive research overall pilot projects, at all scales of projects, need to be done, in order to acquire more knowledge so as to provide all facts and figures within the context of current market situation of Pakistan.
vi. Regulatory bodies need to be developed which can overlook the progress and implementation of BIM by AEC sectors.
vii. These regulatory bodies should provide contracts for BIM implementation between all team members, in order to make BIM process secure for sponsors and stakeholders etc. Satisfying such security requirements are important as they are of great help in gaining trust of all the team members for BIM implementations.
viii. Organizations can work for spreading awareness of BIM through education systems, seminars, workshops etc.

ix. Such institutions could become a body of knowledge for all size and age of firms who want to implement and adopt BIM in their projects.

x. These initiatives could bring a positive impact on L and XL projects at government level, which usually takes more time and cost than estimated through traditional methods.

xi. In current constraints of environment (global warming), electric power supply issues and economic crisis in developing countries such as Pakistan, a high need of awareness towards sustainability through BIM process is required in AEC sector on both stakeholder and client's side.

xii. Each and every project should be processed through proper tests of sustainability which can only be achieved by shifting from traditional methods (CAD method) to BIM process, as already under practice in developed countries.

xiii. Similar survey and research should be conducted in other sectors of AEC to get a more precise data for BIM implementation Roadmap in Pakistan.

These ingenuities can become possible only if BIM becomes a mandatory process set by government authorities

Figure 4.2: 10 years of roadmap for BIM implementation for educational and training institutes

Strategy Stages	Applications 1st Phase	Scales 2nd Phase	Software 3rd Phase	Level of Development LOD
1st LEVEL OF STRATEGY 2019 - 2024	Cost Estimation CE-5D 93.06% Design Visualization DV-3D 90.28% Scheduling and Sequencing SS-4D 77.78% Design Assistance and Construction Review DACR-3D 75.00% Site Planning and Site Utilization SPSU-3D 70.83%	Extra Large (XL) Large (L)	Autodesk REVIT Digital Project	LOD Level 2
2nd LEVEL OF STRATEGY 2024 - 2019	System Coordination SC-6D 58.34% Layout and Fieldwork LF-5D 38.89% Prefabrications PREFAB-3D 38.89% Integration of Subcontractor and Suppliers Models ISSM-6D 36.12% Operation and Maintenance OM-6D 31.95%	Medium (M) Small (S)	Vector works Architects Navis Work	LOD Level 3

Figure 4.3: Correlation diagram of overcoming limitation through BIM applications usage

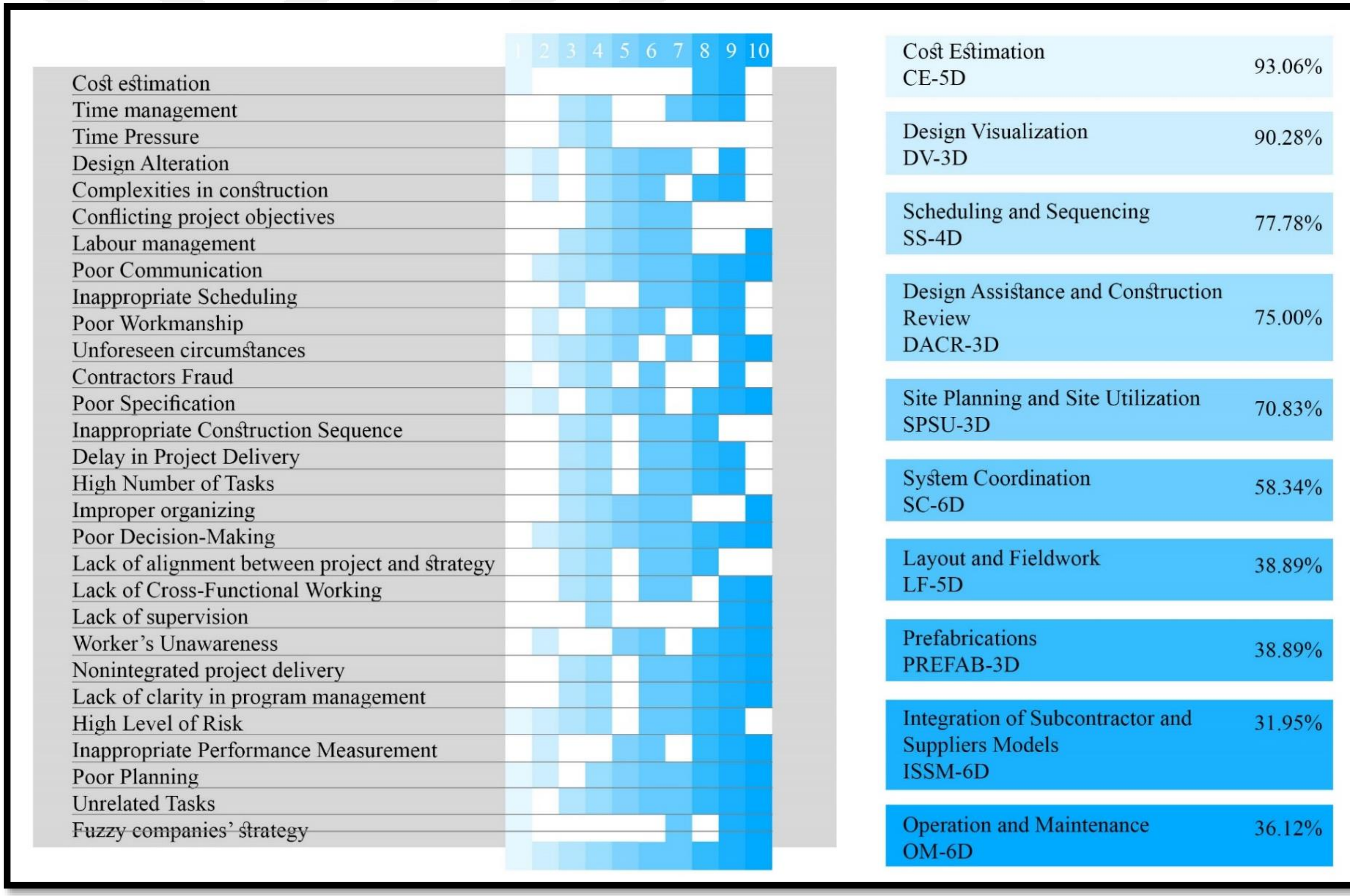


Figure 4.4: Correlation diagram between applications and motivation factors

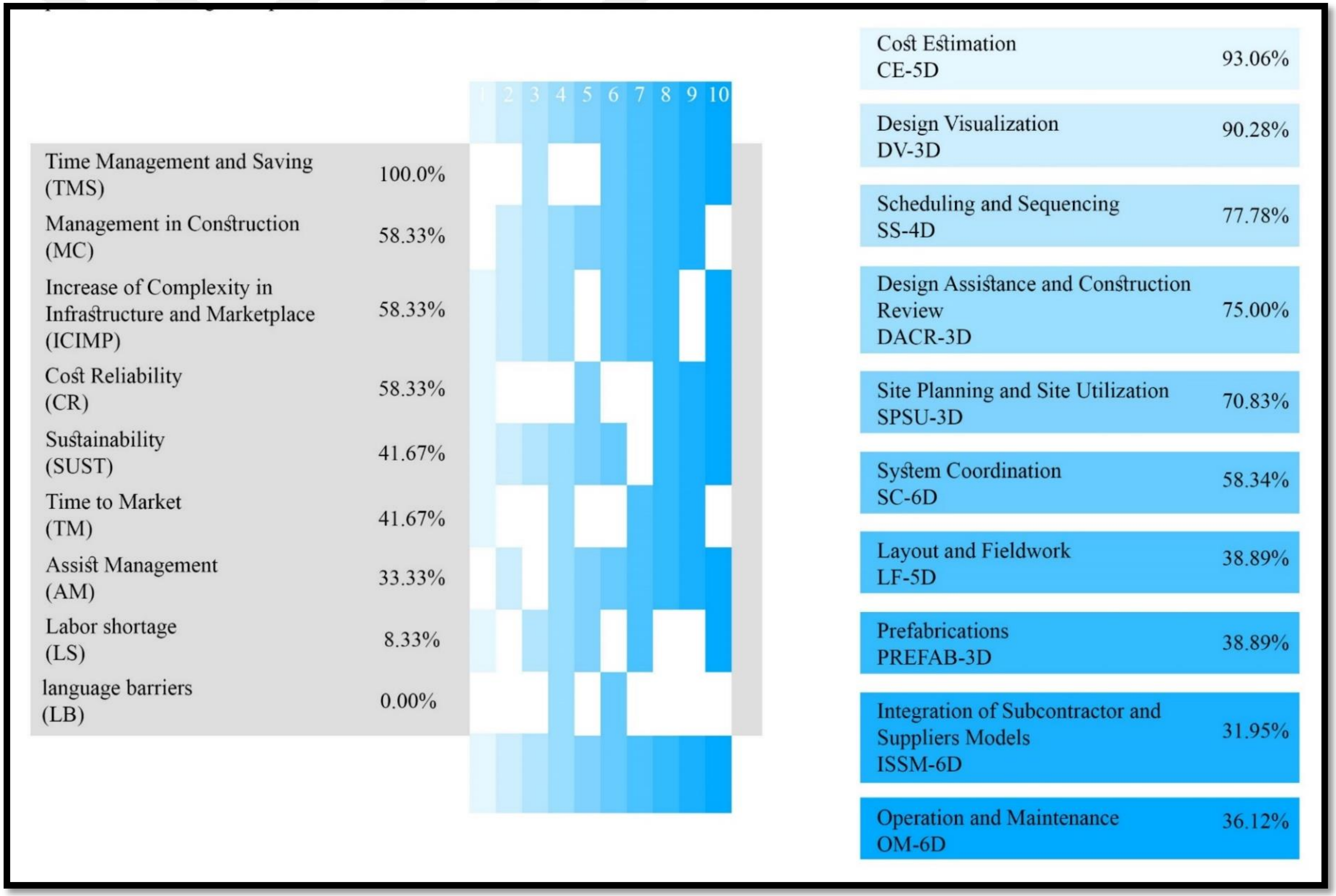


Table 4.1: Organizations for BIM development and implementation in Pakistan

	BIM Implementation			Role of BIM in Private Sector					
ORG / NGO	**Target and Promises**	**BIM implementation projects**	**BIM standard and guidelines**	**Initiator and Drivers**	**BIM Regulatory**	**Education**	**Funding**	**Demonstrator**	**Research and Development**
PIBIM	Level 2	Database and roadmaps for all sectors of AEC	PIBIM Guideline for BIM implementation in AEC projects	BIM road Map 2019-2024	Pakistan BIM protocols for LOD 2	BIM training Workshops and courses	PIBIM funding	Pilot projects for XL, L scale of projects	PIBIM R&D department
PIBIM	Level 3	Database and roadmaps for all sectors of AEC	PIBIM Guideline for BIM implementation in organization	BIM road Map 2024 - 2029	Pakistan BIM protocols for LOD 3	BIM awareness symposium to achieve sustainability	PIBIM Funding	Pilot Projects	PIBIM R&D department

*Pakistan Institute of Building Information Modeling (PIBIM)

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APPENDICES

Appendix A.1 COMMON QUESTIONNAIRE

1. Personal Information
    a. Name of firm (if you want to disclose your firm identity)
    b. Company Headquarter is located at
    c. As Chief Architect what is your degree of qualification (undergraduate, graduate, MSc., PhD. etc.)
    d. Which university you got your degree from?
    e. Email (personal / firm)

2. From how long your firm is practicing architecture
    a. 1 year - 3 year
    b. 3 year - 7 year
    c. 7 year - 15 year
    d. 15 year - 30 year
    e. 30 years +
    f. Other (please specify):

3. Type of projects your firm is specialized in
    a. Residential
    b. Commercial
    c. Urban Design
    d. Interior Design
    e. Landscape Design
    f. Industrial Design
    g. Green & Sustainable Design
    h. Other (please specify)

4. Scale of projects your firm develops

	Project Type	Project Name	Approx sq/ft Area
Small			
Medium			
Large			
Extra Large			

5. Total number of employees in your firm
   a. 01 - 05
   b. 05 - 10
   c. 10 - 20
   d. 20 - 50
   e. 50+
   f. Comments:

6. How often do you require the use of that pre-construction planning method in your projects?
   a. Always
   b. Usually
   c. Sometimes
   d. Rarely
   e. Never
   f. Other (please specify)

7. Which methods of pre-construction planning have you utilized in your professional practice?
   a. Design-Phase Construction Planning
   b. Building Information Modeling and scheduling
   c. Establishing a Project Control System or Unit
   d. Using Past Projects Data to Improve Performance

e. None of above
f. Other (please specify)

8. How important the concept of sustainability in building construction is as far as you concern?
   a. Not Important
   b. Neutral
   c. Important
   d. Very Important
   e. Other (please specify)

9. Have you ever applied ‘sustainable/green design concepts’ in your projects?
   a. Yes
   b. No
   c. Comments

10. Does your company implement BIM (Building Information Modeling) in projects?
    a. Always
    b. Usually
    c. Sometimes
    d. Rarely
    e. Never
    f. Comments:

Appendix A.2 NON-BIM USER QUESTIONNARE

Attend page if your firm is "NOT" implementing BIM, at Design and Development phase otherwise skip this page

1. What type of limitations your firm face in professional practice?
    a) Complexities in construction process
    b) Conflicting project objectives
    c) Contractors Fraud
    d) Delay in Project Delivery
    e) Design Alteration
    f) Discrepancy in Contract Forms
    g) Fuzzy companies' strategy
    h) High Level of Risk
    i) High Number of Tasks
    j) Improper organizing
    k) Inadequate Payment
    l) Inappropriate Construction Sequence
    m) Inappropriate Performance Measurement
    n) Inappropriate Scheduling
    o) Lack of alignment between project and strategy
    p) Lack of clarity in program management
    q) Lack of Cross-Functional Working
    r) Lack of Portfolio Management Knowledge
    s) Lack of Resources
    t) Lack of supervision
    u) Nonintegrated project delivery
    v) Poor Communication
    w) Poor Decision-Making
    x) Poor Planning
    y) Poor Specification
    z) Poor Workmanship

aa) Time Pressure

bb) Unclear Contract

cc) Unfamiliar Technology

dd) Unfamiliarity with Green Building and Materials

ee) Unforeseen circumstances

ff) Unrelated Tasks

2. On average, in which scale of projects you face limitations (above described) in professional practice?

	Always	Usually	Sometimes	Rarely	Never
Small	☐	☐	☐	☐	☐
Medium	☐	☐	☐	☐	☐
Large	☐	☐	☐	☐	☐
Extra Large	☐	☐	☐	☐	☐

3. What are your reasons for not implementing BIM?
    a. Cost of Set-Up
    b. Lack of Trained BIM Professionals
    c. Education & Training issues
    d. Other companies not using BIM
    e. Lack of demand for BIM
    f. Other (please specify)

4. Are you considering to use BIM in future?
    a. Yes
    b. No
    c. Please indicate your reasons

5. If yes, for which aspects of BIM do you plan to utilize?
    a. Design Visualization
    b. Design assistance and constructability review

c. Site Planning and Site utilization
d. Scheduling and Sequencing (4D)
e. Cost Estimating (5D)
f. Integration of Subcontractors and supplier models
g. Systems coordination
h. Layout and fieldwork
i. Prefabrication
j. Operations and Maintenance (including as-built records)

6. How often have you request for the BIM expert(s) / professional(s) help in your projects?
   a. Always
   b. Usually
   c. Sometimes
   d. Rarely
   e. Never
   f. Please give details about the project and reasons of need.

7. Do you believe that the BIM culture needs to be adopted in delivering a successful project?
   a. Yes
   b. No
   c. Comments

8. What is your future regarding BIM?

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Implementing BIM until 2020	☐	☐	☐	☐	☐
Not yet	☐	☐	☐	☐	☐
Advancing to Level 3 modeling by 2020	☐	☐	☐	☐	☐
Advancing to Level 2 modeling by 2020	☐	☐	☐	☐	☐
Move BIM into other sectors (e.g. Facilities Management)	☐	☐	☐	☐	☐

Appendix A.3 - BIM USER QUESTIONNARE

1. How can you describe BIM? What are its advantages?

2. Which BIM software have you used?
    a. Autodesk Revit Architecture
    b. Graph iSOFT ArchiCAD
    c. Nemetschek Allplan Architecture
    d. Gehry Technologies - Digital Project Designer
    e. Nemetschek Vector works Architect
    f. Bentley Architecture
    g. 4MSA IDEA Architectural Design (IntelliCAD)
    h. Vector works Architect
    i. Digital Project
    j. Other (please specify):

3. What was your reason for selecting that specific software(s)?

4. What is your motivation to implement BIM in your projects?
    a. Cost Reliability
    b. Management and Communication
    c. Time to Market
    d. Increasing complexity in infrastructure and Marketplace
    e. Time management and saving
    f. Sustainability
    g. Labor Shortages
    h. Language Barriers
    i. Assist Management
    j. Other (please specify):

5. In which aspects BIM has supported 'sustainability' and solved issues in your projects?
    a) Complexities in construction process
    b) Conflicting project objectives
    c) Contractors Fraud
    d) Delay in Project Delivery
    e) Design Alteration
    f) Discrepancy in Contract Forms
    g) Fuzzy companies' strategy
    h) High Level of Risk
    i) High Number of Tasks
    j) Improper organizing
    k) Inadequate Payment
    l) Inappropriate Construction Sequence
    m) Inappropriate Performance Measurement
    n) Inappropriate Scheduling
    o) Lack of alignment between project and strategy
    p) Lack of clarity in program management
    q) Lack of Cross-Functional Working
    r) Lack of Portfolio Management Knowledge
    s) Lack of Resources
    t) Lack of supervision
    u) Nonintegrated project delivery
    v) Poor Communication
    w) Poor Decision-Making
    x) Poor Planning
    y) Poor Specification
    z) Poor Workmanship
    aa) Time Pressure
    bb) Unclear Contract
    cc) Unfamiliar Technology
    dd) Unfamiliarity with Green Building and Materials

ee) Unforeseen circumstances

ff) Unrelated Tasks

6. What are the benefits of using BIM in comparison with traditional methods?
   a. Design Visualization
   b. Design assistance and constructability review
   c. Site Planning and Site utilization
   d. Scheduling and Sequencing (4D)
   e. Cost Estimating (5D)
   f. Integration of Subcontractors and supplier models
   g. Systems coordination
   h. Layout and fieldwork
   i. Prefabrication
   j. Operations and Maintenance (including as-built records)
   k. Other (please specify)

7. In which stages of the projects, how BIM affects the Cost, Quality and Time Efficiency?

	Cost	Quality	Time
Design	☐	☐	☐
Documentation	☐	☐	☐
Construction	☐	☐	☐
Operation and maintenance	☐	☐	☐
Overall	☐	☐	☐

8. Through implementation of BIM, what is your experience of Quality of project delivery, Cost saving, and Time-saving on average?

	Yes	No
Quality of Project Delivery	○	○
Time Saving	○	○
Cost Saving	○	○

9. Do you believe that the BIM culture needs to be adopted in delivering a successful project?
   a. Yes
   b. No

10. According to your opinion on what scale of projects BIM is more useful than conventional methods

	Useless	Not very useful	Neutral	Useful	Very Useful
Small	○	○	○	○	○
Medium	○	○	○	○	○
Large	○	○	○	○	○
Extra Large	○	○	○	○	○

11. Indicate your BIM implemented projects with Sq/ft Area according to a scale of small, Medium Large and Extra Large

	Small	Medium	Large	Extra Large
Name of Project				
Approx Sq/ft Area				
Type of Project				

12. If requested would you share data of your BIM implemented projects?
   a. Yes
   b. No