# Survey of BIM Implementation in Turkish Construction Industry

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# ABSTRACT

BIM is a 3D model-based technology that involves everything related to a construction project within an integrated system of information management across the project life cycle. BIM has been explored and adopted widely across the world in construction industry related to its major role in increasing quality, productivity and efficiency in construction project management, design, documentations, plan and scheduling.

This research is carried out to investigate the current state of BIM implementation in Turkish construction industry and to address barriers of BIM implementation and facilitators for BIM adoption in Turkey in order to improve BIM adoption and provide process to facilitate BIM application and to overcome challenges faced by professionals in construction industry.

Questionnaire survey technique is used in this research to address barriers and obstacles of BIM implementation and to address facilitators for BIM adoption and directed at all professionals of Turkish construction industry. The results showed that top barriers to BIM implementation in Turkey are: lack of BIM education and training, lack of publicity, lack of client demand. Top facilitators addressed for BIM adoption are: providing training to staff on new process and workflow, providing training to staff on new software and technology and providing guidance on use of BIM.

**Keywords:** Building Information Modeling, Turkish Construction Industry, BIM, Barriers, Facilitators.

# ÖZ

Yapı Bilgi Modellemesi (YBM), proje yaşam döngüsü boyunca entegre bir bilgi yönetimi sistemiyle bir inşaat projesi ile ilgili her şeyi içeren 3 boyutlu (3B) modelleme özelliğine sahip olan bir teknolojidir. YBM, inşaat sektöründe, inşaat proje yönetimi, tasarım, dökümantasyon, plan ve zaman çizelgesinde kalite, ve verimliliğin artırılmasındaki önemli katkısı için dünya inşaat sektöründe yaygın bir şekilde benimsenmiştir.

Bu araştırma, Türk inşaat sektöründe YBM uygulamasının geliştirilmesi ve zorluklarının alt edilmesi amacıyla Türkiyedeki YBM uygulamasının mevcut durumunu incelemek, YBM uygulamasını önleyen engelleri ve YBM uygulamasını kolaylaştıracak faktörleri belirlemek için oluşturulmuştur.

Bu araştırmada, YBM uygulamasının engellerini ve kolaylaştırıcı faktörlerini belirlemek için tüm Türk inşaat sektörü çalışanlarına yönelik anket çalışması oluşturulmuştur. Anketin sonuçlarına göre, Türk inşaat sektöründe YBM uygulamasının ana engelleri YBM eğitimi eksikliği, YBM'nin tanıtılmaması ve müşterilerin talep etmemesi olarak belirlenmiştir. Kolaylaştırcı faktörler ise, YBM uygulaması ve iş akışı hakkında personel eğitimi sağlamak, YBM yazılımlar ve teknolojisi hakkında personel eğitimi sağlamak ve YBM kullanımı için rehber sağlamak olarak belirlenmiştir.

**Anahtar Kelimeler:** Yapı Bilgi Modellemesi, Türk İnşaat Sektörü, YBM, Engeller, Kolaylaştırıcı faktörler.

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| | |
|---|---|
| 2D | Two Dimensional |
| 3D | Three Dimensional |
| 4D | Four Dimensional |
| 5D | Five Dimensional |
| 6D | Six Dimensional |
| 7D | Seven Dimensional |
| BIM | Building Information Modeling |
| CAD | Computer Aided Design |
| CDE | Common Data Environment |
| HVAC | Heating, Ventilation, and Air Conditioning |
| iBIM | integrated BIM |
| NBIMS | National BIM Standards |
| NBS | National Building Specification |
| pBIM | proprietary BIM |
| RII | Relative Importance Index |
| $a_h$ | The Mean Score |
| $n$ | The Number of Respondents |
| $m$ | Number of Attributes |
| $h$ | The Reference of Attributes |
| $\sum$ | Summation of Total Scores |
| $w_h$ | The Weight of Each Factor |
| $w_{max}$ | The Maximum Weight of Attributes |
| $\sigma$ | The Standard Deviation |

| | |
|---|---|
| $N$ | The Number of Values |
| $x$ | Each Value in Population |
| μ | Mean of Values |
| $W$ | The Value of Each Factor |
| $A$ | The Highest Weight |
| $N$ | The Total Number of Respondents |

# Chapter 1

# INTRODUCTION

## 1.1 Background

Applying digital models for design in projects has been common practice in construction industry for decades and has been placed at the core of engineering processes by project teams. New 3D digital model called building information modeling (BIM) is increasingly being adopted in projects. BIM creates new process of working by using intelligent objects in design that enables project teams to collaborate and provide a clear vision to all stakeholders. BIM increases the efficiency of work by creating sustainable design foundation and enables designers to develop intelligent design processes during design phase (Zeiss, 2011).

BIM is a strategic process that enables designers and engineers to accelerate the efficiency of construction and design which is a key driver for time planning even ahead of production on site. BIM has the ability to reduce cost and time wastes and eliminate any unexpected cost overruns which is a key driver for success of project. BIM facilitates the success of project not because of only technological benefits of BIM, but because of the collaborative environment it creates (Köseoğlu, 2017).

Stakeholders was using BIM mainly as an organization and visualization tool in the past. Nowadays, the aim of using BIM has changed and it developed to be a process for improving performance during the whole life cycle of project. BIM is used for

purposes of cost estimation, scheduling, integration of design and construction, risk management, documentation, facilities management, communication and coordination (Aladag et al., 2016).

## 1.2 Research Aim and Objectives

The aim of this research is to develop a conceptual process and framework to improve BIM implementation in Turkish construction industry by analyzing the current state of BIM implementation and addressing barriers and facilitators for BIM adoption in Turkey. Therefore, main objectives of this research are as follows:

1- To investigate the current state of BIM implementation in Turkey.

2- To address barriers of BIM implementation in Turkey.

3- To address facilitators for BIM adoption in Turkey.

4- To develop a conceptual framework as a suggestion of solution to identified challenges in order to improve BIM implementation in Turkey.

## 1.3 Scope and Limitation

The scope of this study includes the investigation of BIM adoption in Turkish construction industry and identification of barriers and facilitators for BIM implementation in Turkey. This study is limited to BIM implementation in Turkey, questionnaire survey is distributed among construction firms and collected from all across the country to gain comprehensive results.

## 1.4 Research Methodology

Questionnaire survey technique is used in this research and directed at all professionals of Turkish construction industry including engineers, architects, contractors, owners, consultants and academic researchers. The total number of questions in the questionnaire is 104 questions and it took 45 days to collect the data. Methods used to

analyze results are weight index method, mean and standard deviation methods and relative importance index method (RII).

The questionnaire consists of five parts as follows:

1- Respondents' profile

2- Current state of BIM implementation

3- Barriers to BIM implementation

4- Facilitators for BIM adoption

5- Future estimates and vision of BIM adoption

## 1.5 Overview of Thesis

This research consists of five chapters. Chapter 1 presents an introduction about the study including background of BIM, research aim and objectives, scope and limitation of the research, research methodology and the overview of the thesis.

Chapter 2 presents a comprehensive literature review about BIM including definition of BIM, BIM adoption around the world, BIM maturity levels, BIM adoption barriers, BIM adoption facilitators, BIM dimensions and BIM benefits.

Chapter 3 presents the research methodology of the study including information about the questionnaire and methods used to analyze the results.

Chapter 4 presents the results of the study and its analysis and discussion

Chapter 5 presents a conceptual framework developed by author according to results and includes conclusions and recommendations for further studies.

# Chapter 2

# LITERATURE REVIEW

## 2.1 BIM Definition

BIM is an ambiguous term that defined in various ways and has different meanings to different users. According to some professionals BIM is not more than a software application. Some professionals define BIM as a process for documentation of building information and designing and others define BIM as a new approach that improves the profession and leads to application of new policies and development of relationships between stakeholders of project (Aranda-Mena et al., 2008). All different definitions of BIM have a common concept which is BIM is an information management process (Department of Transport and Main Roads, 2017).

BIM is an application that uses a 3D intelligent model to develop project decisions. BIM provides design, simulation, visualization and collaboration to offer clarity during lifecycle of project to all stakeholders. BIM facilitates the achievement of business goals of project. (Autodesk).

BIM is a digital model that represents the functional and physical characteristics of the building and provides a shared knowledge resource for a building information and reliable basis for decisions through the life cycle (NBIMS).

BIM is a rich information model that consists of elements and data sources that can be shared between all stakeholders and can be maintained during the life of building. The information includes programming, cost, specification and contract properties, spaces, quantities and geometry (NBS).

## 2.2 BIM Adoption around the World

Today, BIM has been widely embraced and adopted widely across the world in construction industry related to its major role in increasing quality, productivity and efficiency of building. BIM has been adopted by more than sixty countries around the world (Amarnath, 2016). Designers around the world are applying BIM as a new process and technology in their firms (Nanajkar, 2014).

In Europe, Denmark has a high BIM adoption rate with 78% and Czech Republic has the lowest rate with only 25%. The percentage of using BIM in UK has increased from 54% in 2016 to 62% in 2017 and users became more skillful and knowledgeable in using BIM whereas 95% of firms not using BIM agreed that BIM will be used within the next three years. UK government mandated the use of BIM in public sector projects from 2016 onward, and it aims to become the leader in BIM adoption in Europe. According to a survey, 65% of respondents in Finland indicated that they are using BIM in their projects (NBS, 2017).

In the North America, BIM adoption expended to over 71% in 2012 from 28% in 2007. According to size, about 90% of large firms and 49% of small firms are engaged with BIM in North America (McGraw Hill Construction, 2012). In Canada, 67% of respondents answered in a survey in 2016 that they are currently using BIM in their projects (NBS, 2016).

In many other regions such as Brazil, Germany, France, Japan and South Korea, BIM has been adopted widely by contractors. Figure 1 shows the rise of BIM adoption by contractors within two years and how rapidly BIM is advancing.

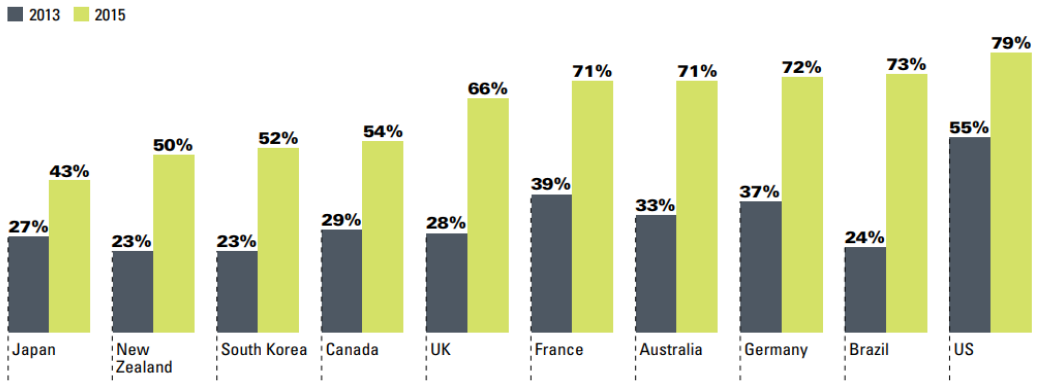


Figure 1: Rise of BIM adoption by contractors (McGraw Hill Construction, 2013)

Middle East has the lowest rate of BIM implementation compared to developed countries with no steps taken to implement it by public sector (Awwad and Ammoury, 2013). UAE is the first public authority to apply BIM for large scale projects and has the highest rate of BIM adoption with 23% followed by Egypt with 19% (Gerges et al., 2017). Figure 2 illustrates BIM adoption rates in Middle East.

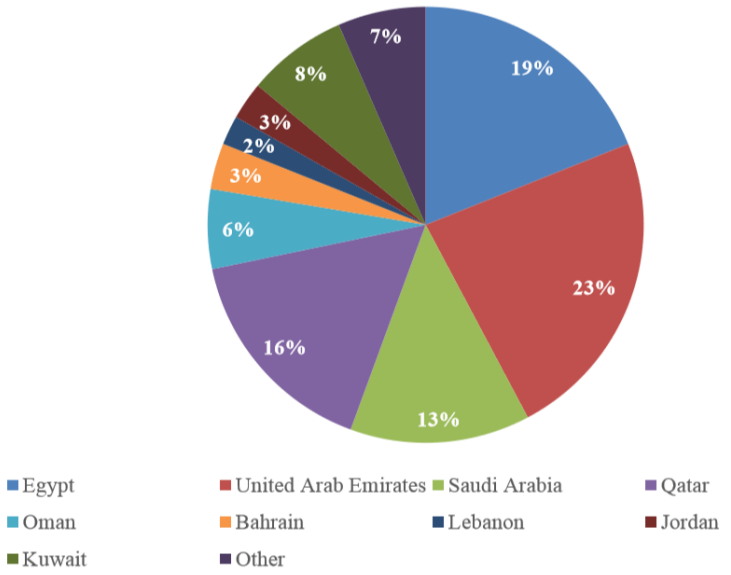


Figure 2: BIM Adoption in Middle East (Gerges et al., 2017)

## 2.3 BIM Maturity Levels

BIM has four maturity levels that ranges from level 0 to level 3. The purpose of maturity levels is to classify collaborative and technical tasks and to identify technical specifications and standards in order to provide a clear BIM understanding and common language for use (Arayici, 2015).

**Level 0:** Level 0 contains the use of CAD tools with 2D drawings. Information in this level is shared through traditional methods without common standards. Traditional paper drawings and files with traditional formats such as PDF and DWG are used in this level. It also called unmanaged CAD level.

**Level 1:** Level 1 contains 2D and 3D information with concept development models and visualizations. Collaboration in this level is provided thorough common data environment (CDE). It is also called managed CAD level.

**Level 2:** Data in this level may include 4D and 5D information. This level includes discipline-based models which assembled to create a federated model without losing their integrity and identity within common data environment (CDE). It is also called proprietary BIM (pBIM).

**Level 3:** Level 3 is a fully integrated information model and fully created in common data environment (CDE). This level includes 6D information. Information is supplied by single shared model which all professionals can access and modify. It is also called integrated BIM (iBIM). Figure 3 illustrates BIM maturity levels.

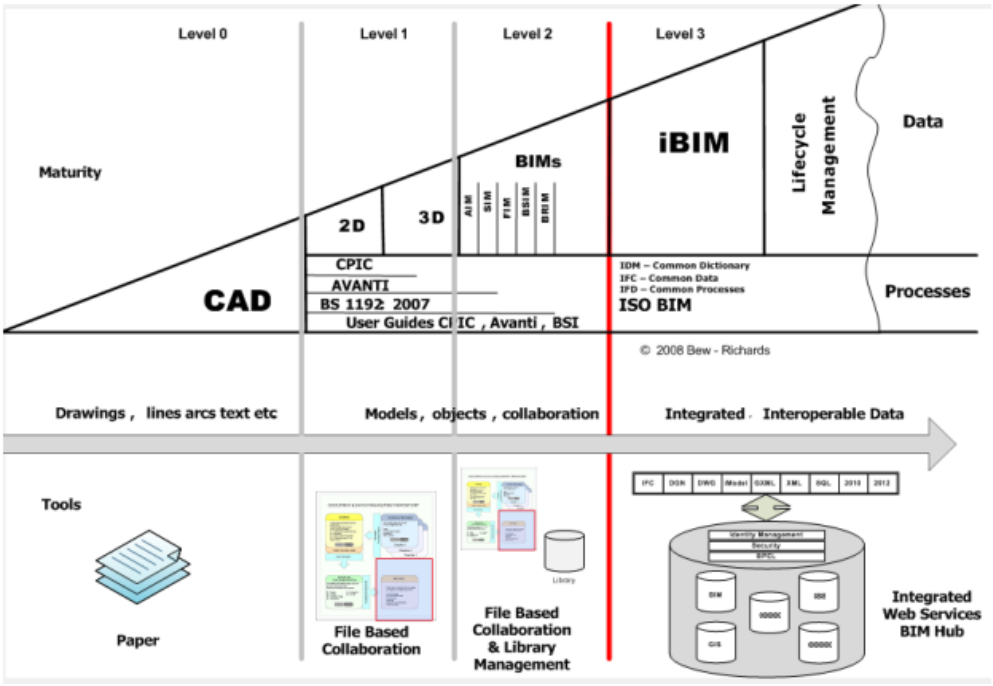


Figure 3: BIM maturity levels

## 2.4 BIM Dimensions

Integrating more data dimensions to information models is the key to provide clear vision and rich understanding about project delivery, cost and maintenance. More dimensions give extra information that facilitates making better decisions to achieve better buildings (NBS).

### 2.4.1 3rd Dimension

3D model is the representation of data in the three dimensional geometric axis x, y and z including all spatial and non-graphical information and coordination design information and coordination design shared in common data environment (NBS). Creating the 3D model at early phase is useful for owners, contractors and designers to coordinate and reduce design errors and for clash detection of building tasks, therefore problems are identified early before they occur on site (Eastman et al., 2011).

### 2.4.2 4th Dimension

The fourth dimension is adding the application of time element or scheduling data to 3D model. 4D model provides the information about entire duration of events, and displays the construction activities progress through the lifetime of project. Time-related information of 4D model can be used to create and accurate program and visualizations that show the sequence development of projects (NBS). Using the technology of 4D allows to optimize people, equipment, material movement and space requirements day by day in terms of duration and period.

### 2.4.3 5th Dimension

5D model is the integration of cost planning with 3D model by setting actual costs of personnel, equipment and materials. Using 5D technology leads to prepare and extract an accurate information and detailed analysis about project cost including quantities, schedules, prices and financial performance throughout all phases. Budget planning of project at early stage can facilitate setting the project design to fit the budget. One of the advantages of 5D model is that the data can be created at any time during the project and the information can be regularly updated which increases error elimination and productivity (AGK Creative BIM, 2017).

### 2.4.4 6th Dimension

6D is about everything related to the sustainability of building. It provides comprehensive and accurate building energy analysis at early stage. As a result of implementing 6D process, the consumption of power and energy will be reduced and therefore the relevance and quality of project will be increased.

### 2.4.5 7th Dimension

7D is refers to facilities management. It is about the project life cycle information and involves the inclusion of information to support facilities management and operation

to drive better business outcomes. The data includes information about manufacturer, warranty and specifications of a component and details about how should it be maintained and operated to achieve optimum performance and streamlined asset life cycle management over time (AGK Creative BIM, 2017). Figure 4 shows the summery of BIM dimensions with benefits of each dimension.

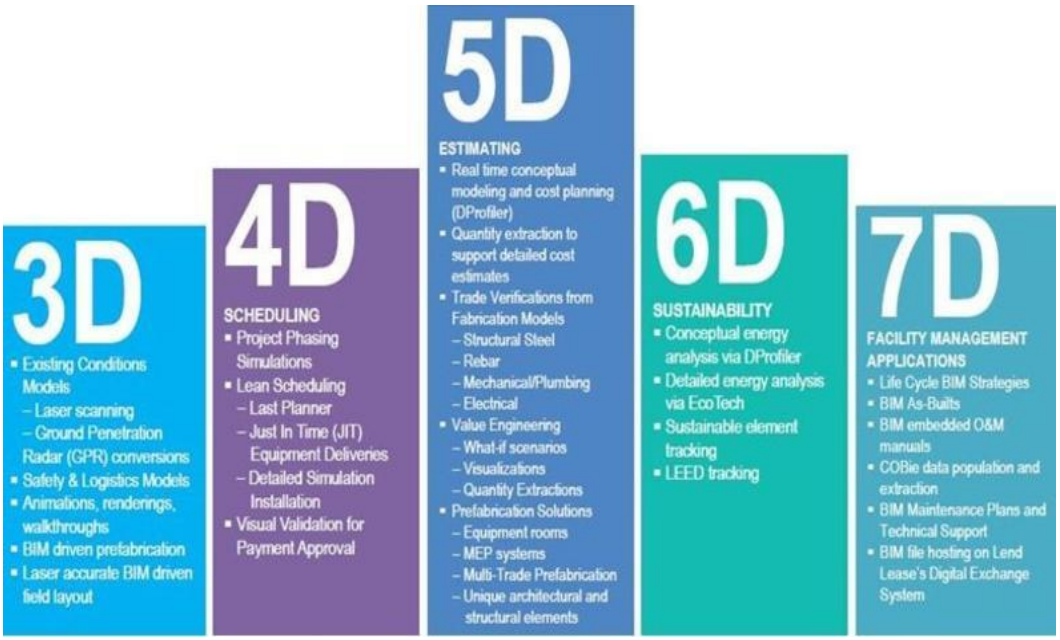

Figure 4: BIM Dimensions

## 2.5 Benefits of BIM

Applying new technologies and processes rather than traditional methods in construction projects will lead to completion of project on time and within the budget. BIM plays a major role in developing key aspects of construction project delivery. By BIM application in projects, cost is the most positively affected factor followed by time factor (Bryde, 2012). In addition, BIM can reduce human resource and improve quality and sustainability (Yan and Demian, 2008). The results of using BIM in projects are lower costs, higher quality work and greater speed and productivity in design, construction and operation phases (Autodesk).

### 2.5.1 Benefits of BIM for Designers

Applying 3D models instead of 2D models effects construction design practices in many ways. At early stages of design, 3D modeling is useful to increase design documentation productivity. The range of gain in potential productivity is from 15% to 41% in terms of hours needed to develop structural design and reinforced concrete detailing (Sacks and Barak, 2008). In design phase, BIM is useful for architects to make changes at any time without difficulties (Yan and Demian, 2008).

In Fortis print and distribution center project, BIM was used for purposes of clash detection between the structural frame, fire extinction system, electrical installations, HVAC, data cabling and lighting. BIM also used to provide an efficient communication between all project parties. As a result of using BIM, the reductions of time and cost in design phase were 25% and 10% respectively (Bentley systems, 2008).

In a series of six design-build projects in USA, BIM was used to enhance communication and sharing data in highly collaborative environment between all project teams for purposes of creating 3D models, scheduling and managing documents across multiple geographical locations. By using BIM, the number of documents and models shared by project teams reached 80000 and more than 85 gigabytes of data updated and maintained. As a result of using BIM, construction budget trimmed by 5%, the schedule accelerated by more than 12% and the total save in print costs was $100,000 (Bentley systems, 2008).

Benefits of BIM for designers are as follows (Eastman et al., 2011):

- BIM provides earlier and accurate visualization of design in terms of 3D models.
- BIM provides automatic corrections to design changes.

- BIM provides collaboration and simultaneous work between multiple design disciplines.
- Reduction of design errors and omissions.
- BIM provides an accurate cost estimation and bill of quantity during design stage.
- BIM provides an efficient energy analysis and sustainability.

### 2.5.2 Benefits of BIM for Owners

Owners evaluate the success of project by three factors; budget variation, schedule variation and conformity to expectations, in other words the factors are cost, time and quality. The best delivery method for owners to control these factors is design-build method (Songer et al., 1997).

It is found through many studies that implementing BIM has significant impact on reducing the time of project. A study by Kaner et al., (2008) showed that the part of project designed and managed by BIM technology was ended up in 119 days, while it was estimated to be 149 days by using traditional 2D CAD methods with productivity of 20%. So BIM accelerates the design process by reducing rework and increasing efficiency by providing high collaborative environment between project parties, therefore facilitates clash detection in construction phase, which are not provided in traditional 2D CAD methods.

Benefits of BIM for owners are as follows (Eastman et al., 2011):

- BIM reduces project duration.
- BIM increases building value and overall performance by using BIM-based energy design.
- BIM provides enhanced facility management and maintenance.

- BIM provides and accurate and reliable cost estimation analysis and earlier feedback through automatic quantity take-off from building model.

### 2.5.3 Benefits of BIM for Contractors

In a project of medical center in California where BIM was applied, the contractor reported that by using BIM the labor savings was $400,000 on a $9,000,000 guaranteed maximum price contract and a 2-to-1 net return on investment of $415,000 was realized (Carbasho, 2008).

In a design-build public construction project in Taiwan, BIM was used by contractor for purposes of digital fabrication, coordination and virtual mockup. As a result of using BIM, the reduction of rework cost was 0.16% and the reductions of schedule delay and delay penalty were 6.49% and 5% respectively (Chou and Chen, 2017).

Benefits of BIM for contractors are as follows (Eastman et al., 2011):

- BIM provides detailed building information, graphic views of building components in terms of 3D model and property information of component.
- BIM provides performance levels information such as shear, moment, structural loads and HVAC system analysis.
- BIM provides construction and design status of components.
- BIM provide temporary components which are critical for planning and sequencing of the project such as formwork and equipment.
- BIM provides specific information of each building component.

## 2.6 BIM Implementation Barriers

The application of any new technology will face barriers and obstacles before fully applied. The same can be said for application of building information modeling

technology. Barriers and obstacles of BIM implementation must be eliminated to improve the success of adoption and to achieve perceived BIM benefits.

Many studies showed many approaches to address BIM barriers. Linbland (2013) classified the source of barriers into barriers caused by BIM users, barriers caused by BIM processes and barriers caused by BIM product. Aladag et al., (2016) classified barriers of BIM adoption into four categories. The first category is barriers related to characteristic of industry such as inadequate BIM education. The second category is barriers related to acquisition of firms such as customer satisfaction. The third category is barriers related to organizational culture such as the absence of leadership to implement BIM. The fourth category is barriers related to resources. To achieve comprehensive results, barriers in this research is divided into five categories; personal, technical, business, market and organizational barriers.

Table 1 shows top barriers addressed by different researchers. As shown, some barriers are common and addressed by many authors, this means that this factors have high importance to identify sources of barriers. For instance, client demand factor is addressed by five authors, so clients are considered as an important factor to eliminate BIM adoption barriers. Also cost factor is addressed by four authors, reduction of costs regarding BIM implementation will improve BIM adoption success.

Table 1: Barriers addressed by different researchers

| Researchers | Top Barriers |
|---|---|
| Zahrizan et al., 2013 | • Lack of knowledge about BIM<br>• Clients do not request/enforce BIM<br>• Reluctance from clients, contractors or consultants to implement BIM<br>• BIM is not required by other team members |
| Matarneh and Hamed, 2017 | • Lack of support and incentives from construction policy makers<br>• BIM industry standards and codes are not available<br>• Lack of awareness about BIM<br>• We don't know where to start |
| Kiani et al., 2013 | • Lack of competent operators to use software<br>• Expensive software<br>• Clients are requesting in only a few phases<br>• Lack of teaching aids of BIM based IPD |
| Arayici et al., 2009 | • Firms are not familiar enough with BIM use<br>• Reluctance to initiate new workflows, or train staff<br>• Firms do not have enough opportunity for BIM implementation<br>• Benefits from BIM implementation do not outweigh the costs to implement it |
| NBS, 2017 | • Lack of in house expertise<br>• No client demand<br>• Lack of training<br>• Cost |
| Newton and Chileshe, 2012 | • Lack of understanding<br>• Training and education costs.<br>• Start-up costs<br>• Changing business way of organizations. |
| BCIS 2011 Building Information Modelling Survey Report, 2011 | • Lack of client demand<br>• Lack of application interfaces between BIM systems and 3rd party applications of choice<br>• Lack of education and training<br>• Lack of standards |
| Nanajkar, 2014 | • Personnel shortage<br>• Low client demand<br>• High cost of implementation |

## 2.7 BIM Adoption Facilitators

After addressing barriers of BIM implementation, developing BIM adoption facilitators according to barriers is the next step to improve success of BIM

implementation. Without providing BIM adoption facilitators, BIM application will remain an issue. Developing facilitators in the way that professionals can realize the advantages and perceived benefits of BIM is the key driver to increase the rate of BIM adoption.

Many researchers identified BIM facilitators from different perspectives. Arayici et al., (2009) identified the organizational culture factor as the top facilitator for BIM adoption in terms of creating a culture that can accept new processes and new technologies and preparing professionals which are familiar with this environment.

Actors that can facilitate BIM adoption can be classified into three categories; government, organization and people. Government plays a major role in facilitating BIM adoption, with the support of government many methods can be developed to increase success of BIM adoption. Organizations can lead their employees to be BIM professionals. Many methods can be established in the organization with the support of top management to facilitate BIM adoption such as providing BIM training programs and BIM using guidelines. People such as professionals and clients can be supporting factors to increase the rate of BIM adoption. Table 2 shows top BIM adoption facilitators addressed by different researchers

Table 2: Facilitators addressed by different researchers

| Researchers | Top Facilitators |
|---|---|
| Sinclair, 2012 | • Creating integrated and collaborative working methods between designers<br>• Knowledge of databases and how these can be integrated with the building model<br>• New procurement routes and forms of contracts aligned to the new working methods<br>• Software interoperability to enable concurrent design activities |
| Newton and Chileshe, 2012 | • Project cost reduction<br>• Risk reduction<br>• Requests by clients |
| Zikic, 2009 | • Top management support<br>• Provide staff training<br>• Raising the BIM understanding |
| Eadie et al., 2013 | • Clash detection<br>• Government pressure<br>• Competitive pressure<br>• Accurate Construction Sequencing |
| Akkaya, 2012 | • Decreasing the price of BIM software<br>• Provide BIM training<br>• Changing the traditional work methods<br>• Legal obligations |
| Olugboyega and Aina, 2016 | • Enforcement BIM by government<br>• Request of BIM by client<br>• Provide BIM training program<br>• Provide BIM education in higher institution |
| Zahrizan et al., 2013 | • Support and enforcement in the implementation of BIM by the government<br>• Provide BIM training programs<br>• Leadership of senior management<br>• Provide a grant scheme for training BIM |
| Kiani et al., 2013 | • Introduction of BIM in university curriculum<br>• Training of construction staff<br>• Mobilizing clients on the importance of BIM based methods |

# Chapter 3

# RESEARCH METHODOLOGY

## 3.1 Introduction

The aim of this chapter is to provide the research methodology including data collection technique and methods used for analysis.

Data collected in this study through questionnaire survey designed based on factors related to BIM implementation gathered from worldwide literature researches to investigate the current state of BIM adoption and the most significant facilitators and barriers of BIM implementation in Turkish construction industry. Questionnaire survey technique is useful method when information needed is not clearly recognized or extracted from documents.

## 3.2 Questionnaire Survey

The questionnaire survey designed by using Google Forms and distributed online by e-mails sent to construction industries around the country and also delivered by hand to locations. The questionnaire included a brief introduction of BIM definition and its benefits to help professionals to understand the purpose of the survey. The questionnaire is direct at professionals of Turkish construction industry including engineers, architects, academics, contractors, owners and consultants.

The questionnaire divided into five sections as follows:

Section A: Respondents' profile

Section B: Current state of BIM implementation

Section C: Barriers to BIM implementation

Section D: Facilitators for BIM adoption

Section E: Future estimates and vision of BIM adoption

Section A is about respondents' profile which contains questions about personal and organizational information of the respondent. Professionals in this section were asked seven (7) close-ended questions and one (1) open-ended question. The personal questions were about work position, educational level and years of experience. The organizational questions were about the description of the firm, sector, number of employees in the firm and location.

Section B is about the current state of BIM implementation. This section contains ten (10) close-ended questions and two (2) rating scale questions that have answers ranges from one (1) to five (5) where 1 indicates the lowest rate and 5 indicates the highest rate. This section is created to investigate the current state of BIM implementation in Turkey. Questions were abut awareness of BIM and its benefits, skills of using BIM, experience of using BIM by the professional, the current state of BIM adoption in the organization, reasons for using or not using BIM, services offered by BIM and problems solved by BIM.

Section C is about barriers of BIM implementation. The questions in section are about factors considered as a potential barriers to adoption of BIM. The barriers are classified into personal barriers, technical barriers, business barriers, market barriers and organizational barriers. Section D is about facilitators for BIM adoption in Turkish construction industry. The question type in sections C and D is agree/disagree type

questions. This type of questions has answers that ranges from one (1) to five (5) Where 1 indicates strongly disagreed and 5 indicates strongly agreed.

Section E is about future estimates and vision of BIM adoption. In this section, professionals were asked about their expectations for the future of BIM adoption by construction firms in Turkey. The section contains four (4) close-ended questions.

The total number of questions in the questionnaire is one hundred and four (104) questions. The sample of questions is shown in Appendix A.

## 3.3 Data Collection

Above two hundred (200) copies of questionnaire survey were distributed both online by Google Forms and delivered by hand to locations. The total number of respondents was one hundred and eight (108), forty-six (46) copies received by hand and sixty-two (62) copies received using Google Forms. The aim was to achieve a minimum of one hundred (100) completed questionnaires, and it was achieved. The total time taken to complete data collection was 45 days.

## 3.4 Data Analysis Methods

In sections A and B, answers of close-ended questions were analyzed using pie charts, bar charts and tables to view results in clear way and to be simple to evaluate.

### 3.4.1 Mean Score

Rate questions in section B analyzed using mean score formula. Rate questions have answers ranges from one (1) to five (5) where 1 indicates the lowest rate and 5 indicates the highest rate. The formula of mean score is:

$$Mean\ Score = \frac{(1*n_1)+(2*n_2)+(3*n_3)+(4*n_4)+(5*n_5)}{n_1+n_2+n_3+n_4+n_5} \qquad \text{(Equation 1)}$$

Where $n$ is the number of respondents who rated the attributes as 1 (the lowest rate) to 5 (the highest rate).

### 3.4.2 Weight Index

In sections C and D, the results are analyzed using weight index formula, the type of questions in this sections is agree/disagree questions that have answers range from one (1) to five (5) Where 1 indicates strongly disagreed and 5 indicates strongly agreed.

$$Weight = \frac{a_h}{\sum_h^m a_h} \quad \text{(Equation 2)}$$

Where $a_h$ is the mean score, $m$ is the number of attributes and $h$ is the reference of attributes.

$$Weight\ Index = \frac{w_h}{w_{max}} \quad \text{(Equation 3)}$$

Where $w_h$ is the weight obtained from equation 2 and $w_{max}$ is the maximum weight of attributes.

### 3.4.3 Mean and Standard Deviation

Mean and standard deviation analysis was used to analyze results of sections C and D. Mean is the average of data set. Standard deviation is the measure of dispersion of values of data set. Lower standard deviation means that values are close to mean, higher standard deviation means that values are spread out over wide range.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i-\mu)^2}{N}} \quad \text{(Equation 4)}$$

Where $\sigma$ is the standard deviation, $N$ is the number of values, $x$ is the value and μ is the mean.

### 3.4.4 Relative Importance Index (RII)

RII analysis is used in sections C and D. Relative importance index is calculated for indicators to evaluate the importance of each indicator.

$$RII = \frac{\sum W}{A \times N}(0 \leq RII \leq 1) \quad \text{(Equation 5)}$$

Where $W$ is the value of each factor and ranges from 1 (strongly disagree) to 5 (strongly agree), $A$ is the highest weight which is 5 and $N$ is the total number of respondents which is 108.

# Chapter 4

# RESULTS AND DISCUSSION

## 4.1 Section A: Respondents' profile

### 4.1.1 Work Position

The work position of professionals is shown in percentages in Figure 5. 47.2% of professionals are civil engineers, 41.7% are architects and 11.1% are academics to add the point of view of academics to results. The total number of academics in this questionnaire is 12.

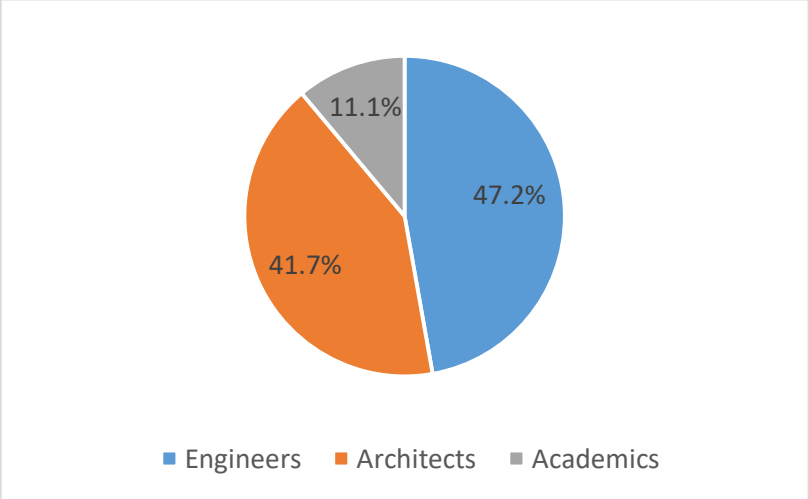


Figure 5: Professionals' work position

### 4.1.2 Level of Education

The educational level of professionals is shown in Figure 6. 55.6% of professionals are Bachelor's Degree holders, 39.8% are Master's Degree holders and 4.6% are PhD

Degree holders. The minimum educational level is Bachelor's Degree and all professionals are educated in this questionnaire.

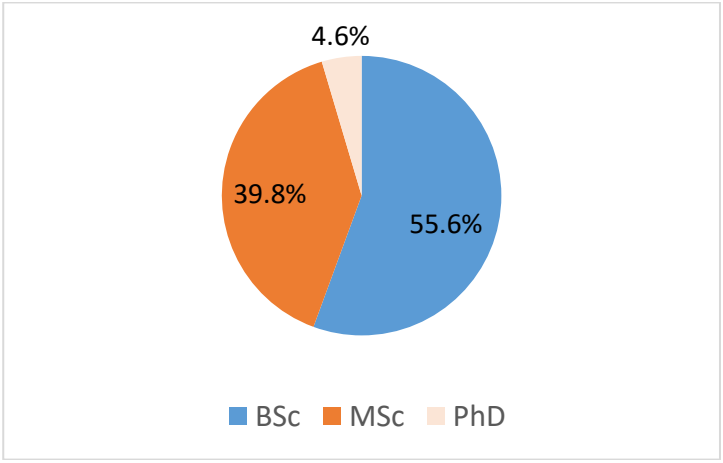

Figure 6: Educational level of professionals

### 4.1.3 Experience

Experience of professionals is varied as shown in Figure 7. 32.4% of professionals have experience between 1 to 5 years, 21.3% have experience between 5 to 10 years, 33.3% have experience between 10 to 15 years and 32.4% have more than 15 years of experience. Most of professionals (87%) in this questionnaire have more than 5 years of experience.

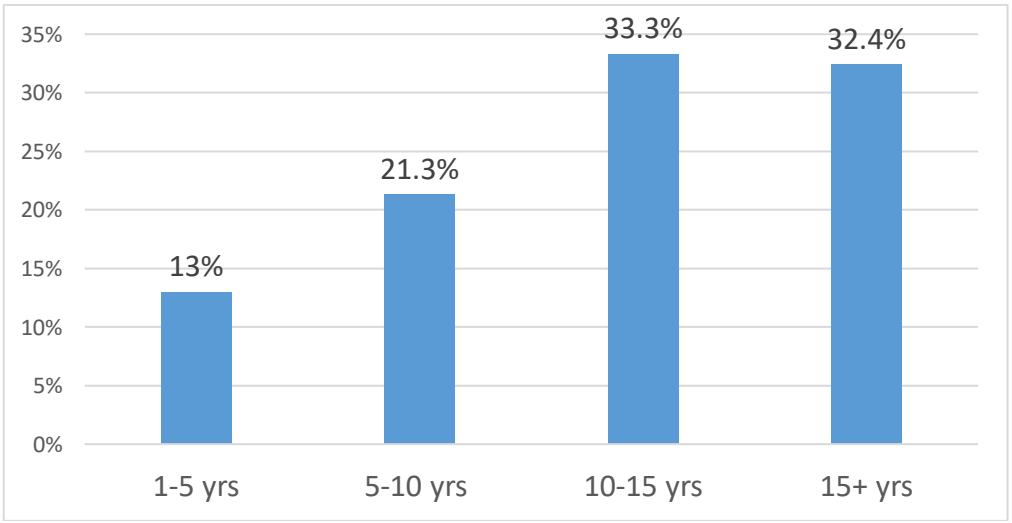

Figure 7: Experience of professionals

### 4.1.4 Description of Firms

Professionals were asked to describe the firms they are working with. Figure 8 shows types of firms of professionals. 41.7% of firms are contractor firms, 25.9% are consulting firms, 21.3% are architecture firms and 11.1% are research institutes.

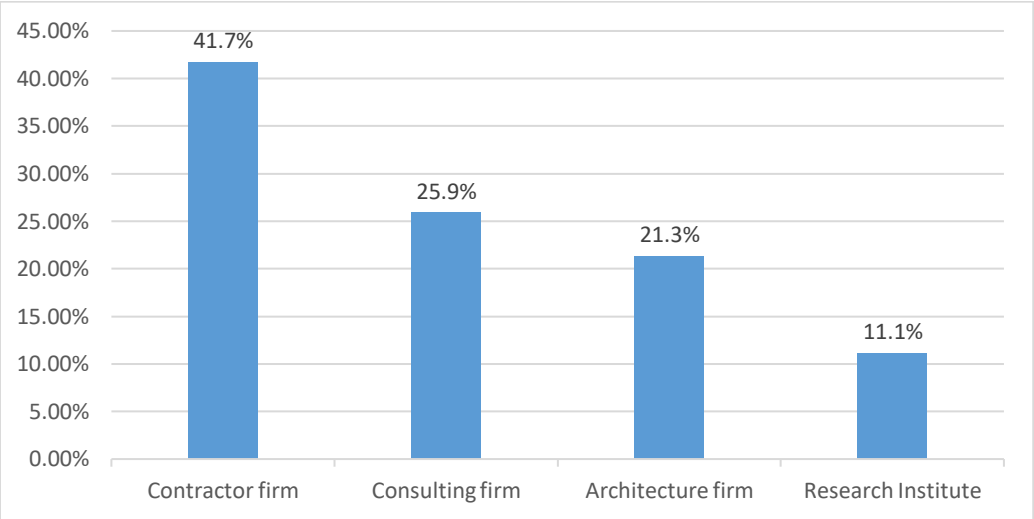


Figure 8: Types of firms

### 4.1.5 Ownership of Firms

Figure 9 shows the ownership of firms weather it is public or private. 67% of respondents answered that their firms are privately owned whereas 33% answered that their firms are public. The purpose of this part is to address government role in dealing with firms of both sectors.

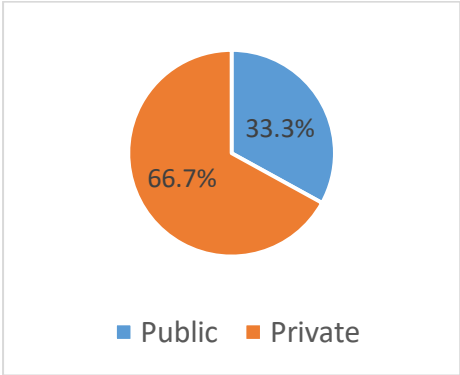


Figure 9: Ownership of firms

### 4.1.6 Principal Industry of Firms

Table 3 illustrates the principle industry of firms. 41.7% of firms specialized in residential sector, 21.3% in commercial sector, 17.6% in government sector, 15.7% in industrial sector and 3.7% in other sectors.

Table 3: Principal industry of firms

| Principal Industry | Number of Firms | Percentages (%) |
|---|---|---|
| Residential | 45 | 41.7 |
| Commercial | 23 | 21.3 |
| Government | 19 | 17.6 |
| Industrial | 17 | 15.7 |
| Other | 4 | 3.7 |
| TOTAL | 108 | 100 |

### 4.1.7 Number of Employees

The majority of professionals (57.4%) are working in large firms that have more than 50 employees. 29.6% of professionals are working in medium sized firms that have 20 to 50 employees and the rest (13%) are working in small firms that have less than 20 employees. Figure 10 shows number of employees in firms. The purpose of this part is to create the relation between size of firm and BIM adoption. Large firms have more opportunity to adopt BIM. As shown in the literature review, 90% of large firms in North America are engaged with BIM.

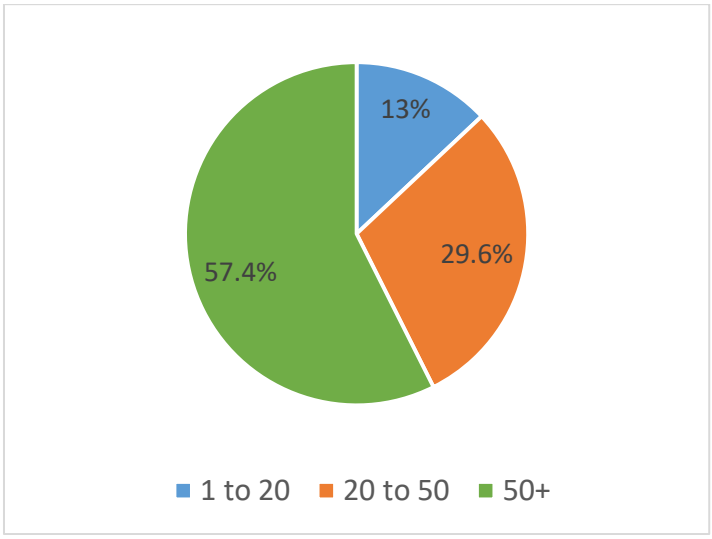

Figure 10: Number of employees in firms

### 4.1.8 Location

Professionals were asked to locate their firms. Results showed that the majority of respondents are working in firms located in Istanbul (31.5%) which is the largest city in Turkey and in Ankara (24.1%) which is the second largest city in Turkey, with a total of 55.6%. The rest firms are located in different cities across the country as shown in Figure 11.

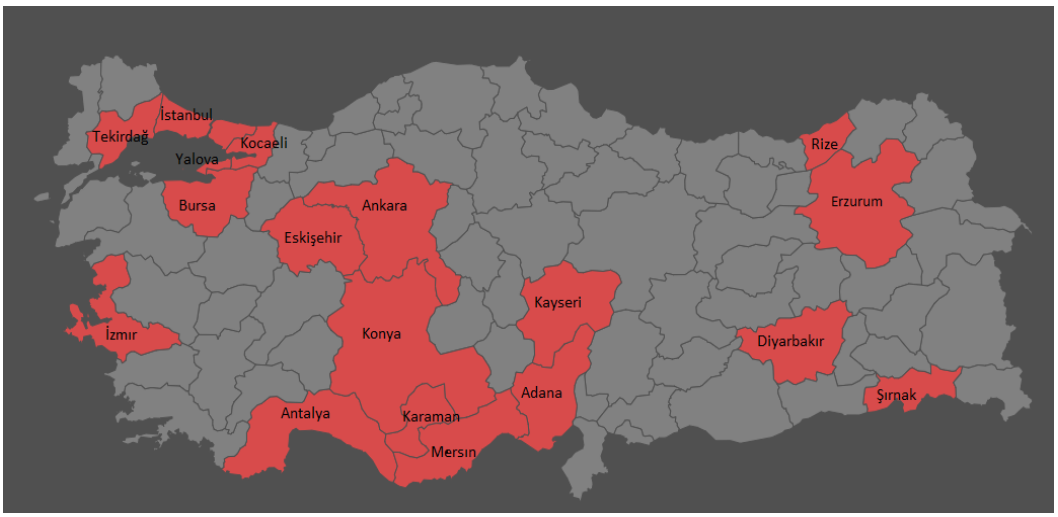

Figure 11: Locations of firms

## 4.2 Section B: Current State of BIM Implementation

### 4.2.1 Awareness of BIM

Professionals were asked if they were aware of BIM technology, 64.8% answered that they are aware of BIM whereas 35.2% answered that they have no idea as shown in Figure 12. When they were asked about benefits of BIM, 58.3% answered that they are aware of benefits of BIM whereas 41.7% answered that they have no idea as shown in Figures 13. This shows the lack of BIM awareness among professionals. When they were asked about the reason in interviews, the most common answer was the lack of publicity which makes them to follow traditional methods as requested from them.

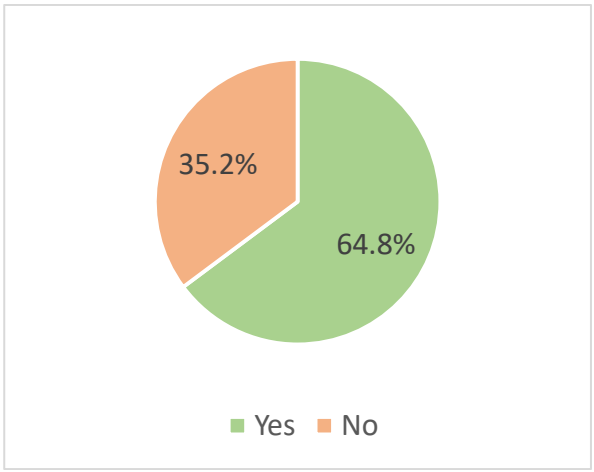


Figure 12: Awareness of BIM

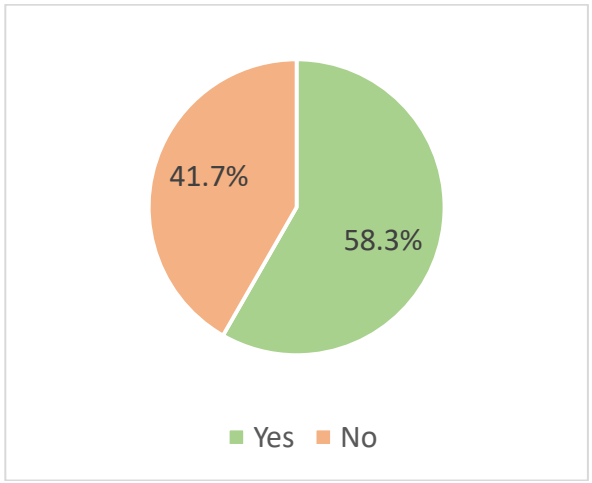


Figure 13: Awareness of benefits of BIM

### 4.2.2 Use of BIM

In organizational level, 42.6% of firms are currently using BIM whereas BIM is not used in 48.1% of firms, the rest (9.3%) are preparing for BIM use as shown in Figure 14. In personal level, 34.3% of professionals know how to use BIM whereas 45.4% don't know how to use BIM and the rest (20.4%) are learning how to use BIM and this indicates the lack of technological skills in Turkey as shown in Figure 15.

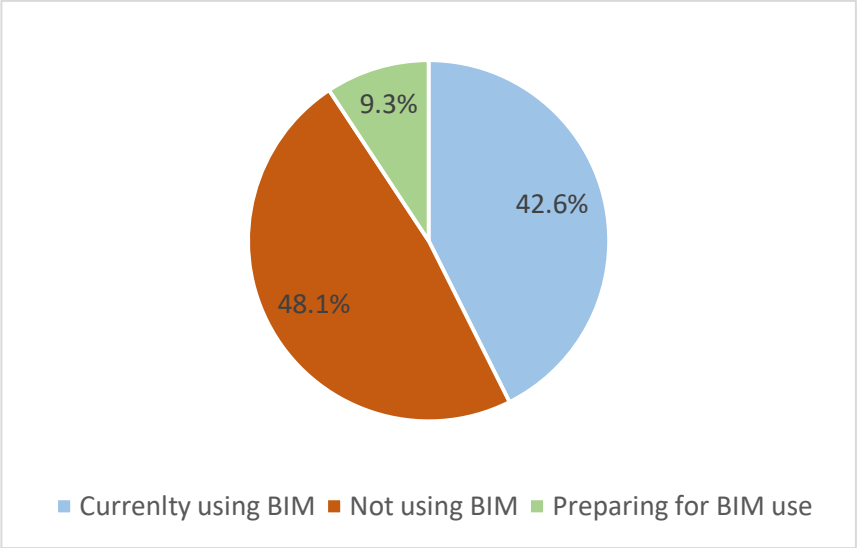


Figure 14: Use of BIM in firms

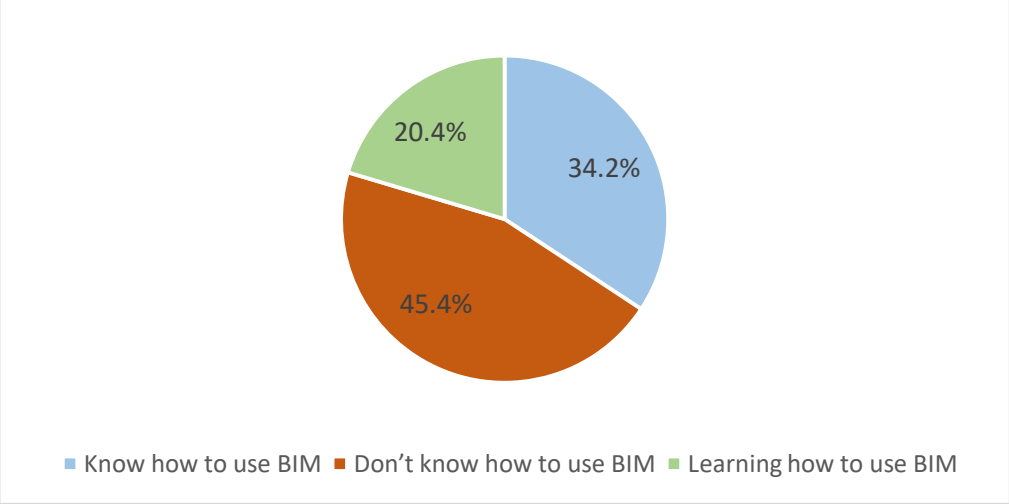


Figure 15: Use of BIM by professionals

### 4.2.3 Experience of Using BIM

Professionals were asked about number of projects that they used BIM in, the majority (65.7%) had never used BIM before. 23.1% of professionals used BIM before in 1 to 5 projects, 7.4% used BIM before in 6 to 10 projects and 3.7% used BIM before in more than 10 projects as shown in Figure 16. This results indicates the lack of technical experts in Turkey and this is related to the lack of technological skills.

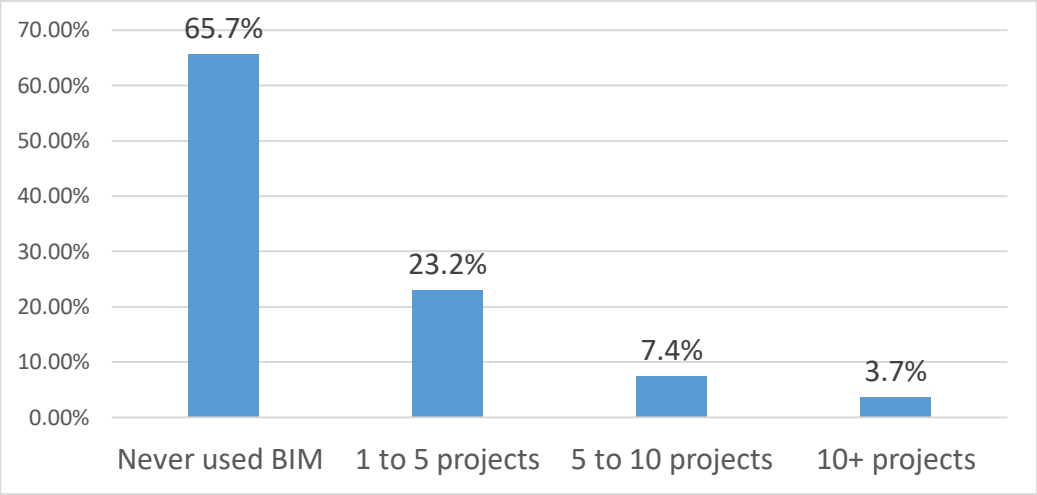


Figure 16: Number of projects that professionals used BIM before

### 4.2.4 Adaptation to BIM

In this research, number of firms that use BIM currently is 46 firms. Professionals in these firms were asked about how long it took for their firms to be adapted to BIM. It took 1 year for 23.9% of firms to be adopted to BIM, 1 to 2 years for 65.2% of firms and more than 2 years for 10.9% of firms as shown in Figure 17. It took more than 1 year for most of firms (76.1%) and this indicates the slow adoption of new technologies in Turkey due to cultural and environmental reasons. When professionals were asked interviews about the reasons, they reflected the difficulty of changing from traditional methods to new processes without creating suitable environment for changing.

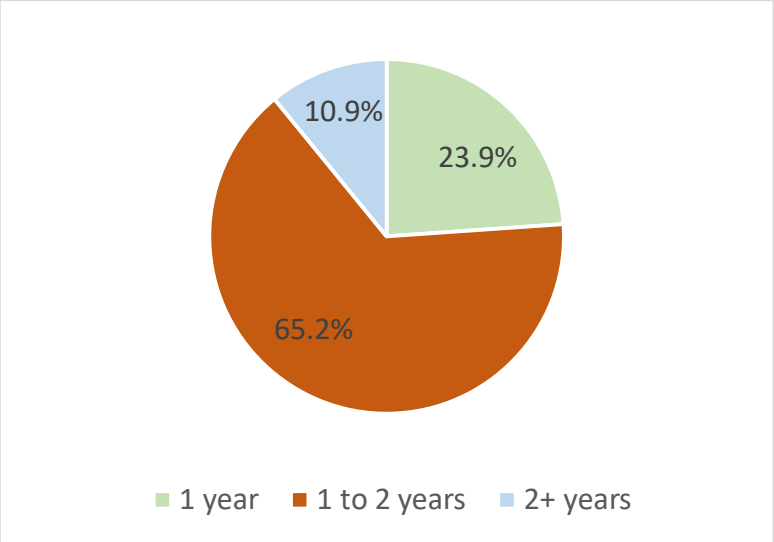

Figure 17: Adaptation to BIM in firms

### 4.2.5 BIM Software Tools

This part is about software tools of BIM used by firms in Turkish construction industry, most of firms (96.3%) are using AutoCAD software tool, 75.9% are using Revit, 50.9% are using MS Project and 45.4% are using ArchiCAD. The use of common BIM software tools by firms is shown in Figure 18. This indicates that the technology is enough in Turkey since the most common BIM software tools are used in most of firms.

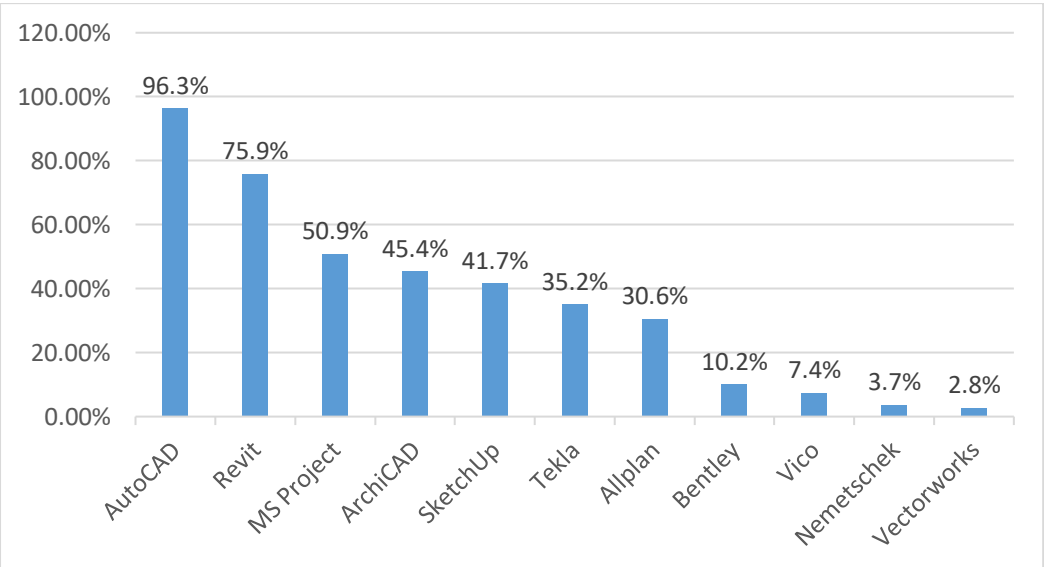

Figure 18: Most common BIM software tools

### 4.2.6 BIM Application Areas

BIM has various application areas during life cycle of project regarding design, visualization, quantity takeoff, documentation and management of time and cost. This part investigates application areas of BIM in Turkish firms. Integrating more application areas of BIM and more dimensions will facilitate the achievement of perceived benefits of BIM.

All firms are using BIM for proposes of 3D parametric modeling which is the basic application of BIM. 89.1% of firms are using BIM to improve documentations and drawings. 87% of firms are applying time management processes which is the fourth dimension by using BIM and 84.8% of firms are using BIM for purposes of clash detection in all project phases.

The percentage of firms that use BIM for quantity surveying and cost analysis is 71.7% while the percentages of firms that use BIM for feasibility analysis and work schedule planning are 60.9% and 56.5% respectively. Other application areas of BIM are environment and energy analysis (52.2%), site planning (43.5%), infrastructure planning (28.3%) and carrier system analysis (19.6%). Table 4 shows BIM application areas in Turkish firms. This indicates that BIM is not fully applied in most of firms which will affect the achievement of BIM goals and benefits negatively.

Table 4: BIM application areas

| | **BIM Application Areas** | **Firms (%)** |
|---|---|---|
| 1 | 3D parametric modeling | 100 |
| 2 | Documentations and drawings | 89.1 |
| 3 | 4D time based simulation | 87 |

| | | |
|---|---|---|
| 4 | Clash detection | 84.8 |
| 5 | Quantity surveying and cost analysis | 71.7 |
| 6 | Feasibility analysis | 60.9 |
| 7 | Work schedule planning | 56.5 |
| 8 | Environment and energy analysis | 52.2 |
| 9 | Construction site planning | 43.5 |
| 10 | Infrastructure planning | 28.3 |
| 11 | Carrier system analysis | 19.6 |

### 4.2.7 Services Offered by BIM

BIM has an impact on efficiency and effectiveness of outcomes thorough services offered by implementing it in projects, this part is about the most common services offered by BIM.

Shop drawing production service has the highest mean score with 3.891. BIM has an impact on accelerating drawing processes, fast drawing has the second highest mean score with 3.804. Construction management service has the third highest means score with 3.562.

BIM is used in projects to improve project documentations (3.456), to improve quality in design and construction phases (3.456), to improve decision making processes (3.369) and to improve quality of building output (3.348).

BIM provides a common understanding of project costs, schedule and progress among project parties and stakeholders (3.304). BIM has the ability to accelerate modification

processes thorough addressing problems in earlier stages. The mean score of fast modification service is 3.283.

BIM has a direct impact on maximizing productivity (3.239), on increasing the ability to meet sustainability needs (3.239) and on increasing cost savings (3.217).

There are other services offered by BIM such as competitive advantage (2.957), risk management (2.870), increasing the ability to response to requests for information (2.848) and increasing total profitability (2.845). Table 5 illustrates service offered by BIM with mean scores. The outcomes of this table reflects the results of Table 4 which is about BIM application areas. More integrated application areas will lead to achievement of BIM goals. For instance, cost saving service has low mean score (3.217) in the 12$^{th}$ place since BIM is used for cost analysis in only 71.7% of firms.

Table 5: Services offered by BIM

| | **Services Offered by BIM** | **Mean Score** |
|---|---|---|
| 1 | Shop drawings production | 3.891 |
| 2 | Fast drawing | 3.804 |
| 3 | Construction management | 3.562 |
| 4 | Improved project documentation | 3.456 |
| 5 | Improved quality in design and construction phases | 3.456 |
| 6 | Improved decision making in design and construction | 3.369 |
| 7 | Improved quality of building output | 3.348 |
| 8 | Common understanding of project costs, schedule and project progress | 3.304 |
| 9 | Fast modification | 3.283 |

| | | |
|---|---|---|
| 10 | Maximizing productivity | 3.239 |
| 11 | Improving the ability to meet sustainability needs | 3.239 |
| 12 | Cost savings | 3.217 |
| 13 | Competitive advantage | 2.957 |
| 14 | Risk management | 2.870 |
| 15 | Increasing the ability to response to requests for information | 2.848 |
| 16 | Total profitability increasing | 2.845 |

### 4.2.8 Problems Solved by BIM

Most of professionals agreed with a mean score of 3.957 that problems in their projects were identified earlier as a result of using BIM. BIM is used to reduce errors (3.870), conflicts (3.783), communication problems (3.457) and waste and rework (3.326).

BIM also has an impact on improving the relations between professionals; such as providing solutions to teamwork problems (3.065), solutions to coordination problems between project parties (2.913) and solutions to collaboration problems between stakeholders (2.891). BIM reduces the cost (2.848) and the time of project (2.826). Table shows the mean scores of problems solved by BIM.

Table 6: Problems Solved by BIM

| | **Problems Solved By BIM** | **Mean Score** |
|---|---|---|
| 1 | Problems were identified earlier | 3.957 |
| 2 | Errors were reduced | 3.870 |
| 3 | Conflicts were reduced | 3.783 |
| 4 | Collaboration and communication problems were solved | 3.457 |
| 5 | Waste and rework were reduced | 3.326 |

| | | |
|---|---|---|
| 6 | Teamwork problems were solved | 3.065 |
| 7 | Coordination problems amongst project parties were solved | 2.913 |
| 8 | Collaboration problems amongst construction stakeholders were solved | 2.891 |
| 9 | Construction cost was reduced | 2.848 |
| 10 | Construction time was reduced | 2.826 |

## 4.3 Section C: Barriers to BM Implementation

### 4.3.1 Barriers with Weight Index

This part shows the results of addressed barriers to BIM adoption in Turkish construction industry. Barriers are classified into personal barriers, technical barriers, business barriers, market barriers and organizational barriers. The purpose of weight index is to evaluate the barrier according to its category.

For personal barriers, lack of BIM education and training has the highest rank with weight index of 1 followed by lack of awareness by professionals with weight index of 0.929. Lack of understanding BIM and it benefits has the third highest rank with weight index of 0.747. The last two barriers are some professionals are refusing to learn BIM for many reasons (0.678) and some have a point of view that BIM is difficult to learn (0.626).

For technical barriers, Lack of standards and guidelines for using BIM is in the first place with weight index of 1. The second barrier is the adoption processes of new technologies is slow in Turkey (0.991) and it is showed in section B that the adaptation to BIM for most of firms (76.1%) took more than 1 year. The lack of technological skills and technical experts have a high weight index with 0.863 and 0.861

respectively, this is supported by the results of section B when the percentage of professionals who know how to use BIM was only 34.3% and the percentage of professionals who used BIM in more than 5 projects was only 11.1%. The Barriers with lowest rank are the data loss while transferring data between BIM software tools and other tools (0.829) and some professionals said that the current technology is not enough in Turkey (0.756).

For Business barriers, the first barrier is the lack of investment in BIM with weight index of 1 followed by barriers regarding cost; the high costs of implementation (0.979), software and updates (0.974), training (0.971) and additional costs that may arise from using BIM (0.829). Some professionals pointed that the benefits of BIM are unclear (0.791), the financial gain from using BIM is not enough (0.778) and benefits from BIM implementation do not outweigh the costs to implement it (0.765).

The market barriers are the lack of publicity (1), the lack of client demand (0.973), the lack of government support (0.960) and some professionals said that the market is not ready in Turkey. (0.867).

For organizational barriers, the first barrier is the unwillingness to change from traditional methods to new methods (1) followed by the lack of opportunity for firms to adopt BIM (0.880) and the lack of senior management support (0.808). According to some professionals, benefits of BIM are not tangible enough (0.768) and managing the impact of BIM is difficult (0.720). The summery of barriers with mean and weight index is shown in Table 7.

Table 7: Barriers with weight index

| | Barriers | Mean | Weight | Weight Index |
|---|---|---|---|---|
| **Personal Barriers** | | | | |
| 1 | Lack of BIM education and training | 4.287 | 0.251 | 1 |
| 2 | Lack of awareness | 3.981 | 0.234 | 0.929 |
| 3 | Lack of understanding BIM and its benefits | 3.204 | 0.188 | 0.747 |
| 4 | Refuse to learn BIM | 2.907 | 0.171 | 0.678 |
| 5 | BIM is difficult to learn | 2.667 | 0.156 | 0.626 |
| **Technical Barriers** | | | | |
| 1 | Lack of standards and guidelines | 4.056 | 0.189 | 1 |
| 2 | Slow adoption of new technology | 4.019 | 0.187 | 0.991 |
| 3 | Lack of technological skills | 3.5 | 0.163 | 0.863 |
| 4 | Lack of technical experts | 3.491 | 0.162 | 0.861 |
| 5 | Data loss while transferring data between BIM software tools and other tools | 3.361 | 0.156 | 0.829 |
| 6 | Current technology is not enough | 3.065 | 0.143 | 0.756 |
| **Business Barriers** | | | | |
| 1 | Lack of investment in BIM | 3.5 | 0.141 | 1 |
| 2 | High cost of implementation | 3.426 | 0.138 | 0.979 |
| 3 | High cost of software and updates | 3.407 | 0.137 | 0.974 |
| 4 | High cost of training | 3.398 | 0.137 | 0.971 |
| 5 | Additional costs that may arise from using BIM | 2.898 | 0.117 | 0.829 |
| 6 | Benefits are unclear | 2.769 | 0.112 | 0.791 |
| 7 | BIM does not offer enough of a financial gain to warrant its use | 2.722 | 0.110 | 0.778 |

| | | | | |
|---|---|---|---|---|
| 8 | Benefits from BIM implementation do not outweigh the costs to implement it | 2.676 | 0.108 | 0.765 |
| **Market Barriers** | | | | |
| 1 | Lack of publicity | 4.185 | 0.263 | 1 |
| 2 | Lack of client demand | 4.074 | 0.256 | 0.973 |
| 3 | Lack of government support | 4.019 | 0.253 | 0.960 |
| 4 | Market is not ready | 3.630 | 0.228 | 0.867 |
| **Organizational Barriers** | | | | |
| 1 | Unwillingness to change | 3.704 | 0.240 | 1 |
| 2 | Firms do not have enough opportunity for BIM implementation | 3.259 | 0.211 | 0.880 |
| 3 | Lack of senior management support | 2.991 | 0.193 | 0.808 |
| 4 | Benefits are not tangible enough to warrant its use | 2.843 | 0.184 | 0.768 |
| 5 | Difficult in managing the impact of BIM | 2.667 | 0.172 | 0.720 |

The first category is the personal barriers which the professionals are the source of this barriers. The first barrier in this category is the lack of BIM education and training although the number of universities in Turkey is exceeding 180 university. The main reasons for this barrier is the poor collaboration between the universities and BIM courses providers and the lack of students demand for this type of courses. The second barrier is the lack of awareness among professionals which has a strong relationship with the lack of publicity which is also addressed as a barrier in the market barriers. The rest barriers in this category are due to the culture of professionals. They don't have desire to change to new processes after being familiar with traditional methods, so they refuse to learn BIM and have a point of view that BIM is difficult to learn.

The second category is the technical barriers. The first barrier in this category is the lack of standards and guidelines. Providing guidelines in firms will draw the roadmap for using BIM and will allow professionals to use BIM with perception and knowledge and will provide common understanding between users. The second barrier is the slow adoption of new technologies and this reflects the poor environment of new technologies in firms. The third barrier is the lack of technological skills due to the lack of training programs which will lead also to the lack of experts. Some professionals see that the technology is not enough in Turkey to adopt BIM which is the last barrier and has the lowest rank. Section B results showed that the technology is enough and most of firms are using BIM software tools.

For business barriers, the first barrier the lack of investment in BIM. Continuous investment in BIM is a part of creating the vision for BIM use in the future. High costs regarding BIM implementation are addressed as barriers. It was investigated by the author that the cost of BIM training program was 10000 TRY which reflects the high cost of training programs.

For market barriers, the lack of publicity is the first barrier. When professionals were asked about the reasons for the lack of awareness among professionals, the most common answer was the lack of publicity. Increasing the rate of awareness among professionals will increase the rate of awareness among clients which will lead to increase the rate of client demand. Lack of government support is the third barrier in this category. Government has the ability to increase the rate of BIM implementation through many factors such as increasing publicity, forcing public firms to use BIM and working in collaborative way with private firms.

For organizational barriers, unwillingness to change is the first barrier due to cultural reasons. Some firms don't have the opportunity for BIM implementation due to many reasons such as size and budget. Lack of top management support is the third barrier in this category. Top management has the role of leadership in the organization that will facilitate BIM adoption.

### 4.3.2 Barriers with RII

In this part results are analyzed in terms of relative importance index (RII), barriers with higher value of RII (closer to 1) have more importance. RII analysis can be used to obtain the overall rank of barriers.

For personal barriers, lack of BIM education and training (0.857) and lack of awareness (0.796) have the highest RII. For technical barriers, lack of standards and guidelines (0.811) and slow adoption of new technology (0.804) have the highest RII. For business barriers, lack of investment in BIM is in the first place with 0.700 RII value. Market barriers have high RII values, 0.837 for lack of publicity, 0.815 for lack of client demand and 0.804 for lack government support. For organizational barriers, the highest RII value is for unwillingness to change barrier (0.741).

In terms of categories, market barriers have the highest RII values with group RII value of 0.796 followed by technical barriers with group RII value of 0.716. Personal barriers is in the third place with group RII value of 0.682 followed by business barriers with group RII value of 0.620. Organizational barriers is in the last place with group RII value of 0.619.

Standard deviation value indicates the dispersion of values, higher SD indicated that values are spread out over wide range and lower SD means that values are close to mean. Table 8 shows RII and SD values for barriers.

Table 8: Barriers with RII

| | Barriers | Mean | SD | RII | Group RII |
|---|---|---|---|---|---|
| **Personal Barriers** | | | | | |
| 1 | Lack of BIM education and training | 4.287 | 5.933 | 0.857 | |
| 2 | Lack of awareness | 3.981 | 5.360 | 0.796 | |
| 3 | Lack of understanding BIM and its benefits | 3.204 | 4.457 | 0.641 | 0.682 |
| 4 | Refuse to learn BIM | 2.907 | 5.425 | 0.581 | |
| 5 | BIM is difficult to learn | 2.667 | 5.794 | 0.533 | |
| **Technical Barriers** | | | | | |
| 1 | Lack of standards and guidelines | 4.056 | 5.849 | 0.811 | |
| 2 | Slow adoption of new technology | 4.019 | 5.474 | 0.804 | |
| 3 | Lack of technological skills | 3.500 | 5.273 | 0.700 | |
| 4 | Lack of technical experts | 3.491 | 5.415 | 0.698 | 0.716 |
| 5 | Data loss while transferring data between BIM software tools and other tools | 3.361 | 6.234 | 0.672 | |
| 6 | Current technology is not enough | 3.065 | 4.856 | 0.613 | |

| | | | | | |
|---|---|---|---|---|---|
| **Business Barriers** | | | | | |
| 1 | Lack of investment in BIM | 3.500 | 6.311 | 0.700 | 0.620 |
| 2 | High cost of implementation | 3.426 | 6.768 | 0.685 | |
| 3 | High cost of software and updates | 3.407 | 6.364 | 0.681 | |
| 4 | High cost of training | 3.398 | 6.640 | 0680 | |
| 5 | Additional costs that may arise from using BIM | 2.898 | 6.616 | 0.580 | |
| 6 | Benefits are unclear | 2.769 | 4.779 | 0.554 | |
| 7 | BIM does not offer enough of a financial gain to warrant its use | 2.722 | 6.213 | 0.544 | |
| 8 | Benefits from BIM implementation do not outweigh the costs to implement it | 2.676 | 6.512 | 0.535 | |
| **Market Barriers** | | | | | |
| 1 | Lack of publicity | 4.185 | 5.474 | 0.837 | 0.796 |
| 2 | Lack of client demand | 4.074 | 5.710 | 0.815 | |
| 3 | Lack of government support | 4.019 | 6.004 | 0.804 | |
| 4 | Market is not ready | 3.630 | 4.686 | 0.726 | |
| **Organizational Barriers** | | | | | |
| 1 | Unwillingness to change | 3.704 | 5.273 | 0.741 | 0.619 |
| 2 | Firms do not have enough opportunity for BIM implementation | 3.259 | 4.889 | 0.652 | |
| 3 | Lack of senior management support | 2.991 | 5.515 | 0.598 | |
| 4 | Benefits are not tangible enough to warrant its use | 2.843 | 5.325 | 0.569 | |
| 5 | Difficulty in managing the impact of BIM | 2.667 | 6.658 | 0.533 | |

For overall rank of barriers, top barriers for BIM adoption are lack of BIM education and training, lack of publicity, lack of client demand, lack standards and guidelines, lack of government support and slow adoption of new technology respectively. Table 9 shows overall rank of barriers with mean and RII values.

Table 9: Overall rank of barriers

| | Barriers | Mean | RII |
|---|---|---|---|
| 1 | Lack of BIM education and training | 4.287 | 0.857 |
| 2 | Lack of publicity | 4.185 | 0.837 |
| 3 | Lack of client demand | 4.074 | 0.815 |
| 4 | Lack of standards and guidelines | 4.056 | 0.811 |
| 5 | Lack of government support | 4.019 | 0.804 |
| 6 | Slow adoption of new technology | 4.019 | 0.804 |
| 7 | Lack of awareness | 3.981 | 0.796 |
| 8 | Unwillingness to change | 3.704 | 0.741 |
| 9 | Market is not ready | 3.630 | 0.726 |
| 10 | Lack of technological skills | 3.500 | 0.700 |
| 11 | Lack of investment in BIM | 3.500 | 0.700 |
| 12 | Lack of technical experts | 3.491 | 0.698 |
| 13 | High cost of implementation | 3.426 | 0.685 |
| 14 | High cost of software and updates | 3.407 | 0.681 |
| 15 | High cost of training | 3.398 | 0.680 |
| 16 | Data loss while transferring data between BIM software tools and other tools | 3.361 | 0.672 |

| | | | |
|---|---|---|---|
| 17 | Firms do not have enough opportunity for BIM implementation | 3.259 | 0.652 |
| 18 | Lack of understanding BIM and its benefits | 3.204 | 0.641 |
| 19 | Current technology is not enough | 3.065 | 0.613 |
| 20 | Lack of senior management support | 2.991 | 0.598 |
| 21 | Refuse to learn BIM | 2.907 | 0.581 |
| 22 | Additional costs that may arise from using BIM | 2.898 | 0.580 |
| 23 | Benefits are not tangible enough to warrant its use | 2.843 | 0.569 |
| 24 | Benefits are unclear | 2.769 | 0.554 |
| 25 | BIM does not offer enough of a financial gain to warrant its use | 2.722 | 0.544 |
| 26 | Benefits from BIM implementation do not outweigh the costs to implement it | 2.676 | 0.535 |
| 27 | BIM is difficult to learn | 2.667 | 0.533 |
| 28 | Difficulty in managing the impact of BIM | 2.667 | 0.533 |

The Conceptual framework in chapter 5 is developed according to Table 9 which shows the overall rank of BIM implementation in Turkey. The first barrier is the lack of BIM education and training. It was investigated by the author and it was found that the number of courses providing BIM education was only 4 in Istanbul. Lack of publicity is the second barrier which was identified by professionals in interviews. The third barrier is the lack of client demand due to the lack of awareness of BIM and its financial benefits. The fourth barrier is the lack of guidelines that can be provided by government and top management in the firms. The fifth barrier is the lack of government support. Government has a major role in eliminating most of barriers

addressed above such as lack of publicity, lack of client demand, lack of guidelines and lack of awareness. The sixth barrier is the slow adoption of new technologies in Turkey due to environmental and cultural reasons. The first six barriers have a mean value greater than 4 and addressed as the top barriers for BIM implementation in Turkey.

### 4.3.3 Similar Results to Barriers

Some previous studies have results that are similar to results of this research, Table 10 shows similar results of top barriers addressed by different researchers.

Table 10: Similar results to barriers

| | Barriers | Similar Results |
|---|---|---|
| 1 | Lack of BIM education and training | • RICS Building Information Modelling Survey Report, 2011<br>• NBS, 2017 |
| 3 | Lack of client demand | • Nanajkar, 2014<br>• Kiani et al., 2014<br>• Zahrizan et al., 2013 |
| 4 | Lack of standards and guidelines | • Matarneh and Hamed, 2017<br>• BCIS Building Information Modelling Survey Report, 2011 |
| 7 | Lack of awareness | • Matarneh and Hamed, 2017<br>• Zahrizan et al., 2013 |
| 8 | Unwillingness to change | • Arayici et al., 2009<br>• Newton and Chileshe, 2012 |

## 4.4 Section D: Facilitators for BIM Adoption

### 4.4.1 Facilitators with Weight Index

Facilitators for BIM adoption in Turkish construction industry with the highest rank are regarding training and education, since lack of BIM education and training is

addressed as the top barrier in this research. Most of professionals agreed on the importance of providing education and training on use of BIM to staff and students. The facilitator with the highest rank is to provide training programs to staff on new process and workflow (1) and on new software and technology (0.994) followed by providing guidance on use of BIM in firms (0.992). Providing education to students at university level and providing collaboration with universities have high importance with weight index of 0.984 and 0.978. After education and training comes the support of government with weight index of 0.978.

Understanding BIM enough before using it will facilitate the adoption of BIM, this facilitator ranked highly by professionals (0.893). Realizing that benefits of BIM are perceived will open the way to implement it (0.879).

High cost of BIM software is addressed as a barrier, decreasing the cost of BIM software has an impact on increasing the rate of implementation (0.862). One of the facilitators that has a high rank is continuous investment in BIM (0.865). Realizing the value of financial benefits of BIM also has an impact on increasing the rate of implementation (0.848).

Applying some processes in organization will facilitate the adoption of BIM such as purchasing BIM software and technology (0.794), top management support (0.792) and providing promotions for BIM users (0.779).

There are many other facilitators that have an impact on increasing the rate of BIM adoption such as client demand (0.739), contractual arrangement (0.729), integration and coordination among project parties (0.727), mobilizing clients on benefits of BIM

(0.672), competitive pressure (0.632) and legal obligations (0.605). Table 11 shows the summery of facilitators for BIM adoption weight index.

Table 11: Facilitators with weight index

| | Facilitator | Mean | Weight | Weight Index |
|---|---|---|---|---|
| 1 | Provide training to staff on new process and workflow | 4.574 | 0.0598 | 1 |
| 2 | Provide training to staff on new software and technology | 4.546 | 0.0594 | 0.994 |
| 3 | Providing guidance on use of BIM | 4.537 | 0.0593 | 0.992 |
| 4 | Provide education and training at university level | 4.500 | 0.0588 | 0.984 |
| 5 | Collaboration with universities | 4.472 | 0.0584 | 0.978 |
| 6 | Government support | 4.472 | 0.0584 | 0.978 |
| 7 | Understanding BIM enough before using it | 4.083 | 0.0534 | 0.893 |
| 8 | Perceived benefits from BIM | 4.019 | 0.0525 | 0.879 |
| 9 | Decreasing the price of BIM software | 3.944 | 0.0515 | 0.862 |
| 10 | Continuous investment in BIM | 3.917 | 0.0512 | 0.856 |
| 11 | Realizing the value from a financial perspective | 3.880 | 0.0507 | 0.848 |
| 12 | Purchasing software and technology | 3.630 | 0.0474 | 0.794 |
| 13 | Top management support | 3.620 | 0.0473 | 0.792 |
| 14 | Promotion for BIM users | 3.565 | 0.0466 | 0.779 |
| 15 | Client demand | 3.380 | 0.0442 | 0.739 |
| 16 | Contractual arrangement | 3.333 | 0.0436 | 0.729 |
| 17 | Integration and coordination among project parties | 3.324 | 0.0434 | 0.727 |
| 18 | Mobilizing clients on benefits of BIM | 3.074 | 0.0402 | 0.672 |
| 19 | Competitive pressure | 2.889 | 0.0378 | 0.632 |
| 20 | Legal obligations | 2.769 | 0.0362 | 0.605 |

### 4.4.2 Facilitators with RII

RII values for top facilitators in this research are 0.915 for providing training to stuff on new process and workflow, 0.909 for providing training to staff on new software and technology, 0.907 for providing guidance on use of BIM, 0.900 for providing education and training at university level and 0.894 for collaboration with universities and government support. Table 12 shows facilitators for BIM adoption with RII values.

Table 12: Facilitators with RII

| | Facilitator | Mean | SD | RII |
|---|---|---|---|---|
| 1 | Provide training to stuff on new process and workflow | 4.574 | 6.820 | 0.915 |
| 2 | Provide training to staff on new software and technology | 4.546 | 6.658 | 0.909 |
| 3 | Providing guidance on use of BIM | 4.537 | 6.609 | 0.907 |
| 4 | Provide education and training at university level | 4.500 | 6.442 | 0.900 |
| 5 | Collaboration with universities | 4.472 | 6.336 | 0.894 |
| 6 | Government support | 4.472 | 6.415 | 0.894 |
| 7 | Understanding BIM enough before using it | 4.083 | 5.635 | 0.817 |
| 8 | Perceived benefits from BIM | 4.019 | 6.463 | 0.804 |
| 9 | Decreasing the price of BIM software | 3.944 | 5.606 | 0.789 |
| 10 | Continuous investment in BIM | 3.917 | 6.050 | 0.783 |
| 11 | Realizing the value from a financial perspective | 3.880 | 6.274 | 0.776 |
| 12 | Purchasing software and technology | 3.630 | 5.130 | 0.726 |
| 13 | Top management support | 3.620 | 5.730 | 0724 |
| 14 | Promotion for BIM users | 3.565 | 5.660 | 0.713 |
| 15 | Client demand | 3.380 | 4.434 | 0.676 |
| 16 | Contractual arrangement | 3.333 | 5.064 | 0.667 |

| | | | | |
|---|---|---|---|---|
| 17 | Integration and coordination among project parties | 3.324 | 5.444 | 0.665 |
| 18 | Mobilizing clients on benefits of BIM | 3.074 | 4.847 | 0.615 |
| 19 | Competitive pressure | 2.889 | 5.215 | 0.578 |
| 20 | Legal obligations | 2.769 | 4.912 | 0.554 |

Facilitators are addressed in this part in order to develop factors to eliminate the addressed barriers. The first two facilitators are regarding training programs. The need for training programs on new process and workflow is more than the need for training programs on BIM use. This will lead to provide clear understanding of new technologies and its benefits before applying it. This is considered in the conceptual framework in chapter 5.

The third facilitator is to provide guidance on use of BIM which will lead to improve the collaboration between users and to use BIM with knowledge and perception. The next facilitator is providing BIM education at university level by creating collaboration between universities and BIM courses providers. This will lead to prepare students that are fully qualified and have the ability of using BIM in projects.

Government support factor is the next facilitator. Developing strategic plan by the government is the way to develop BIM adoption in Turkey in both public and private sectors. Turkish Government can collaborate with governments that have developed BIM implementation plans to develop BIM implementation in Tukey.

Decreasing costs regarding BIM implementation will facilitate BIM adoption in Turkey. BIM software providers play major role in working in collaborative way with firms and decreasing the price of BIM software tools. Also, BIM training courses

providers and universities play major role in decreasing the price of training courses. This will give push for students and staff to attend training programs with desire.

One of facilitators of BIM adoption is creating the fully integrated environment for BIM users in the firm which is considered in the conceptual framework. This can be done through many factors such as creating BIM department, purchasing BIM software tools and providing promotion for BIM users with the support of top management.

### 4.4.3 Similar Results to Facilitators

Some previous studies have results that are similar to results of this research, Table 13 shows results of top facilitators addressed by different researchers.

Table 13: Similar results to facilitators

| | Facilitator | Similar Results |
|---|---|---|
| 1 | Provide training to stuff on new process and workflow | • Zahrizan et al., 2013<br>• Zikic, 2009<br>• Akkaya, 2012<br>• Olugboyega and Aina, 2016<br>• Kiani et al., 2015 |
| 2 | Provide training to staff on new software and technology | |
| 4 | Provide education and training at university level | • Kiani et al., 2015<br>• Olugboyega and Aina, 2016 |
| 6 | Government support | • Eadie et al., 2013<br>• Zahrizan et al., 2013<br>• Olugboyega and Aina, 2016 |

## 4.5 Section E: Future Estimates and vision of BIM Implementation

This part is about the expectations of professionals for BIM implementation in Turkey in the future. Firstly, 53.7% of professionals think that the percentage of firms that use

BIM currently in Turkey is fewer than 20%, while 37% think that the percentage is between 20% and 40%, and only 9.3% think that the percentage is between 40% and 60%.

63% of professionals agreed on “BIM will be widely used in the near future in Turkish construction industry” whereas 20.4% said no and 16.7% had neutral point of view.

About BIM implementation in Turkey after 10 years, only 5.6% of professionals believe that the percentage of firms that will BIM will be fewer than 20% while 35.2% think that the percentage will be between 20% and 40%, 31.5% believe that the percentage will be between 40% and 60%, 24.1% believe that the percentage will be between 60% and 80%. And only 3.7% believe that the percentage will be between 80% and 100%.

About the time it will take for most of Turkish firms to use BIM on regular basis, only 1.9% said it will take less than 5 years, 14.8% said it will take 5 to 10 years, 45.4% said it will take 10 to 15 years and 38% said it will take more than 15 years.

# Chapter 5

# CONCEPTUAL FRAMEWORK FOR BIM ADOPTION IN TURKEY

## 5.1 Introduction

In this chapter, a conceptual framework is provided by the author and developed according to the results of the research. The conceptual framework shows the roadmap that will improve BIM implementation in Turkey as shown in Figure 19 and consists of actors, factors and detailed BIM implementation process.

## 5.2 Actors

Actors in this conceptual framework are divided into three categories which are the government, organizations and people. Each category has its role in developing the process of BIM implementation in Turkey and all roles are integrated with each other to achieve goals of this process. First category is Turkish government that plays major role in supporting BIM implementation regarding its authority in public sector through many factors such as investment and publicity. Second category is organizations which are the firms of construction industry in Turkey including contractor firms, consulting firms, architecture firms and academic institutes. Third category is people which are the professionals of construction industry in Turkey including engineers, architects, contractors, owners, clients, students and academic staff.

## 5.3 Factors

The conceptual framework is based on critical factors which are developed to eliminate addressed barriers and to facilitate BIM implementation in Turkey.

The factors are ranked below according to importance:

1- BIM Education

2- Staff Training

3- Awareness and Publicity

4- Culture

5- Cost

6- Environment

7- Government Support

8- Client Demand

### 5.3.1 BIM Education

Providing BIM education for students at university level will increase the rate of awareness and knowledge of BIM among students and will lead to qualify skilled professionals which are familiar with the use of BIM in construction industry. Universities must collaborate with construction firms to gain guidelines and standards to build the outline of courses that will be provided for students. Providing BIM education to staff in firms and training centers is quite important as providing education to students. The point in this factor is to provide theoretical education that involves clear understanding of BIM and its benefits before practical education on use of BIM.

### 5.3.2 Staff Training

One of the most significant factors to improve BIM implementation in Turkey is to provide training programs for staff to increase the rate of technological skills, since the success of implementation depends directly on skills of users. Training programs must be on new process and workflow to overcome the impact of changing from traditional methods to new methods and on the use of new software and technology to allow professionals to be familiar with the use of BIM. Construction firms and training centers play a major role in creating training programs for professionals.

### 5.3.3 Awareness and Publicity

One of the important factors to facilitate BIM implementation in Turkey is the increased publicity of BIM that will lead to rise of BIM awareness. Creating methods for publicity of BIM and its benefits such as providing guidance and documentations supported with case studies and examples from previous projects will increase the awareness of BIM and will provide a clear background of BIM and its benefits. BIM awareness must be increased among all categories regarding construction industry including contractors, owners, consultants, engineers, architects, students and clients.

### 5.3.4 Culture

Culture of professionals is an important factor that will facilitate BIM adoption in Turkish firms. This includes changing from traditional methods to new processes and technologies. Management of changing and its impacts can be done through many factors such as education and training by providing a clear understanding of BIM and its benefits which will allow professionals to realize benefits of BIM. This will lead to prepare professionals that are open-minded about new processes and technologies.

### 5.3.5 Cost

Factor of high costs regarding BIM implementation is addressed as a barrier to the success of BIM adoption in Turkey. Reducing these costs will give a push to apply BIM in firms. These costs are including training cost, software cost and BIM implementation cost. Academic institutes and training centers play major role in reducing training costs. BIM software providers can work in collaborative way with firms and reduce the cost of BIM software tools.

### 5.3.6 Environment

One of the methods to facilitate BIM implementation is to create supportive work environment in the organization that have the ability to adopt new technology and process. Top management in the organization has the responsibility to overcome the impacts that occur from changing form environment of traditional methods to environment of new methods. Many ways to prepare professionals which are ready to work in BIM environment such as providing training programs, providing guidance on use of BIM, allowing professionals to realize the benefits of BIM, purchasing BIM software and providing promotion for BIM users.

### 5.3.7 Government Support

One of largest factors that will facilitate BIM adoption in Turkey is government support factor. Turkish government must take serious steps for creating a strategic roadmap and vision plan for BIM implementation in Turkish construction industry. Government has the ability to take a role in all factors such as providing BIM training and education programs, increasing the rate of publicity, requesting use of BIM as a client and creating standards and guidelines for BIM use. Government must promote BIM adoption at least in projects of public sector and work in collaborative way with firms of private sector to facilitate BIM adoption in Turkey.

### 5.3.8 Client Demand

Client demand of applying BIM in construction projects will give a push for firms to implement BIM. The way to increase the rate of client demand is to allow clients to realize the value of BIM benefits from financial perspective. Turkish government plays the role of leader in this factor since it is the largest client and has the ability to push and increase the rate of client demand for applying BIM in construction projects.

## 5.4 BIM Implementation Process

In this part, a process has been developed by the author in terms of steps based on critical factors mentioned above. The objective of this process is to create a roadmap for authorities and professionals of construction industry in Turkey to improve BIM implementation starting from zero point. This process consists of two main phases. The first phase is the phase of understanding BIM which deals with preparing professionals that have the ability of using BIM and applying it in projects. The second phase is the phase of implementing BIM which deals with applying BIM in projects and creating fully integrated environment in the organization for professionals that are prepared from the first phase.

### 5.4.1 Understanding BIM

The first phase in this process is to provide a clear understanding of BIM and its benefits to professionals. This can be done through the first four factors which are BIM education factor, staff training factor, awareness and publicity factor and culture factor. The starting point is from universities and training centers by providing BIM education and training for students and professionals and increasing the publicity of BIM by BIM providers which will lead to increase the awareness of BIM among all categories. Education, training and publicity programs must be created based on integrated outline that provides a clear understanding of BIM and its benefits. The first step in this phase

is to provide a theoretical background of BIM which can be gained from literature review including the definition of BIM concept, levels and stages of BIM and dimensions of BIM. The next step is to identify BIM goals and the purposes of applying BIM in projects including application areas of BIM, benefits of BIM for project parties and challenges of BIM implementation. The next step is to identify BIM implementation barriers and facilitators in Turkey in order to facilitate BIM adoption. BIM implementation barriers are addressed in this study in Table 9 and facilitators are addressed in Table 12. Applying all these steps will lead to the final step in this phase which is the culture factor. Culture factor includes the changing from traditional methods to new technologies, preparing professionals that are open-minded about new technologies and accelerating the adaptation to new technologies. At the end of this phase, all professionals will be fully qualified and have the ability of using BIM and moving to the next phase which is the implementation phase.

### 5.4.2 Implementing BIM

The second phase in this process is the phase of implementing BIM in projects. The first step in this phase is to create BIM environment in the organization for professionals to support BIM adoption in the firm. This can be done in many ways such as creating separated and fully integrated BIM department that has the authority to deal with everything regarding BIM, purchasing BIM software tools, providing standards and guidelines for using BIM in projects and providing priority for BIM users. The next factor in this phase is the government factor. Government has the authority to force firms of public sector to implement BIM in their projects and has the ability as a client to request BIM implementation from firms of private sector. Also, one of the ways to improve BIM implementation is the continuous investment in BIM by the government. Client demand is an important factor in this phase that will increase

the rate of BIM implementation. Realizing financial benefits of BIM by the client is the way to request BIM implementation in projects. Figure 19 shows the conceptual framework for BIM adoption in Turkey.

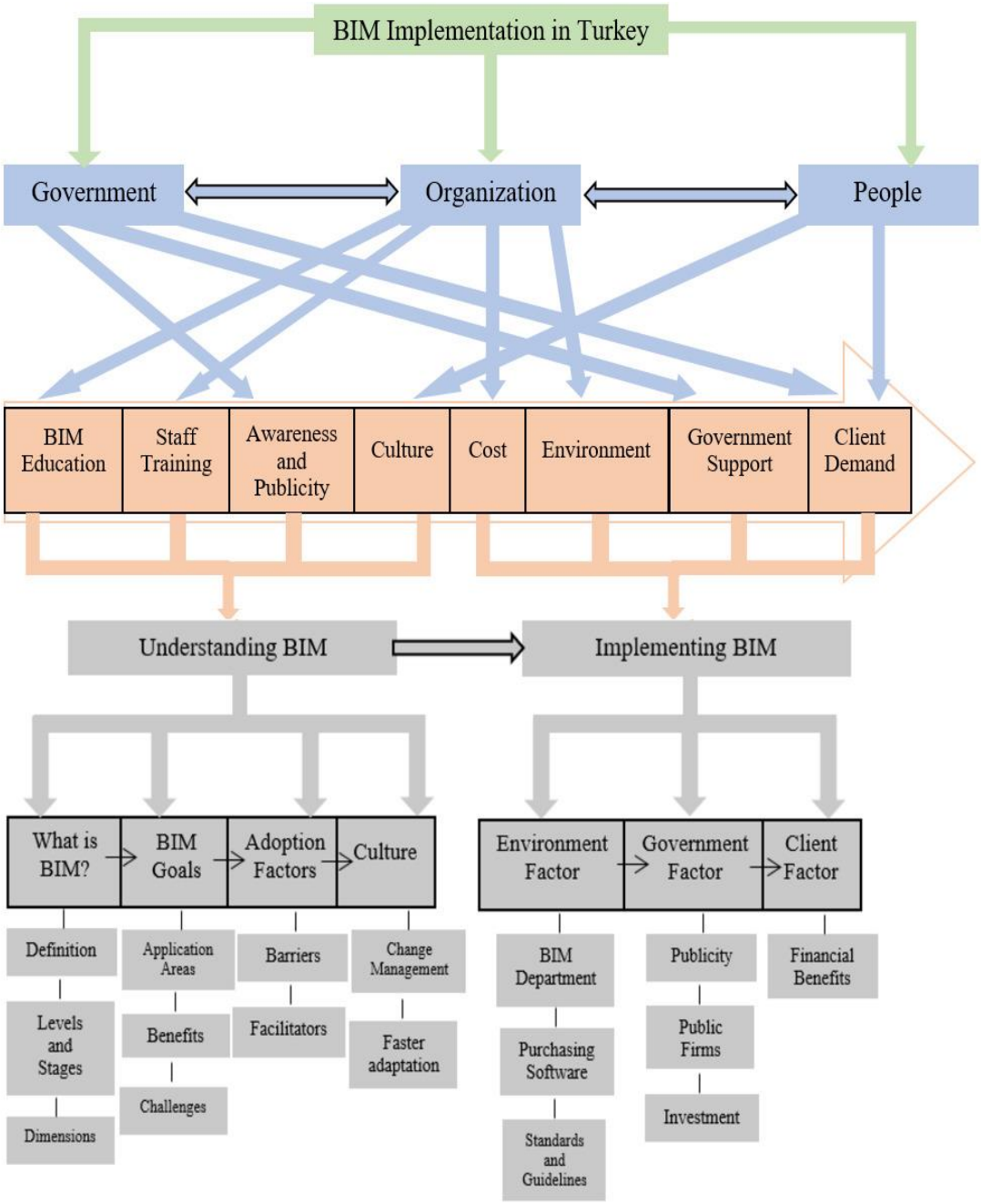


Figure 19: Conceptual Framework for BIM Adoption in Turkey

# Chapter 6

# CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Introduction

This chapter consists of two parts, conclusions and recommendations. First part is the conclusions part which includes the overall summary of the study and results achieved. The second part is about recommendations developed by the author based on results in order to improve BIM implementation in Turkey.

## 6.2 Conclusions

The conclusions of the research are pointed as follows:

- The purpose of this research was to investigate BIM implementation in Turkey including studying the current state of BIM implementation and addressing barriers and facilitators for BIM adoption.

- Questionnaire survey technique is used in this research to collect data from construction firms in Turkey. Questions were divided into five sections which are respondents' profiles, current state of BIM implementation, Barriers to BIM implementation, facilitators for BIM adoption and future estimates and vision for BIM implementation.

- The first objective of this study was to investigate the current state of BIM implementation in Turkey. Section B in the questionnaire was created for this purpose.

- Section B results showed that BIM adoption in Turkey is still in primitive phase. BIM is used in only 42.6% of firms.

- Only 64.8% of professionals in Turkey are aware of BIM and only 58.3% are aware of its benefits. This indicates the lack of awareness of BIM in Turkey.

- The lack of technological skills and experts in Turkey is addressed. Only 34.3% of professionals know how to use BIM and 65.7% of professionals had never used BIM before.

- The adaptation to BIM in most of Turkish firms was slow. It took more than 1 year for 76.1% of firms to be adapted to BIM.

- The most common BIM software tools in Turkey are AutoCAD, Revit and MS Project. This indicates that the technology is enough to adopt BIM. Table 14 shows the summery of the current state of BIM implementation in Tukey.

Table 14: Current state of BIM implementation

| Description | Status |
|---|---|
| BIM adoption in firms | 42.6% of firms are using BIM. |
| Awareness | 64.8% of professionals are aware of BIM and 58.3% are aware of its benefits. |
| Technological skills | 34.3% of professionals know how to use BIM. |
| Technical experts | 65.7% of professionals had never used BIM before. |
| Adaptation to BIM | It took more than 1 year for 76.1% of firms to be adapted to BIM. |
| BIM software tools | AutoCAD, Revit and MS Project |

- The second objective of this study was to address barriers of BIM implementation in Turkey. Section C in the questionnaire was created for this purpose.

- In terms of categories, ranking of barriers from the highest to the lowest was as follows: Market barriers, technical barriers, personal barriers, business barriers and organizational barriers. Table 15 shows categories of barriers with RII values with the first two barriers in each category.

Table 15: Top barriers in terms of categories

| Category | RII Value | First Two Barriers |
|---|---|---|
| Market barriers | 0.796 | Lack of publicity |
| | | Lack of client demand |
| Technical barriers | 0.716 | Lack of standards and guidelines |
| | | Slow adoption of new technology |
| Personal barriers | 0.682 | Lack of BIM education and training |
| | | Lack of awareness |
| Business barriers | 0.620 | Lack of investment in BIM |
| | | High cost of implementation |
| Organizational barriers | 0.619 | Unwillingness to change |
| | | Firms do not have enough opportunity for BIM implementation |

- The most significant barriers to BIM implantation in Turkey are the lack of BIM education and training, the lack of publicity, the lack of client demand, the lack of standards and guidelines and the lack of government support. Table 16 shows top five barriers to BIM implementation in Turkey.

Table 16: Top five barriers for BIM implementation

| | Barriers | RII Value |
|---|---|---|
| 1 | Lack of BIM education and training | 0.857 |
| 2 | Lack of publicity | 0.837 |
| 3 | Lack of client demand | 0.815 |
| 4 | Lack of standards and guidelines | 0.811 |
| 5 | Lack of government support | 0.804 |

- The third objective of this study was to address the facilitators for BIM adoption in Turkey. Section D in the questionnaire was created for this purpose.

- The most significant facilitators for BIM implementation in Turkey are providing BIM training programs no new process and workflow, providing training programs on use of BIM, providing guidance on use of BIM, providing BIM education at university level and providing collaboration with Universities. Table 17 shows the top five facilitators for BIM adoption in Turkey.

Table 17: Top five facilitators for BIM Adoption

| | Facilitators | RII Value |
|---|---|---|
| 1 | Provide training to stuff on new process and workflow | 0.915 |
| 2 | Provide training to staff on new software and technology | 0.909 |
| 3 | Providing guidance on use of BIM | 0.907 |
| 4 | Provide education and training at University level | 0.900 |
| 5 | Collaboration with Universities | 0.894 |

- The fourth objective of this study was to develop a conceptual framework for BIM adoption in Turkey. After analyzing the results of the questionnaire, a conceptual framework was developed by the author according to barriers and facilitators addressed in this study. The purpose of the framework is to develop a roadmap to

improve BIM implementation in Turkey. The framework consists of actor, factors and BIM implementation process. Actors are divided into three categories which are the government, organizations and people. The framework based on eight factors which are education factor, training factor. Awareness factor, culture factor, cost factor, environment factor, government factor and client factor. The BIM implementation process is developed in terms of steps and consists of two main phases which are understanding BIM phase and implementing BIM phase. Figure 19 shows the conceptual framework for BIM adoption in Turkey.

## 6.3 Recommendations

The following recommendations are pointed by author and can be used for further studies:

- The results of this research must be considered by Turkish construction industry authorities to establish the roadmap for implementing BIM in Turkey.

- Turkish government must collaborate with governments of developed countries that have an advanced BIM implementation. BIM specialists and experts can be invited to Turkey to develop BIM training and education factor and to develop guidelines and standards for BIM use in Turkey.

- Turkish construction firms and academic institutes must work together in collaborative way to create syllabuses and outlines that will improve BIM education for students and staff.

- BIM courses must be provided in Turkish universities and must be added to academic programs of civil engineering and architecture departments, at least as an elective courses.

- Professionals of Turkish construction industry must change the traditional way of thinking and must be open minded toward changing from traditional methods to new processes and technologies.

- BIM must be applied with knowledge and perception and after understanding it well to achieve the perceived benefits of BIM.

- Separated BIM department with BIM specialists and experts must be created in each Turkish construction firm that deals with everything regarding BIM and has full authority to manage projects by using BIM.

# REFERENCES

AGK Creative BIM. (n.d.). Retrieved April 13, 2018, from http://agkdesignbim.blogspot.com/

Akkaya, D. (2012). İnşaat Sektöründe Yapı Bilgi Modellemesi Hakkında İnceleme. *T.C. Yıldız Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi.*

Aladag, H., Demrdögen, G., & Isık Z. (2016). Building Information Modeling (BIM) use in Turkish Construction Industry. *World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium 2016, WMCAUS 2016. Procedia Engineering 161 ( 2016 ) 174 – 179.*

Amarnath, C., B., Chnag, Y., & Hsieh, S. (2016). An overview of global research trends in BIM from analysis of BIM publications. 1*6th international conference on computing in civil and building engineering, ICCCBE 2016 - July 6th-8th, At Osaka, Japan.*

Aranda-Mena, G., Crawford, J., Chevez, A., & Froese, T. (2008). Building information modelling demystified: does it make business sense to adopt BIM?. *International Journal of Managing Projects in Business, 2(3), pp. 419 - 434.*

Arayici, Y., Khosrowshahi, Y., Ponting, A.M., & Mihindu, S. (2009). Towards Implementation of Building Information Modelling in the Construction Industry. *5th International Conferance on Constrcution in the 21st Century*

*(CITC-V). Collaboration and Integration in Engineering, Management and Technology. May 20-22, 2009, Istanbul ,Turkey.*

Arayici, Y., (2015). Building Information Modeling. *Yusuf Arayici & bookboon.com. ISBN 978-87-403-1098-6*

Autodesk (2002). Autodesk Building Industry Solutions, Building Information Modeling. Retrieved April 20, 2018, from http://www.laiserin.com/features/bim/autodesk_bim.pdf

Awwad, R., & Ammoury, M. (2013). Surveying BIM in the Lebansese Construction Industry. *International Association for Automation and Robotics in Construction.*

Bentley (2008). The Year in Infrastructure 2008. *Bentley systems.* Retrieved April 11, 2018, from http://www.yearininfrastructure-digital.com/yearininfrastructure/2008?pg=1#pg1

BIM Ireland (2017). BIM in Turkey: Using BIM on Istanbul Grand Airport. Retrieved March 11, 2018, from http://www.bimireland.ie/2017/04/04/bim-in-turkey-using-bim-on-istanbul-grand-airport

Bryde, D., Broquetas, M., & Volm, J. M. (2013). The project benefits of Building Information Modelling (BIM). *International Journal of Project Management, 31 (2013) 971–980.*

Building Cost Information Service BCIS (2011). Building Information Modelling Survey Report (2011). *Building Cost Information Service Royal Institution of Chartered Surveyors.*

Carbasho, T. (2008). Building Information Modeling Drives Lean Construction Management. Available at https://www.tradelineinc.com/reports/2008-9/building-information-modeling-drives-lean-construction-management

Chou, H., & Chen, P. (2017). Benefit Evaluation of Implementing BIM in Construction Projects. *WMCAUS, IOP Conf. Series: Materials Science and Engineering 245 (2017) 062049.*

Department of Transport and Main Roads (2017). Building Information Modelling (BIM) for Transport and Main Roads: A guide to enabling BIM on Road Infrastructure Projects. *State of Queensland.*

Eadie, R., Odeyinka, H., Browne, M., McKeown., C., & Yohanis, M. (2013). An Analysis of the Drivers for Adopting Building Information Modelling. *Journal of Information Technology in Construction (ITcon), Vol. 18, pg. 338-352*

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors. *John Wiley & Sons, Inc.*

Gerges, M., Austin, S., Mauouf, M., Ahiakwo, O., Jaeger, M., Saad, S., & Gohary, T. (2017). An Investigation into the Implementation of Building Information Modeling in the Middle East. *Journal of Information Technology in Construction - ISSN 1874-4753.* Availabe at http://www.itcon.org/2017/1

Kaner, I., Sacks, R., Kassian, W., & Quitt, T. (2008). Case Studies of BIM Adoption for Precast Concrete Design by Mid-Sized Structural Engineering Firms. *ITcon, Information Technology in Construction 13 (3), 303–323.*

Kiani, I., Ghomi, S., Johor, M., Alerasoul, S., & Khoshnava, S. (2013). The Barriers and Implementation of Building Information Modeling (BIM) based on Integrated Project Delivery (IPD) In the Construction Industry. *Conference Paper: IGCESH 2013*. Available at https://www.researchgate.net/publication/272789025

Kushwaha, V., & Adhikari, M. (2016). *Exploring The Adoption of Building Information Modelling in India and Need for Further Implementation. International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 01, Jan-2016.*

Lindbland, H. (2013). Study of the implementation process of BIM in construction projects. Analysis of the barriers limiting BIM adoption in the AEC-industry. *KTH Architecture and the Built Environment. Thesis no.263.*

Matarneh, R., & Hamed, S. (2017). Exploring the Adoption of Building Information Modeling (BIM) in the Jordanian Construction Industry. *J Archit Eng Tech 2017, 6:1 DOI: 10.4172/2168-9717.1000189, Research Article, OMICS International.*

McGraw Hill Contrcution (2013). The Business Value of BIM in North America. *Smart Market Report*. Retrieved April 28, 2018, from https://damassets.autodesk.net/content/dam/autodesk/www/solutions/bim/Business_value_of_BIM_2012_North_America.pdf

McGraw Hill Contrcution (2014). The Business Value of BIM for Constrcution on Major Global Markets. *Smart Market Report*. Retrieved May 10, 2018, from https://www.icn-solutions.nl/pdf/bim_construction.pdf

Nanajkar, A. (2014). Implemeting Building Information Modeling (BIM) at AEC Firms in India. *North Dakota State University of Agriculture and Applied Science, Master Thesis.*

National BIM Standards NBIMS. Retrieved May 15, 2018, from https://www.nationalbimstandard.org/

National Building Specification NBS (2013). NBS International BIM Report 2013. Retrieved May 23, 2018, from https://www.thenbs.com/knowledge/nbs-international-bim-report-2013

National Building Specification NBS (2016). NBS International BIM Report 2016. Retrieved June 12, 2018, from https://www.thenbs.com/knowledge/nbs-international-bim-report-2016

National Building Specification NBS (2017). NBS National BIM Report 2017. Retrieved June 14, 2018, from https://www.thenbs.com/knowledge/nbs-national-bim-report-2017

Newton, L., & Chileshe, N. (2012). Awareness, usage and benefits of building information modelling (BIM) adoption-the case of South Australian construction organizations. *28th Annual Association of Researchers in Construction Management (ARCOM) Conference, At Edinburgh, Scotland.* Available at: https://www.researchgate.net/publication/262262747

Newton, L., & Chileshe, N. (2012). Enablers and barriers of building information modelling (BIM) within South Australian construction organizations. *37th Annual Conference of Australian University Building Educators Association (AUBEA), At Sydney, Australia. Available at: https://www.researchgate.net/publication/264420987*

Olugboyega, O., & Aina, O. (2016). Analysis of Building Information Modelling Usage Indices and Facilitators in the Nigerian Construction Industry. *Journal of Logistics, Informatics and Service Sciences Vol. 3 (2016) No. 2, pp. 1-36. ISSN 2409-2665.*

Rodgers, C., Hosseini, M., Chileshe, N., & Rameezdeen, R. (2015). Building information modelling (BIM) within the Australian construction related small and medium sized enterprises: Awareness, practices and drivers. *31st Annual ARCOM Conference, 7-9 September 2015, Lincoln, UK, Association of Researchers in Construction Management, 691-700.*

Sacks, R., & Barak, R. (2008). Impact of three-dimensional parametric modeling of buildings on productivity in structural engineering practice. *Automation in Construction 17(4):439-449 · May 2008.*

Sinclair, D. (2012). BIM Overlay to the RIBA Outline Plan of Work. *Royal Institute of British Architects "RIBA". London, UK.*

Songer, A., Ibbs, C., & Napier, T. (1994). Process Model for Public Sector Design-Build Planning. *Journal of Construction Engineering and Management, Vol. 120, Issue 4 (December 1994).*

Yan, H. & Demian, P. (2008). Benefits and barriers of building information modelling. *12th International Conference on Computing in Civil and Building*

*Engineering, Beijin 2008.* Retrieved March 15, 2018, from https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/23773

Zahrizan, Z., Ali, N., Haron A., Ponting, A., & Hamid, Z. (2013). Exploring the Barriers and Driving Factors in Implementing Building Information Modelling (BIM) in the Malaysian Construction Industry: A Preliminary Study. *The Journal of the Institution of Engineers, Malaysia, VOL. 75, NO.1.*

Zikic, N. (2009). Building Information Modeling Uses for Design in the Architecture, Esngineering, and Construction (AEC) Industry. *The Pennsylvania State University. A Thesis in Architectural Engineering.*

Zeiss, G. (2011). Building Information Modeling. *2nd International Conferance on Computing for Geospatial Research and Applications Article No. 71.*

# APPENDIX

## Appendix A: Sample of Questionnaire Survey

### Section A: Respondents' Profile

1- **Work position?**

a) Engineer b) Architects c) Academic d) Other

2- **Education level?**

a) BSc b) MSc c) PhD d) Other

3- **Years of experience?**

a) 1-5 b) 5-10 c) 10-15 d) 15+

4- **The description of your firm?**

a) Contractor firm b) Consulting firm c) Architecture firm

d) University / Research firm e) Other

5- **Sector?**

a) Private b) Public

6- **The sector of the construction project?**

a) Commercial b) Residential c) Governmental

d) Industrial e) Other

7- **Number of employees?**

a) 1-20 b) 21-50 c) 21-50 d) 50+

8- **How long has your firm existed?**

a) 1-5 years b) 6-10 years c) 11-15 years d) 15+ years

9- **Which city your organization located in?**

## Section B: Current State of BIM Adoption:

**1- Did you know/hear about BIM?**

a) Yes b) No

**2- Does your firm use BIM?**

a) No b) Preparing for it c)Yes

**3- Do you know how to use BIM?**

a) No b) Still learning c) Yes

**4- Are you aware of benefits of BIM?**

a) No b) Yes

**5- Number of projects you used BIM in?**

a) Never b) 1-5 c) 6-10 d) 10+

**6- How long did it take for your firm to be adapted to BIM?**

a) Not using BIM b) 0-6 months c) 6 months – 1 year

d) 1-2 years e) 2+ years

**7- What software tools does your firm use?**

**8- What are the file formats used in your firm?**

**9- For what does your firm use BIM?**

a) 3D (parametric modelling) b) Documentations and drawings

c) Clash detection d) 4D (time based simulation)

e) Feasibility analysis f) Quantity surveying and cost analysis

g) Work schedule planning h) Construction site planning

i) Carrier system analysis j) Environment and energy analysis

k) Infrastructure planning l) Budgeting

m) Other

**10- As a result of implementing BIM in your firm, what are the services offered?**

| Service | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly Agree 5 |
|---|---|---|---|---|---|
| Construction management? | | | | | |
| Risk management? | | | | | |
| Shop drawings production? | | | | | |
| Fast drawing? | | | | | |
| Common understanding of project costs, schedule and project progress? | | | | | |
| Maximizing productivity? | | | | | |
| Improve project documentation? | | | | | |
| Improve quality in design and construction phases? | | | | | |
| Improve built output quality? | | | | | |
| Cost savings? | | | | | |
| Total profitability increasing? | | | | | |
| Increasing the ability to response to requests for information? | | | | | |
| Fast modification? | | | | | |
| Improving the ability to meet sustainability needs? | | | | | |
| Competitive advantage? | | | | | |
| Improved decision making in design and construction? | | | | | |

Other?

**11- As a result of using BIM in your firm, what are the problems solved?**

| Problem | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly Agree 5 |
|---|---|---|---|---|---|
| Problems are identified earlier? | | | | | |
| Errors are reduced? | | | | | |
| Collaboration and communication problems are solved? | | | | | |
| Conflicts are reduced? | | | | | |
| Clashes are detected? | | | | | |
| Construction time was reduced? | | | | | |
| Construction cost was reduced? | | | | | |
| Waste and rework are reduced? | | | | | |
| Teamwork problems were solved? | | | | | |
| Coordination problems amongst project parties were solved? | | | | | |
| Collaboration problems amongst construction stakeholders were solved? | | | | | |

Other?

## Section C: Barriers to BIM Implementation

**To what extent do you agree with the following barriers?**

**Personal Barriers:**

| Barriers | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly agree 5 |
|---|---|---|---|---|---|
| Lack of awareness? | | | | | |
| Lack of BIM education and training? | | | | | |
| Lack of understanding of BIM and its benefits? | | | | | |
| Refuse to learn BIM? | | | | | |
| BIM is difficult to learn? | | | | | |

**Technical Barriers:**

| Barriers | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly agree 5 |
|---|---|---|---|---|---|
| Current technology is not enough? | | | | | |
| Lack of technological skills? | | | | | |
| Lack of technical experts? | | | | | |
| Lack of standards and guidelines? | | | | | |
| Slow adoption of technology? | | | | | |
| Data loss while transferring data between BIM software tools and other tools? | | | | | |

**Business Barriers:**

| Barriers | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly agree 5 |
|---|---|---|---|---|---|
| Lack of investment in BIM? | | | | | |
| High cost of implementation? | | | | | |
| High cost of training? | | | | | |
| Benefits are unclear? | | | | | |
| High cost of software and updates? | | | | | |
| Benefits from BIM implementation do not outweigh the costs to implement it? | | | | | |
| BIM does not offer enough of a financial gain to warrant its use? | | | | | |
| Additional costs that may arise from using BIM? | | | | | |

**Market Barriers:**

| Barriers | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly agree 5 |
|---|---|---|---|---|---|
| Market is not ready? | | | | | |
| Lack of government support? | | | | | |
| Lack of client demand? | | | | | |
| Lack of publicity? | | | | | |

**Organization Barriers:**

| Barriers | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly agree 5 |
|---|---|---|---|---|---|
| Lack of senior management support? | | | | | |
| Difficult in managing the impact of BIM? | | | | | |
| Unwillingness to change? | | | | | |
| Firms do not have enough opportunity for BIM implementation? | | | | | |
| Benefits are not tangible enough to warrant its use? | | | | | |

## Section D: Facilitators for BIM Adoption

**To what extent do you agree with the following facilitator factors?**

| Facilitators | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly agree 5 |
|---|---|---|---|---|---|
| Provide education and training at university level? | | | | | |
| Collaboration with universities? | | | | | |
| Provide training to stuff on new process and workflow? | | | | | |
| Provide training to staff on new software and technology? | | | | | |
| Understanding BIM enough before using it? | | | | | |
| Providing guidance on use of BIM? | | | | | |
| Government support? | | | | | |
| Client demand? | | | | | |
| Competitive pressure? | | | | | |
| Legal obligations? | | | | | |
| Contractual arrangement? | | | | | |
| Top management support? | | | | | |
| Promotion for BIM users? | | | | | |
| Continuous investment in BIM? | | | | | |
| Perceived benefits from BIM? | | | | | |
| Realizing the value from a financial perspective? | | | | | |
| Integration and coordination among project parties? | | | | | |
| Purchasing software and technology? | | | | | |
| Decreasing the price of BIM software? | | | | | |
| Mobilizing clients on benefits of BIM? | | | | | |

## Section E: Future Estimates and Vision of BIM Adoption

1- **According to you, what is percentage of firms using BIM currently in Turkey?**

a) 0 – 20 b) 20-40 c)40-60 d) 60-80 e) 80-100

2- **Do you agree: "BIM will be widely used in the near future in Turkish construction industry"?**

a) No b) Yes c) Neutral

3- **According to you, what will be the percentage of firms using BIM after 10 years in Turkey?**

a) 0 -20 b) 20-40 c) 40-60 d) 60-80 e) 80-100

4- **According to you, how long it will take for most of construction firms in Turkey to use BIM on regular basis?**

a) 5 years b) 5-10 years c) 10-15 years d) 15+ years