

**EVALUATION OF SUSTAINABLE BUILDING DESIGN AND ITS
ASSOCIATED MANAGEMENT TOOLS IN DESIGN FIRMS:
CASE OF IRAN**

A thesis

by

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**EVALUATION OF SUSTAINABLE BUILDING DESIGN AND ITS
ASSOCIATED MANAGEMENT TOOLS IN DESIGN FIRMS:
CASE OF IRAN**

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ABSTRACT

As the importance of sustainable development gained momentum, the extent to which it should be implemented remained a matter of concern. Among all, buildings are among the remarkable results of human activities that have a substantial impact on the environment, from construction to demolition. On the other hand, sustainable buildings provide ways to reduce the harshness of buildings' impacts on the environment and help to promote a sustainable way of living and to achieve sustainable development targets. The fact that in each region, "Sustainable Development" needs to follow regional conditions led this research to choose a case study (Iran) to evaluate Sustainable Building Design (SBD). The thesis aims to study the Iranian design firms who have showed their will to follow SBD guidelines and to analyze the drivers justifying their interests. Regarding the aim of the research, the following questions raised: i) To what extent have SBD and its associated management techniques and tools implemented in building design firms? ii) What are the barriers and success factors in implementing sustainable building design management and its associated tools? iii) What are the influencing factors for implementing SBD? iv) How much acceptance, readiness, and willingness exist among the firms regarding Sustainable Building Design Management (SBDM) and its associated tools? v) To what extent are the issues mentioned above implemented in the case of Iran?

Understanding sustainable development would help to make decisions to improve the procedure for implementing sustainability in building design. It would also suggest a way to mitigate and eliminate problems and obstacles in adopting sustainable principles through management techniques. In the thesis, first, a literature review is conducted. Secondly, a survey was built on the inspiration of the literature review. Following the survey formation, interviews conducted at thirteen sustainable building design firms in Tehran, Iran's capital. Finally, the results showed that there were insufficiencies in the education and regulation system regarding SBD in Iran. In addition, barriers and obstacles to implementing SBD, SBD Management (SBDM), and SBD Management Tools (SBDMT) were revealed from the perspective of participating firms. The training and acceptance of SBD, SBDM, and SBDMT were evaluated among firms. Finally, the recommendations were based on literature and survey results.

Keywords: *Sustainable Building Design, Sustainable Building Design Management, Sustainable Building Design Management Tools, Iran*

ÖZET

Günümüzde sürdürülebilir kalkınmanın önemi gittikçe artmakta, uygulanma boyutu da bu oranda daha dikkate değer hale gelmektedir. İnsan faaliyetleri içinde binalar, yapımdan yıkıma dek çevreye etkisi en yüksek faaliyetler içindedir. Öte yandan, sürdürülebilir binalar, binaların çevre üzerindeki etkilerini azaltmak ve sürdürülebilir bir yaşam biçimini teşvik etmek ve sürdürülebilir kalkınma hedeflerine ulaşmak için yollar sunmaktadır. “Sürdürülebilir Kalkınma”nın bölgesel koşulları izlemesi gerektiği gerçeği ile bu araştırmada, Sürdürülebilir Bina Tasarımını (SBT) değerlendirmek için vaka olarak İran seçilmiştir. Tez, İranlı yapı tasarım firmaları özelinde SBT uygulamalarını, bu konuda isteklerini ve uygulamada karşılaşılan engellerin analizini amaçlamaktadır. Araştırmanın soruları aşağıdaki şekilde belirlenmiştir: i) SBT ve bununla ilişkili yönetim teknik ve araçları bina tasarım firmalarında ne ölçüde uygulanmıştır? ii) Sürdürülebilir Bina Tasarım Yönetimi ve bununla ilişkili araçların uygulanmasında engeller ve başarı nedenleri nelerdir? iii) SBT'nin uygulanmasına etki eden faktörler nelerdir? iv) Firmalar arasında Sürdürülebilir Bina Tasarım Yönetimi (SBTY) ve ilgili araçları konusunda ne kadar kabul, hazır olma ve isteklilik bulunmaktadır? v) Yukarıda belirtilen hususlar İran örneğinde ne ölçüde uygulanmaktadır?

Sürdürülebilir kalkınmanın anlaşılmasının, bina tasarımında sürdürülebilirliğin uygulanmasına yönelik prosedürün iyileştirilmesinde ve sürdürülebilirlik ilkeleri benimseme konusundaki sorunları azaltmada yardımcı olacağı düşünülmektedir. Tezde, öncelikli olarak sürdürülebilirlik, sürdürülebilir bina tasarımı ve yönetimi konularında literatür taraması yapılmıştır. İkinci olarak, literatür taramasından esinlenerek bir görüşme formu hazırlanmış, bunu takiben, İran'ın başkenti Tahran'da on üç sürdürülebilir bina tasarım deneyimi olan firma ile görüşmeler yapılmıştır. Sonuçlar, İran'da SBT ile ilgili eğitim ve düzenleme sisteminde yetersizliklerin olduğunu göstermiştir. Ayrıca, SBT, SBT Yönetimi (SBTY) ve SBT Yönetim Araçları'nın (SBTYA) uygulanmasında karşılaşılan engeller katılımcı firmalar açısından ortaya çıkarılmıştır. Son olarak, literatür ve görüşme sonuçlarına dayanan öneriler ortaya konmuştur.

Anahtar Kelimeler: *Sürdürülebilir Bina Tasarımı, Sürdürülebilir Bina Tasarım Yönetimi, Sürdürülebilir Bina Tasarım Yönetim Araçları, İran*

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ABBREVIATIONS

<i>SBD</i>	Sustainable Building Design		
<i>SBDP</i>	Sustainable Building Design Principles		
<i>BDM</i>	Building Design Management		
<i>SBDM</i>	Sustainable Building Design Management		
<i>SBDMT</i>	Sustainable Building Design Management Tools		
<i>PBD</i>	Passive Building Design		
<i>IUPN</i>	International Union for the Protection of Nature	<i>ICC/IRC</i>	International Commercial or Residential Code
<i>IUCN</i>	International Union for Conservation of Nature and Natural Resources	<i>USGBC</i>	United States Green Building Code
<i>EPA</i>	Environmental Pollution Agency	<i>BIM</i>	Building information modeling
<i>UNEP</i>	United Nation Environmental Program	<i>AHRI</i>	Air-Conditioning, Heating, & Refrigeration Institute
<i>CITES</i>	Convention on International Trade in Endangered Species of Wild Fauna and Flora	<i>IEC</i>	International Electro Technical Commission
<i>WWF</i>	World Wide Fund for Nature	<i>ISO</i>	International Organization for Standardization
<i>LCA</i>	Life Cycle Assessment	<i>FCC</i>	Federal Communications Commission
<i>SWOT</i>	Strengths and Weaknesses, Opportunities and Threats	<i>IEQ</i>	Indoor Environmental Quality
<i>LEED</i>	Leadership in Energy and Environmental Design	<i>IEECE</i>	Approval of Electrical Equipment Product Safety Certification
<i>BREEAM</i>	Building Research Establishment Environmental Assessment Method	<i>TCB</i>	Telecommunication Certification Body
<i>SBtool</i>	International Initiative for a Sustainable Built Environment	<i>BSI</i>	Building sustainability Index
<i>CASBEE</i>	Comprehensive Assessment System for Built-Environment Efficiency	<i>EIA</i>	Environment impact assessment
<i>ISIRI</i>	Institute of Standards and Industrial Research of Iran	<i>BSAR</i>	building sustainability assessment ratio
<i>IRCEO</i>	Iran construction engineering organization	<i>SATBA</i>	renewable energies and electric energy efficiency of Iran

CHAPTER 1

INTRODUCTION

Sustainable development has been studied through the literature for half a century. When it comes to practice, the applicability, status of implementation, and the readiness of individual regions to implement it are questionable. Even though sustainability is the frontier solution for saving the environment for the next generation, it has not fully implemented around the world. Since sustainable development is a global issue, success in achieving it requires a substantial global contribution.

Sustainability is a way of life and thinking that affect all human actions. The first step is to appreciate the subsequent impacts of each activity on life. Buildings are a prominent result of direct human activities, which have a substantial impact on the environment at various stages, from construction to demolition. Sustainable buildings not only provide ways to reduce the harshness of buildings' impacts on the environment but can also promote a sustainable lifestyle.

Both sustainability and sustainable development have been described as societal and directing procedures that need management's techniques. Sustainable management is a lost chain of many construction and architecture firms to accomplish sustainability. Needless to say, that like any other project and activity, sustainable building design management needs tools for increasing the integrity, continuity, and productivity. Also, it necessarily needs tools for optimal output and ease of implementation.

1.1 Problem Statement and Research Questions

In order to investigate the status of sustainable building design management and the associated tools for it, the following questions raised to which this study intends to answer.

- To what extent have building design firms employed sustainable building design and its associated management tools and techniques?
- What are the influencing factors in implementing sustainable design?
- What are the barriers and success factors in implementing sustainable building design management and their associated tools?
- How much acceptance, readiness, and willingness among the firms exist regarding sustainable building design management and their associated tools?
- To which extent, the issues above under questions implemented in the case of Iran?

1.2 Aim and objectives

This study aims to understand to what extent sustainable building designs are implemented through sustainable building design management and its associated tools. Also, this study intends to understand the firms' accepting of sustainable building design, its associated management techniques and tools. To identify factors that influence their sustainable building design practices (both obstacles and contributors or success factors). It further expects to identify the legislations, policies, and building regulations for adopting sustainable building design in the case of Iran.

This understanding may help to make decisions to improve the procedure of implementing sustainability in building design. It would hint to the way of isolating the problems and barriers of adopting sustainable principles through management techniques (Juan et al., 2016).

Regarding the course of the aim, this study intended to reach the goals below:

- To determine the extent to which sustainable building design and its managerial techniques and tools are implemented within Iran.
- To reveal factors (i.e., barriers and contributors or solutions) that are hindering or promoting sustainable building design practices.
- To present recommendations to the building design profession in Iran
- To study the case of firms that showed their will to follow the guideline of the sustainable building design and to analyze the drivers justifying their interests.

1.3 Methodology and Scope of the Thesis

This study was conducted within Tehran, the Iranian capital. The study's scope was restricted to building design firms. In order to answer the research questions, first, a literature review was conducted on sustainability, sustainable development, and sustainable building design, sustainable building design management, tools for sustainable building design management and architectural education, codes and standards in terms of sustainability in Iran. Inspired by the literature review and the recent relevant research, a semi open-end survey questionnaire (Table 19) was constructed. The survey questionnaire was based on the areas of concentrations in the literature review and the associated readiness, willingness, and barriers of sustainable building design and management implementation in Iranian architectural design firms in Tehran. The survey questionnaire was structured as contingency questions, rating questions using a Likert scale, multi answers questions, and open-ended questions based on the structures introduced by Babbie's research method (2011) and Groat & Wang, (2013). Tehran Province Building Engineering System Organization, (2020) provides information on Tehran's building design firms. Among these firms, the ones who had sustainable building design experience and were willing to contribute to this study were chosen. Totally thirteen firms could be conducted at the end. Table 2 in section 5.4.1 shows the characteristics of these firms.

In order to analyse open-ended questions, first, a text format of the answers was prepared for coding. For analyzing the output data of findings, Vensim software was used to manage the mind maps, cause trees, uses trees, and loops. This way, not only the relationships between the thematic opinions of the survey results become evident, but also the most mentioned keywords show up. For the quantitative part, Excel charts used as well as partial python data analysis coding for calculation and visualization.

1.4 Structure of The Thesis

This thesis is structured based on seven chapters. Chapter 0 includes the problem statement, the aim, and the scope of the thesis, explains the methodology and the structure of the thesis. In chapter 2, literature review on sustainability, sustainable development and sustainable building design is given. Chapter 3 concentrates on Sustainable Building Design Management (SBDM). In chapter 4, tools for SBDM are reviewed. Chapter 5 elaborates the case study (Iranian building design firms) and explains

the survey questions for this study. Subsequently, chapter 6 presents the survey results. Chapter 7 provides a conclusion, discussion, recommendations and future work.



CHAPTER 2

SUSTAINABILITY, SUSTAINABLE DEVELOPMENT, AND SUSTAINABLE BUILDING DESIGN

Limited adjacent available resources and energy were the limitation and the norms of past centuries. However, increasing population as well as easiness brought by the industrial revolution resulted in a high amount of energy use, a high amount of constructions, and vast pollutant transportation. These changes brought the ease of material availability and construction and easy, affordable full active energy-consuming buildings without any consideration about the environmental crises (Brophy & Lewis, 2011). These destructive crises are not limited to construction issues. However, ever-increasing disappearance of species due to human intervention, human-based global warming, emission, depletions of resources, and habitat destruction are among the dangers threatening the life on earth. Besides these, the population growth on earth worsens the problem (Sassi, 2006). In the wake of this destructive process, reactions emerged. In 1948 an organization for resource and nature conservation was found named International Union for the Protection of Nature (IUPN). In 1956, the International Union for Conservation of Nature and Natural Resources (IUCN) was the name of this organization, which was given to it following the 1956 conference in France. Since that date, the organization has been regularly assisting with environmental and nature policy agendas every two or four years. It is responsible for many of the current regulations on environmental conservation (*International Union for Conservation of Nature*, n.d.).

EPA, which represents the Environmental Pollution Agency, also emerged in 1970. EPA aims to protect the environment following the enactment of activities, monitoring, and researching and tries to provide a healthier environment for the Americans (US Environmental Pollution Agency, n.d.). In 1972, the United Nations Environmental Program (UNEP) founded following the United Nations Human Environment Conference. Since then, this organization is responsible for the environmental problems in United Nations Agencies (United Nations Environmental Programs, n.d.). In the same year, 1972, IUCN led to three newer conventions, including World Heritage Convention, CITES (the

Convention on International Trade in Endangered Species of Wild Fauna and Flora), and the Ramsar (wetland conservation), respectively in 1972, 1974, and 1975.

After first worldwide energy crisis in 1973, United States emerged National Association of Convenience Stores (1973). This energy crisis led to broad changes in domestic energy policy and a stress on improving energy efficiency (Britannica, Arab-oil-embargo, 2020). In 1979, the oil pressure community was developed and then faded away for the second time. However, at that time, it became more apparent that environmental crises were inevitable. The environmental destruction became more evident (Brophy & Lewis, 2011; World Commission on Environment and Development, 1987). Finally, in 1980, the integration of conservation and development was introduced by IUCN, UNEP and WWF (World Wide Fund for Nature) through the publication of the World Conservations Strategy (*International Union for Conservation of Nature*, n.d.).

2.1 Sustainability and Sustainable Development

Sustainable development intends to accomplish the needs of today while not putting the future ability to meet the demands of future generations. In this way, society should possess some conditions. First, its consumption of renewable resources quantity should not exceed that of regeneration. Second, its consumption of non-renewable resources quantity should not exceed that of its sustainable substitutes. Finally, its amount of emissions should not exceed environmental capacity. Since the values change over time, a contemporary way of thinking is the prerequisite of sustainability in any area. This is one of the reasons that keep sustainability definition open to modification. According to the discussion above, sustainability is a difficult-to-implement-concept and needs an individual perspective and contribution (Sassi, 2006).

Sustainable development concept dates back to three decades ago. For the first time, it was introduced by the Brundtland Commission Report (World Commission on Environment and Development, 1987). The central core of this concept is to meet the requirements of current life without compromising those of the future. Sustainable development is achievable via sustainability. It also follows sustainability principles. In this manner, sustainability is defined as the procedure to accomplish sustainable development. However, these two terms are sometimes interchangeably used. Sustainability also has been defined from a policy perspective of society as a preventing factor of natural resource depletion. The enhancements in the implementation of sustainability are ought to the worldwide attention toward sustainable development (Olawumi & Chan, 2018).

As a means of balancing between the needs and ecosystem and resources conservation, sustainable development has three critical dimensions: environmental, social, and economic sustainability, which should be harmonized with one another (Georgescu-Roegen et al., 2004) (Figure 1).

Environmental sustainability concerns the quality of life within the boundary of considering the attention to the capacity of the ecosystem in which the region of human life is included. This ecosystem includes land, materials, energy sources, water, and so forth.

Economic sustainability is concerned with the efficiency of consuming the sources to make profits as well as increasing the value of the market. Recycling, reusing, and profitable renewability are among economic sustainability.

Social sustainability deals with the wellbeing among society and individuals and tries to make a balance between them. In this way, it pays attention to the local firms and workforces and their participation. Public awareness is also among the responsibility of social sustainability.



Figure 1. The three pillars of sustainable development
(Georgescu-Roegen et al., 2004; World Commission on Environment and Development, 1987)

Also, the scale is one of the fundamental questions of sustainable development thinking and action. The definition of scale in ecological and socio-political manner was defined by Grantinger (2004) as global, supranational regions, stated, region, locality 1 (city, town), locality 2 (village, community, neighborhood), and household. Sustainable building design consideration occurs in the city and town scale in the context of sustainable buildings. Sustainable buildings put forward, decreasing the detrimental environmental impact through its life span. Building projects as the results of direct human activities have a substantial impact on the environment in different stages, from construction to demolitions. The considerations regarding Sustainable Building Design (SBD) presented in the following;

2.2 Sustainable Building Design

Sustainable Building Design (SBD) is a design process in which the Sustainable Building Design Principles (SBDP) are considered. Building designed with SBDP is economically beneficial, seller, highly rentable, long-lived, and helps regeneration. Sustainable buildings do not put an extra burden on the shoulder of prospective generations in terms of energy consumption, water crises, and waste management by implementing both sustainable design strategies and available technologies. SBD not only provides ways to decrease the harshness impacts of buildings to the environment but also can promote a sustainable living style (Sassi, 2006).

SBD is a multidisciplinary endeavor which needs the collaboration of experts from architecture, mechanic, electricity, renewable energies, structure, social science, etc. (N. Wang & Adeli, 2014). Recognizing the importance of sustainable buildings, some countries such as Germany, put forwards to decrease the detrimental impacts on the environment through sustainable buildings. Germany invests in researches on building energy performance and tries to decrease the annuals energy consumption of buildings around 60 kWh/m² and targets the decrease of office building cooling loads through sustainable strategies (Sodiq et al., 2019).

SBD is achievable via Sustainable Building Design Principles (SBDP). In the following section, the strategies for sustainable building design have been summarized in six categories, including Site and Land Use, Community, Health and Well-being, Materials, Energy, and Water.

Figure 2 shows the SBDP components in summary.

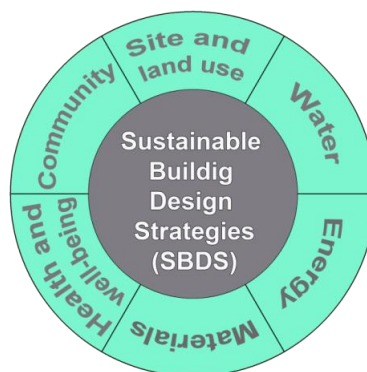


Figure 2. sustainable building design principles
(Sassi, 2006)

2.2.1 Sustainable Building Design Principles

Buildings constitute cities. Future cities should follow sustainable principles for design and construction (Sodiq et al., 2019). This chapter explains each of SBDP, which is illustrated in

Figure 2.

2.2.1.1. *Site and Land Use*

Land benefits species not only because it provides enough space to live on, but also for the resources it poses for continuing life. It also absorbs the waste. Hence, it is a precious surface for all kinds of life. Human activities influence this surface and its species. Urbanism modifies the face of the earth in a detrimental manner, which ends up damaging plants and humans, including human beings (Sassi, 2006). Land use is one of the essential pieces of the puzzle of SBDP. The twentieth-century construction and voracious inadvertent land used led to high distances between activity and travel crises. Therefore, decreasing the quality of life and pollutant has happened (Brophy & Lewis, 2011). These changes also weaken the earth's surface to provide life (Sassi, 2006). In the emergence of environmental consideration and sustainable city development, these issues were addressed (Brophy & Lewis, 2011). The ecological footprint deals with the amount of land to provide a life for humans according to their actions. The scale of the time for ecological footprint is long term. The decrease of ecological footprint is a sustainable strategy.

Urban sprawl is an incredible challenge for land usage for urban development. This is in contrast with the concept of sustainable thrifty land use. To answer the question of how countries are dealing with this challenge, Bovet, Reese, & Köck (2018) conducted legal assessments following the principles of sustainable land use principles in several countries as case studies. The results showed that the lack of determining targets for sustainable land use among the countries caused a deficiency in achieving quality in this sustainable principle. Germany and Switzerland specified quantitative targets in this regard, still, lack of regulations and monitoring to meet these targets are the weakening aspects. Also, the results stated that all the countries under study had a different environmental evaluation. However, none of them was implemented efficiently. less dense cities, minimizing transportation impacts, involving more with nature and local food productions are the factors to be considered for land use portion of sustainable building design (Sassi, 2006).

The more the buildings are close to each other, i.e., compact cities, the more reduction in the amount of energy used, leads to the low cost of infrastructure. A well-mixed used application community that

is dense offers several advantages. Among them are fewer travel crises, less energy consumption, saving more land for greenery, lesser need for infrastructure, more efficient central heating and cooling, and a more thriving community (Brophy & Lewis, 2011; Tappert, Klöti, & Drilling, 2018). Obtaining a sustainable municipal transport system, other facilities such as shops, train stops, work, and leisure areas should be contained in transport nodes. (Sassi, 2006; Sodiq et al., 2019). Bicycle routes also play an essential role in creating a sustainable area. By providing a secure route, pedestrian zones would become more interesting to walk (Jahanshahi et al., 2019).

Individual requirements and the quality of life depend on nature. Nature gives hints to the architects and designers for optimizing the design for less destructive influence. Nature plays a vital role in moderating the global climate by providing cooling and shelter from winds. On the other hand, land usage and energy consumption are the two main features associated with food production. Building developments could decrease the effects of food production and distribution. Locally produced food should be given priority in this content. It helps to reduce the gas emissions from the vehicles while economized the local agriculture (Sassi, 2006).

2.2.1.2. Community

Sustainable strategies also include the way people live. Human activities affect the environment in many different ways. Change in values is a requirement to achieve sustainability. Societies require to be re-educated about the importance of sustainability. Public participation, provision of houses for all, education and employment, the improvement of quality of life, and the promotion of sustainability are viable paths that help to achieve a sustainable community. Furthermore, the feeling of the people is affected by the area in which they live. Not only is this character influenced by the built environment, but it is also affected by people's activities within that environment (Sassi, 2006).

To the accomplishment of flexibility in making the policy, there is a need for a deep understanding of local needs and sustainable goals. This is achievable through effective lively community participation. Mobilizing the public for decision making and affecting their life provides an understanding of the honest, clear situation, needs, and potentials (Spiliotopoulou, 2017). Moreover, everybody has the right to have a home. There are various living options while developing the housing structure. Residents of different ages within the same area could choose from these options based on their requirements. There is another option called mixed housing, which allows the residents

to stay at the same area while altering the personal conditions. Also, affordability is a critical issue while considering the above circumstances.

On the other hand, to be autonomous, individuals require getting an education and employed. It helps people to meet their desires and ambitions. There are a few things that lead to social dispensation. Among those, the deficiency in education and employment plays an important role (Sassi, 2006; Sodiq et al., 2019; Brophy & Lewis, 2011).

The connection between building developments and employment are somewhat obvious. The mental health and wellbeing are two main results of providing people with training and employment. The main feature of a suitable community is its comfort access to the facilities and necessities while guaranteeing the long life for the community. The facilities should satisfy all the requirements of residents in different groups. Buildings may provide an opportunity to increase the understanding of sustainability. Designers may utilize their productions as educational machines that can teach clients, municipal authorities, and other builders with the building process. Knowledge is increased by learning the principles of sustainable buildings while understanding the more efficient operation of the building. However, the more care the inhabitants give to the usage of their buildings the more possible success would be for a sustainable design method (Sassi, 2006; Sodiq et al., 2019).

2.2.1.3. Health and Well-being

Rather than managing to treat the disease, health covers a broader area, including physical, psychological, and socially appropriate status (World Health Organization, 1946). The environment and especially the built environment can affect the health and well-being of occupants. Some of the building design elements affect the well-being immediately like cold/hot space and dark/bright spaces. However, some other building aspects may take a long time to show up their effects like toxic materials that cause cancers. Ill-building syndrome is a term defined for the affecting syndromes on building occupants during their presence in space and living at intervals (Brophy & Lewis, 2011; Sassi, 2006). Comfort is an essential factor in providing physical and psychological health. It is dependent on many factors such as temperature, noise, and light, and so forth. Comfort is also affected by idiosyncrasy and psychological matters. There are several improving and increasing standards and guidelines and literature to support more comfort for the occupants of the buildings for designers in several aspects. Like (ANSI ASHRAE STANDARD 55, 2017) for thermal comfort

(Sassi, 2006; Brophy & Lewis, 2011) and increasing attention to providing indices, review, and innovations in visual comfort (Carlucci et al., 2015)

Comfort out of design is a necessary prerequisite for well-being, productivity, and health. Enabling people to alter their condition for comfort is of high importance. It helps the occupants to make sure that the discomforts are treatable by alternation (Sassi, 2006). It, also, helps for more energy-saving through natural comfort provision (Rijal et al., 2007). An innovative parametric approach and optimization have increasingly helped designers in recent decades to address energy-efficient building investigations. To find out the best form to improve thermal comfort, Abdollahi Rizi, Aminkhani, Abdollahi Rizi, & Moslehi (2018) optimized the ceiling form of an open room in Tehran, Iran. The research showed that for each season, a specific ceiling form better fit environmental conditions towards thermal comfort.

Moreover, providing user requirements is very vital in buildings. Users' age and ability are valuable in design. Besides, designers should consider a sense of happiness that resulted from health and well-being. Happiness is also affected by individuals' expectations, history, and sense of valuable identity. Designers are responsible for providing tranquil spaces which also help to promote productivity. For doing this, a deep understanding of people's reactions to the environment is needed. A lack of controllability of health-related issues is an essential factor that causes a sense of frustration and decreases the sense of self-value. The buildings should not only be designed to let comfortability but also should improve the feeling of well-being, both physically and mentally (Sassi, 2006).

2.2.1.4. *Materials*

Buildings require materials, energy, and water. They consume materials and energy in construction, maintenance, modifications and substantially affect their appearance and costs. Their impact on the environment could occur in more remote places and over time, like deforestation and causing cancers, respectively. Measures to prevent material-related damage to people and the environment should be considered (Sassi, 2006; Brophy & Lewis, 2011). While choosing materials for sustainable building design, there should be awareness and precautions, including durability, using waste as a new resource, resource availability, decreasing manufacturing impacts, energy, and transportations (Sassi, 2006; Brophy & Lewis, 2011).

Durable materials minimize the need for new resources and depletion. They minimize the expenses of maintenance. Also, flexible design, which allows for future modification, is fundamental while designing for longevity. This kind of design provides the situation in which the basic structure can remain intact while changing the spatial layout for improving the interior space. Moreover, the building industry is the pioneer consumers of materials. Therefore, designing the buildings capable of reusing or recycling of their component materials is necessary. In the end, dependency upon the manufacture and resourcing can be decreased. However, the trade-off between the supply and demand of the construction industry should be considered to increase the productivity of this method. Also, it is worth noting that the more the manufacturing process is involved the more environmental effects it has. The energy needed to mine or harvest, process, transport, manufacture the materials ends installing on the building is known as embodied energy. Minimizing this energy is required to prevent emitting CO₂ to the environment. Waste minimization plays an essential role in keeping the environment clean since a large amount of waste hurts all areas of life. Waste minimization reduces disposal effects, and new material could be avoided while recycling waste. As a result, impacts related to material production are reduced by waste minimization. Minimizing the waste could be performed from the building's design to a devastating point. Excessive decoration, intricate designs, and inappropriately sized buildings result in a large amount of waste (Sassi, 2006; Brophy & Lewis, 2011).

One of the difficulties in sustainable building projects is the selection of sustainable materials. Life Cycle Assessment (LCA), is a way of evaluating the impacts of materials on the environment from manufacturing to the recycle period (Mahmoudkelaye et al., 2018). For filling the gap of easing the procedure of optimum material selection for minimizing the environmental footprint in the design stage, Mahmoudkelaye et al. (2018) proposed Life Cycle Assessment (LCA) plus Analytic Network Process. In this method, first a general assessment for the entire impacts in all life span of materials. Then selection principles based on sustainable criteria will be divided into four main groups; economic, technical, social, and environmental. For each category, several subcategories also are defined. After that Analytical Network Process is used; the criteria based on experts is adapted for multi-objective decision making through comparison and questionnaire. In an attempt to understand the barriers to choosing sustainable building materials, a survey is conducted in Nigeria (Akadiri, 2015). The impetrations of "losing high budget while choosing green", the low level of information about sustainable materials, and lack of tools for this purpose are the most substantial barriers for choosing sustainable materials. After understanding the barriers influencing sustainable materials for

buildings, as for the recommendation, Akadiri (2015) proposed governmental interfering for adopting sustainable materials. They proposed that governmental regulation is the best motive for adopting greener materials and seeking to collect information about them.

2.2.1.5. *Energy*

To overcome the pressing problem of global warming, consideration of energy use is a determining priority. Even though climate change is inevitable, the issue of greenhouse emission is well avoidable. It is not doable with a particular portion of countries, however. It requires worldwide collaboration. The three approaches used to minimize the adverse effects of energy outcomes are minimizing energy needs, using energy efficiently, and using green energy sources (Sassi, 2006).

Providing people with sustainable spaces is one of the biggest steps toward decreasing energy needs. Buyle, Braet, & Audenaert (2013), stated that regarding the minimization of energy consumption, building design is among the most influencing factors even more than the technologies and systems. For energy consumption decrease in buildings, passive strategies from formal ones to behavioral ones are the solutions. For example, as an attempt, Amaral, Rodrigues, Gaspar, & Gomes (2016) investigated the potential direction of window openings and windows glass material. In another attempt by Kontoleon & Zenginis (2017), formal design principles, orientation, the windows configuration, insulation thickness were studied to find the best combination for energy efficiency. In association with an efficient design, appropriate and efficient systems and technologies are crucial as a supplement of the procedure of energy-efficient buildings. It was shown that a major saving in electricity is possible through implementing efficient lighting systems. Old boilers are 50% to 70% less efficient than the newer version (Sassi, 2006). Another emerging technology was the combined heat and power production, which was based on a simultaneous combination of heat and power production (Jahangiri et al., 2018a) and many other technology-based improvements in the field of sustainable design. Even though sustainable building design needs high technologies to overcome the barriers, the technology mere could not satisfy the procedure of the sustainable design. Behavioral studies associated with the design are critical in this field (Zhang et al., 2018). Efficient building design and systems also need appropriate control (Sassi, 2006).

According to Gaetani, et al. (2016), modern technology in building energy systems, as well as renewable energy resources, will be more ubiquitous. The technology mere could not overcome the

increasing energy consumptions in buildings. Occupant's behavior is another factor that plays a significant role in efficient design, operation, retrofit towards energy efficiency at low cost (Hong et al., 2015). The behavior of occupants substantially influences building energy consumption. Occupant's presence, activities, and control actions influence buildings (Hoes et al., 2009). This influence is because the occupants of the buildings tend to spend 80%-90% of their time inside the buildings (T. Roberts, 2016). They seek quality and comfort in their indoor environment beyond a mere survival status (Citherlet et al., 2000). Occupant's behavior investigations help the decision-makers, policymakers, as well as architects and designers to promote their outputs concerning building energy performance (Li et al., 2019). Incorporation of occupant behavior in the design process is of the necessities of sustainable building design (Gunay et al., 2013).

For conducting behavioral strategies associated with forms, seasonal movements were studied by Memarian (2011). This term refers to the situation in which the building users move around the building to enjoy thermal comfort. These kinds of behaviors that are prolific in traditional architecture happen horizontally or vertically, depending on the climate. These behaviors were contemporarily investigated in India by Indraganti (2010). The results of the study showed that these movements decrease energy consumptions in buildings (Indraganti, 2010). During their research, Ahn and Park (2016) concluded that each person in spaces, depending on his personality and preference, such as his presence in space, number of opening and closing the window, turning on and shutting down the thermal systems, etc. consumes energy and influences the amount of consumption. Moreover, the amount and quality of his actions are not equal to the others. Also, they showed that differences in characters make differences in the way each person consumes energy in the building. In a study in India, seasonal movement of occupants among the zone of the interior space as well as daily movement through an adaptable designed space had a significant impact on achieving passive thermal comfort and energy efficiency (Indraganti, 2010). Page, Robinson, Morel, & Scartezzini (2008) investigated the influence of occupants' number and their schedule on electricity and lighting loads. The vital impact of culture, clothing, and timing in occupant behaviors on the thermal comfort of the building users was indicated by J Fergus (2001). A study of Cambridge, UK's office occupants' patterns of behavior toward passive strategies for decreasing energy consumption was conducted by Yun & Steemers (2008).

The last piece of the puzzle of sustainable energy consideration takes into account renewable energy. Even though much fewer than non-renewable energy, renewable energies also have operation energies. According to this, zero CO₂ buildings are more realistic terms than zero energy buildings.

The most used kinds of renewable energy systems are photovoltaic panels and geothermal pumps. The limitation of site areas also limits the proliferation of wind powers. The dependency of water sources in special conditions is among the situations for making use of hydro powers. Biofuels are also renewable sources that are much more widespread in potential sites for the primary bio-sources.

Moreover, fuel cells are newer technologies for the production of water, heat, and electricity (Jahangiri et al., 2018a; Sassi, 2006). Also, some other kinds of sources make the feasibility of extracting renewable energies like sewage and waste, including citizen garbage and agricultural waste. Cost and payback time issues are the most important barrier to implement and make use of renewable energies. Low costs of fossil fuels are the demotivating factors for endeavor towards renewable energy extractions. However, the more increasing and scarcity among non-renewable sources of energy the more cost-effective renewable energies become (Jahangiri et al., 2018a).

2.2.1.6. *Water*

Life is strongly dependent on water. Species, including humans, require water for their survival. In contrast, the available quantity of safe water for human beings is only 0.008 percent of all the planet's water through renewable rainfall. Also, wastewater use is an environmental problem. The issue of water crises in buildings is embedded in the way water is consumed, treated, and discharged. Building design can reduce the burden of water crises by designing to reduce water consumption and minimize the entrance of gray, black, and rain to the main sewage. In order to reduce water consumption and waste in buildings, there are three strategies related to design. Combining these construction strategies paves the way for water autonomy. The first step towards addressing the water crisis is to minimize consumption, which in itself reduces waste as well. Each country has a unique way of consuming water. Educating people about sustainable water consumption is critical to achieving water conservation. Efficient equipment is another strategy to minimize water consumption. The third influencing factor is maintenance, which refers to water leakages (Sassi, 2006).

Greywater is defined as the remaining water out of human activities such as washing, excluding solid liquids such as residuals of kitchens. Reuse of greywater is among the golden strategies for sustainable water management, especially in building design considerations. In an attempt to study the greywater reuse in a hot arid climate; Jordan. The results of this investigation have shed light on the fact that the management in greywater in this region needs government support and facilities for success. Greywater reuse like watering the plant, and local food production, and hygienic based activities both in domestic and public scale provide opportunities to keep more fresh water intact. A

strong need for new technologies and facilities for greywater use, standardization of chemical inside the grey water for the secondary users are among the other needs (Al-Jayyousi, 2003).

Rainwater is the other alternatives for the water sources which are treatable to used in building affairs. This alternative is much more popular compared to greywater due to easier treatment. It is also usable without any modifications to some building affairs. However, it suffers from the disadvantage of inadvertently entrance to the main sewer system. Contemporary collection and recycle of water alternatives are not cost-effective due to long payback time. For example, greywater systems' payback time ranges from 15 to 100 years. Rainwater systems are more promising, providing 50 % saving a yearly manner. The technology is to bring new systems capable of doing the treatment jobs of water more easily and efficiently (Sassi, 2006).

One of the building design strategies for sustainable water management is the combination of solar collectors and evaporation mechanisms. The solar thermal energy could be used more efficiently this way. Condensation and evaporation help for not only passive cooling and heating, but also water purification (Figure 3).

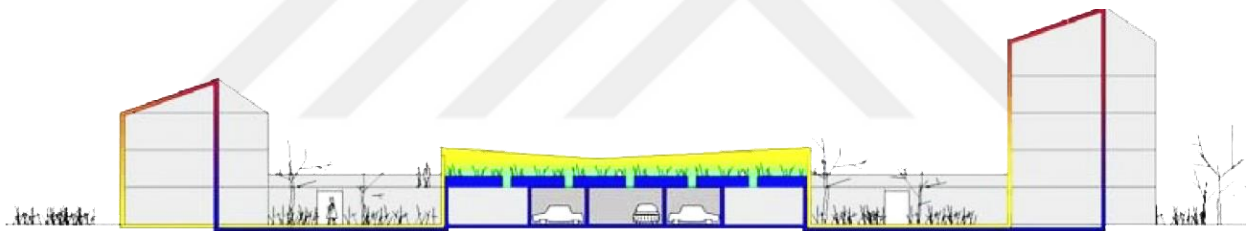


Figure 3. Combination of solar collector and greenhouse
(Zaragoza et al., 2007)

On-site cleaning systems for reuse of water would reduce the need for main sewers and drains and their subsequent pollutions and energy for treatment. Letting less water to main drains and sewers is also beneficial to refill the groundwater sources. Reducing stormwater run-off is the easiest and efficient ways in this field (Sassi, 2006; Sodiq et al., 2019).

2.2.2 Passive Building Design

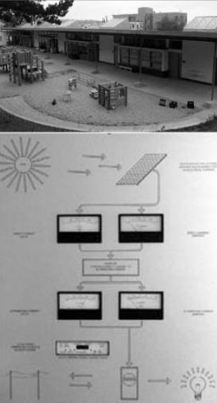
Climate is defined based on the motion behavior of the Sun relative to the Earth's location in the solar system. Systematic locations and movements are responsible for diversity in the Earth's climates, seasons, and weather conditions. Human beings on earth have always used strategies to enjoy more comfort. To do this, they considered the climate/microclimate condition while being careful not to

deplete their available sources. Nevertheless, the emergence of technologies minimized the popularity of Passive Building Design (PBD) strategies.

Passive building design strategies refer to those strategies that do not use energy to be responsive, like optimization of building orientation. On the other hand, active strategies are those techniques that modify the condition of spaces to a pleasurable condition while consuming energies, like electric coolers. The initial step to achieve the goal of energy-efficient buildings is to reduce energy consumption. The majority of energy used in buildings is by active systems to provide a comfortable interior space. PBD not only provides a natural comfort but also decreases energy consumption. These strategies are those for building skins, geometry optimization, and other combination of passive strategies, including heating, cooling solutions, thermal energy storage, and hybrid solutions (S. Wang et al., 2016). Heating solutions include solar direct gain, sunspace, double-skin glass facade, mass wall, water wall, Trombe wall, wind protection; Cooling solutions include solar shading, green roof, natural ventilation, night ventilation cooling, ventilated facade or roof, solar chimney, evaporative cooling, windcatcher, green roofs or walls; Thermal energy storage includes sensible thermal energy- storage thermal mass, latent thermal energy – Phase change material, underground spaces; and hybrid solutions includes active solar shading, Fan-forced ventilation cooling, heat recovery systems, Ground air heat exchange, Mechanical night ventilation, evaporative cooling, dehumidification systems, unglazed transpired solar facade, low-temperature radiant surfaces, sensible thermal energy storage, latent thermal energy storage unit, night sky radiator cooling (Pacheco et al., 2012; Rodriguez-Ubinas et al., 2014). Each climate needs specific passive strategies that are responsive to that climate (Brophy & Lewis, 2011).

2.2.3 Sustainable Building Design Practices

There have been efforts in recent decades to put Sustainable Building Design Practices (SBDP) into practice, using modern technologies and values in contemporary building projects (Sassi, 2006). In the following figures, the contemporary examples of SBD in practice are presented in Figure 4.

Site and land use				
Compact cities  The Point, Bristol, UK Client: Crosby Special Projects Architect: Feilden Clegg Bradley Consultation: BDOR Town planning: Chapman Warren Services engineers: BME Partnership Structural engineers: Clarke Bond Partnership Landscape architect: Cooper Partnership Quantity surveyor: Cyril Sweett Main contractor: Skanska Completed: 2002 High quality and density building sector with a minimum damage to the environment for competing with suburban low density buildings for those who are prejudiced to accept these kind of construction.	Reducing transportation impact  Petuelring Munich, Germany Client: City of Munich Completed: 2004 A transparent cover for roads to decrease the acoustic discomfort and pollution	In harmony with nature  Goethean Science Centre Craft Workshop Pishwanton, Scotland, UK Client: Life Science Trust Architect: Christopher Day Structural engineer: David Tasker Completed: 2002 A well constructed double curved green roof construction.	Local food production  Argonne Child Development Center Sixteenth Avenue, San Francisco, US Client: San Francisco School District Architect: 450 Architects Landscape architect: Cliff Lowe Associates Structural engineer: Acres Engineering A communal food garden	
Community				
Community participation  Fairfield Housing Co-operative Perth, Scotland, UK Client: Scottish Development Agency, Scottish Homes, Perth and Kinross Council and Fairfield Housing Co-operative Architect: Gaia Architects Landscape architects: Turnbull Jeffrey and Gaia Architects Structural engineer: Allen Gordon & Partners Mechanical engineer: Gaia Architects Contractor and developer for the masterplan: Hall and Tawse Completed: 2003 A successful rehabilitation through consultation from the community	Housing for all  Barling Court housing Stockwell, London, UK Client: Hyde Housing Architect: PCKO Main manufacturer: Buma Completed: 2004 Affordable housing	Training and employment  Buoys Wharf East London Client: Urban Space Management Completed: 2003 Affordable spaces for work	Enhancing the quality of life  Glashaus Herten, Germany Client: Herten city Architect: LOG ID Completed: 1994 Comfortable and healthy space which is appropriate for relaxing and reading. this space is environment friendly and is appropriate to share the cultures.	Promoting sustainability  Argonne Child Development Center Sixteenth Avenue, San Francisco, US In this building not only the sustainable building solutions are used but also it is designed in a way to educate the children and adults for more sustainable awareness.

Health and well-being			
Comfort	Insensible agents of disease	Identity and independence	Restorative environments
 Design Centre Linz, Austria Client: Design Centre Architect: Herzog & Partner Lighting specialist: Bartenbach Lichtlabor Interior design: Verena Herzog-Loibl Landscape architect: Annaliese Latz Project management: Heinz Stog-muller Structural engineer: Ingenierbüro Sailer & Stepan/Ingenierbüro Kirsch Muchitsch & Partner Completed: 1994 Indirect daylight for providing visual comfort	 Carlisle Lane housing Carlisle Lane, London, UK Client: Pringle + Richards Architects Architects: Pringle Richards Sharratt Structural engineer: Alan Baxter & Associates General contractor: DF Keane Specialist contractor: Eurban & Finnforest Merk Completed: 2004 Thermo wood is high quality material which is well sealed and tightens and considers thermal and acoustic comfort. The warm character of wood affects positively people. Its embodied carbon and energy is low. It also rarely deals with chemical pollutant.	 Akademie Mont-Cenis Herne, Germany Accessibility for all	 Loudoun EcoVillage Taylorstown, Virginia, US Client: EcoVillage Architect initial house design: Ensar group Completed: first houses completed in 2002, building ongoing Having the relation ship with nature, providing privacy and needs through design and technologies while not to damage the environment.

Materials					
Design for longevity	Waste as a resource	Avoiding resources depletion	Minimising manufacturing impacts	Materials and energy	Waste minimisation
 Environmental Discovery Center Spring Lake Regional Park, Santa Rosa, California, US Client: Sonoma County Water Agency Architect: Obie G. Bowman Main contractor: CWB Christensen-Williams-Bohn Completed: 1992 This building is design in a way which respond to the environment with out detrimental impact on it. The selection of materials are based on site and the form respects to earth harmony. They are durable and need very little maintenance. Let for a graceful aging and environmental growing.	 Research establishment Building 16 Located in London Architect: Feilden, Clegg, Bradley This building is constructed using demolished materials through reuse. It is designed based on energy efficient technique such as natural ventilation. Also, it has renewable	 Weald and Downland Grid-shell Chichester, UK Architect: Edward Cullinan Architects Structural & services engineer: Buro Happold Quantity surveyor: Boxall Sayer Carpenter: The Green Oak Company Contractor: EA Chiverton Completed: 2002 The utility of this building is museum. This building is renovated and save form demolition. A creative renovation include using local adjacent green materials and high technology of joints and for a double curved advanced innovative green construction.	 Eden Centre, bus shelter Cornwall, UK Client: Eden Centre Designers: Jackie Abey and Jill Smallcombe Main contractor: Back to Earth Completed: 2002 This building make use of material potential which are local, recyclable, and environmentally friendly. This building provides a natural heating and cooling based on season and need.	 PowerGen HQ Coventry, UK Client: PowerGen plc. Architect: Bennetts Associates Services engineers: Ernest Griffiths and Son Consulting engineers Structural engineers: Curtins Consulting Engineers Quantity surveyor: The material selection for this building is targeted to decrease the running costs	 Resourceful Building Emeryville, California, US Client: Emeryville Redevelopment Agency Architect: Siegel & Strain Architects Structural engineer: Komendant Engineering Services engineers: Davis Energy Group Environmental life cycle assessment: Boustead Consulting There was a thorough life cycle assessment for material selection in this building to minimise the environmental impact and decreasing the waste out of construction through the design.

Energy		
Minimising energy needs	Using energy efficiently	'Green' energy sources
 Chorton Park Manchester, UK Client: Irwell Valley Housing Association Architect: Stephenson Bell Structural engineer: Whitby Bird & Partners Services engineer: Steven A Hunt & Associates Quantity surveyor: Simon Fenton Partnership Main contractor: Queghans, McGoff & Byrne Completed: 2002 This house is designed and constructed in a way that enjoy the maximum natural light and minimum heat gain	 Schreiber house Aarau, Aargau, Switzerland Client: Familie Schreiber Architect: Theresia Schreiber Energy consultant: Energiesysteme Aschauer Completed: 1999 This building not only is designed for a high natural daylight but also a well insulating innovative material which let for both daylight and heat transfer management.	 Thurgoona Campus Charles Sturt University, Albury, New South Wales, Australia Client: Charles Sturt University Architect: Marci Webster-Mannison Engineers: Advanced Environmental Concepts, Branco Boilers and Engineering Completed: 1999 – 2007 The optimised renewable selection and facility design for this building according to the best available sources and climate condition lets for renewable hot water and space heating.
Water		
Minimising need and maximising efficiency	Alternative water sources	Reducing the use of mains drains
 Thurgoona Campus Charles Sturt University, Albury, New South Wales, Australia Client: Charles Sturt University Architect: Marci Webster-Mannison Engineers: Advanced Environmental Concepts, Branco Boilers and Engineering Completed: 1999 – 2007 An innovative composed water free toilet design in association with landscape design and watering let this building for water management as the most pressing issue of this site.	 Phillip Merrill Environmental Center Annapolis, Maryland, US Client: Chesapeake Bay Foundation Architect : SmithGroup Inc. Civil engineer: Greenman-Pedersen Structural engineer: Sermo Engineering Inc Services engineer: SmithGroup Inc Main contractor: Clark Construction Completed: 2000 This building is designed using a secondary roof considerations and connected tanks for rain water collection and using.	 Thurgoona Campus Charles Sturt University, Albury, New South Wales, Australia Client: Charles Sturt University Architect: Marci Webster-Mannison Engineers: Advanced Environmental Concepts, Branco Boilers and Engineering Completed: 1999 – 2007 Greywater treatment, collection of water from the ground and roofs for hot summers reservoirs.

Figure 4. A summary of examples for Sustainable Building Design Practices (Sassi, 2006)

2.3 Summary of Chapter 2

Due to human-based global warming, increase in carbon emission, decrease of resources and energy crisis led the governments take precautions and bring sanctions against high level of energy consumption. Beginning after WWII, organisations for protection of nature and earth also have begun to be emerged. Since then, these organisations have been regularly assisting with policy agendas regarding environment and nature. The term “Sustainable development” was introduced by Brundtland Commission Report (World Commission on Environment and Development) in 1987 consisting three dimensions as environmental, social and economics. In time, the term has shown its affect in every sector, discipline and has become a part of practices. As the building are known to be one of the important reasons of energy consumption, consequently the global warming, the professionals, academicians in the sector put forward the importance of Sustainable Building Design Principles (SBDP). SBDP include consideration of Site and Land Use, Community (human activities), Health and Well-being, Materials (use of non-toxic, local, less energy consuming), Energy (mitigation of energy use), Water (use of less water). In almost every region, traditional vernacular buildings which were built with the wisdom of the past exist. These buildings are known to use passive building design, also including SBDP. Today, with the intent to leave a liveable environment for the future generations, actors of the construction industry are getting more familiar with SBD.

CHAPTER 3

SUSTAINABLE BUILDING DESIGN MANAGEMENT

Both sustainability and sustainable development are described as societal and directing procedures that need management techniques (Olawumi & Chan, 2018). SBDP for achieving SBD should be managed through Sustainable Building Design Management (SBDM). For SBDM, first of all, Building Design Management (BDM) should be well understood and implemented (de Paula & Melhado, 2018). The BDM is the baseline to implement SBDM. To the best of the author, SBDM nature substantially is rooted in BDM and has a major context in parallel or overlapped with one another. In this regard, Rekola, Mäkeläinen, & Häkkinen (2012) asserted that SBD does not need new tasks more than building design. However, it needs existing tasks to be considered by new substances during design. The importance of BDM is embedded in the fact that it substantially affects productivity and quality. However, according to Knotten, Lædre, & Hansen (2017), compared to the common project management, there is insufficiency regarding BDM research in literature.

3.1 Building Design Management

The BDM definition was first considered in 1964 to improve the business perspective of architecture. It is the result of an attempt to integrate thinking, management, and organization into building design. The majority of attempts to define the BDM concept were made by Estephen Emmitt in 1999. To this end, he considered the roles subject to change in the new technologies and kept the meaning open to interpretation (Emmitt et al., 2009).

Definitions aim to improve the language and prevent ambiguity. Alharbi, Emmitt, & Demian (2015) aimed to remove the vagueness among the existing attempts for BDM definitions and to articulate description for it. First, they reviewed all the attempts toward the definition of BDM using a qualitative meta-analysis with a thematic categorization. After that, they started the process of redefining and improving the meaning of BDM in an international approach. They asked the meaning

from credible architects and researchers to come up with the contemporary trends and concentrations. Finally, they synthesized the first and second stages of their study through a qualitative data synthesis. The results then tested via professional building designers and researchers for the best possible definition. The consequent definition by their attempt is;

" The strategic management of the architectural firm that assures the effective integration between managing the business aspects of the office with its individual projects in order to design and deliver the best value to all stakeholders."

This definition is to date, the most comprehensive one, however still is open to criticism. Notably, BDM is also known as architectural management; however, in the scope of this thesis, BDM is chosen as a terminology.

The importance of BDM is embedded in the fact that it substantially affects productivity and quality in Design, engineering, and construction. However, compared to the common project management, there is insufficiency regarding BDM research in literature and its implementation (Knotten et al., 2017).

3.1.1. Implementing Building Design Management in Practice

Even though there have been many attempts from the perspective of knowledge creation in the investigation on the BDM, still there is not enough bridging the gap for how to implement BDM in practice. Hence, the emergence of a set of guidelines and frameworks for designers in this regard is of importance.

A practical guideline for transferring BDM from theory into practice was introduced by Stephen Emmitt (1999 and 2007). In his attempts, he highlighted the central role of BDM in the combination of design management, construction management, facility management, and recycling management while communicating with people in a project lifetime. A BDM framework helps the designer to have a deeper understanding and management of the business part. To achieve this objective, Alharbi, Emmitt, & Demian, (2015a) adopted the definition of BDM to help the designers to apply BDM in their specific practices productively through a generic framework. In their framework, BDM is defined as a central key role that has four equally important components including management process for projects; Stakeholders, Business, and Learning (Education). See Figure 5.

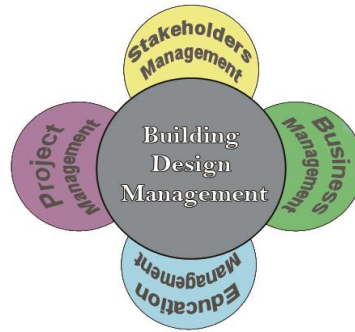


Figure 5. Building design management central role and its equally valued components (Alharbi, Emmitt, & Demian, 2015a)

The BDM is not a linear process for filling and permitting the next level but an iterative and compliance of the design to the building codes, etc. It needs to be managed from the redesign till construction and after that to be controlled to check whether the criteria are fulfilled or not and how to get the feedback. Also, the activities and tasks are not filing and passing in nature. Most of the duties last in the duration of BDM (Rekola et al., 2012). Each managerial components of BDM have several activities. The activities corresponding to each component are presented in Figure 6.

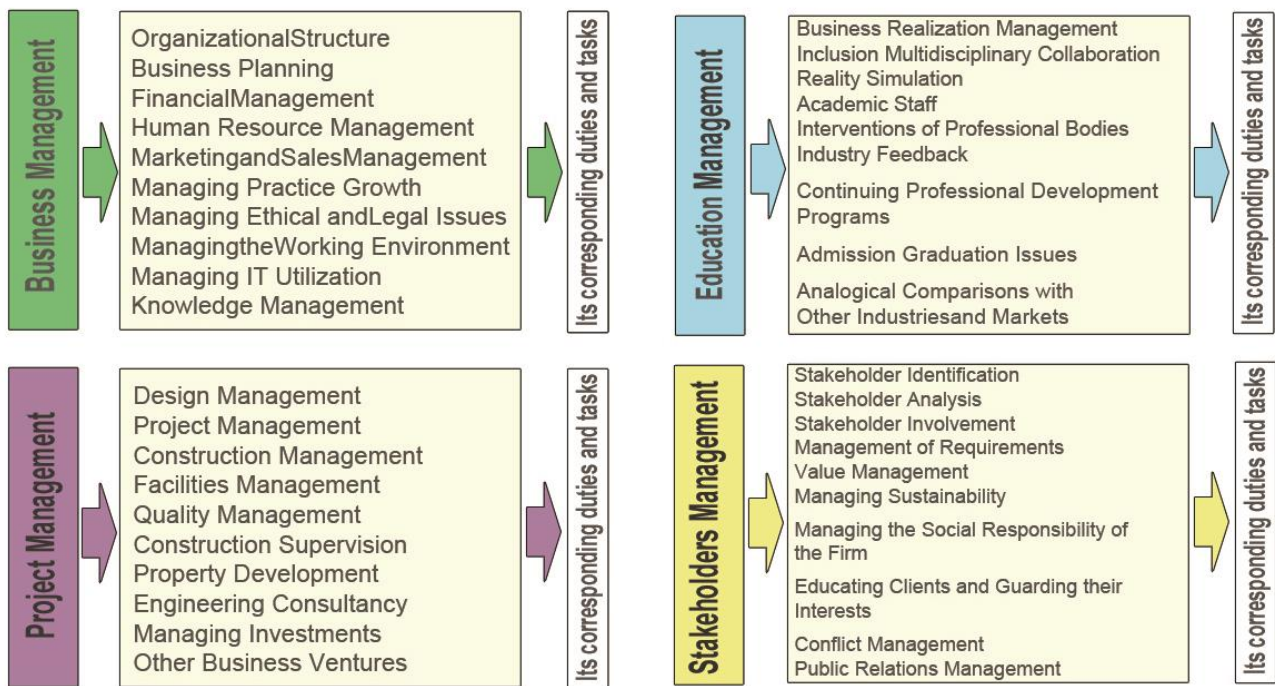


Figure 6. Activities of each component of building design management (Alharbi et al., 2015b)

There are two important points regarding BDM/SBDM. First of all, tasks and duties in BDM/SBDM are not linear. In other words, there is no "filling and passing through the next step" situation and one-time completion. Instead, most of the BDM responsibility and actions are processes and, for most last

till the end of BDM. However, it is not in contrast to the fact that the building design should follow the building codes. Second, the compliance of building design should comply with its objectives and its associated predefined codes and regulation. It means that building design and its objectives need to be managed from the start of design till the construction (controlling/monitoring) and operation (choosing the technology to complete the design objectives, teaching the occupants how to use the buildings and technologies, getting feedback from the users or post-occupancy valuation). (Rekola et al., 2012).

3.1.1.1 Project Management

Project management is defined as time-based initiating, planning, executing, controlling and finishing work in the context of teamwork to accomplish specific goals and success following special criteria and constraints which are determined at the beginning of the procedure documents, including time, scope and budget, and quality using an optimized allocation of inputs to meet clients' objectives. Project profiles are essential in the initial shape of the project management process. It helps address the needs and objectives of clients in all decision-making processes (Phillips, 2004). Also, Maltzman & Shirley (2011) defined project management as the tips, skills, and knowledge for a project to provide stockholders a situation to meet their needs. They included that adding up the necessity of environmentally friendly decision making to the definition of project management completes it to the definition of green project management. In this regard, Silvius (2017) stated sustainability as a new school of thought in project management. Also, Chofreh, Goni, Malik, Khan, & Klemeš (2019) practically, attempts to assist the practitioner in grasping a deeper understanding of sustainability pillars embedded in the context of project management.

Martens & Carvalho (2016) informed that the sustainability issue is not properly included in project management. To address this, they investigated how companies introduce sustainability to the process of project management and how sustainability can affect project management success in Brazil and the United States of America. To do so, they used an online semi-structured questionnaire and interviewed the project managers. Their results showed a gap between the perception of sustainability and real use in practice and a more concentration on social aspects of sustainability by the public companies compared to the others.

Finally, many factors influence the success and failures of project management. Kiani Mayi & Standing (2018) identified and ranked/weighted the interdependence of these factors using the data from several Australian project managers. The highest weight point to the management and sponsor

support, stockholder separations, and end-users restrictions. They concluded that paying weighted attention to the success/failure factors of project management could better end up with a high improvement.

3.1.1.2 Stakeholders Management

The principled identification, analysis, ordering, and fulfillment of actions prepared to participate in the stakeholders is called stakeholder management. In the context of SBDM, it includes any actions to deliver quality in the design process to stakeholders (Alharbi et al., 2015b). It plays an important role in successful project addressing. It is composed of two different parts: Organizations and people. These should be in contact with each other while managing the stakeholder. A given corporation might have various stakeholders comprising of employees, suppliers, clients, and so on. For managing the stakeholders efficiently, four different instructions should be considered including:

i) identification, recognition, and acknowledgment of stakeholder, ii) Determination of their effect and favors; iii) Employment of communication management plan, and iv) Influencing and employing stakeholders (Clancy & Krieg, 2000; Porter, 1998). Srinivasan & Dhivya, (2019) concentrated on an empirical study on stakeholder management in building projects to find out the influencing factor in this process. They pointed out the support that firms get from the stakeholders as well as those given to them in the process of stakeholder management in building projects. Among the important factors, they found in their research are powers of decision making, stakeholder participation, customer factors, organization structure, and quality.

3.1.2.3. Business Management

This part includes agreements that facilitate business and marketing. It, also includes marketing tools and applications (Alharbi et al., 2015b). In this relation, Chan, Qian, & Lam, (2009) indicated that, however, the environmental aspect of SBD is well addressed in the literature the social and economic parts are not. The business operations could be handled and foreseen by business management. Business managers should conduct business analysis, which includes a set of jobs, knowledge, and approaches needed to identify business requirements and obtain the solutions to business problems. Also, planning is another responsibility of the business managers. Planning is the organizational process of creating a plan and the psychological process of thinking about the activities. Usually,

managers encounter various problems, which could be solved by different methods. Developing the systems, improvement of the processes, and even organizational alteration are some of these solutions. Planning, organizing, directing, and controlling a company for accomplishing the purpose of the organization are the main components of business management (Drucker, 2015). Also, business management includes all the managerial attempts to make it possible to compete with other peer offices (Alharbi et al., 2015b). This component has also been addressed in section 3.2.5 titled "Business Management and Marketing" as one of the components of SBDM (de Paula & Melhado, 2018).

3.1.1.4. Education Management

The administration of education upon the process of people and resources management constitutes the concept of education management (Connolly et al., 2019). In the context of building design, education management deals with teaching and learning the BDM (Alharbi et al., 2015b). Figueiró & Raufflet, (2015) focused on sustainability in management education. They showed that this newborn field is in the stage of initial progress and still has distance from a mature status of well-defined epistemological ground. For this new field of science, there is no mapped framework for teaching the strategies.

For using the BDM framework as a generic one in any building design project, there are six bottom-up levels. Level six considers is kept flexible and open to include specific tasks and context like regulations, different clients, projects, tasks, and duties. In level five, the clustering of the tasks to be included in an activity group happens. Level six and five are specific procedures in this taxonomy framework. In level four, each activity clusters under one of the components of BDM. Level three takes into accounts the enhancing patterns and tools that can be used in two or more components of architectural management. The four components of BDM form level two and the first level holds the central role of BDM (Alharbi et al., 2015b) (Figure 7).

The BDM framework was tested to prove its effectiveness and suitability in the real industry by Alharbi et al., (2015b). The survey among the building designers showed that this framework could increase the productivity and competitiveness of the practitioners in offices regardless of size. The results stated that almost the four components of BDM are equally important (Alharbi et al., 2015b).

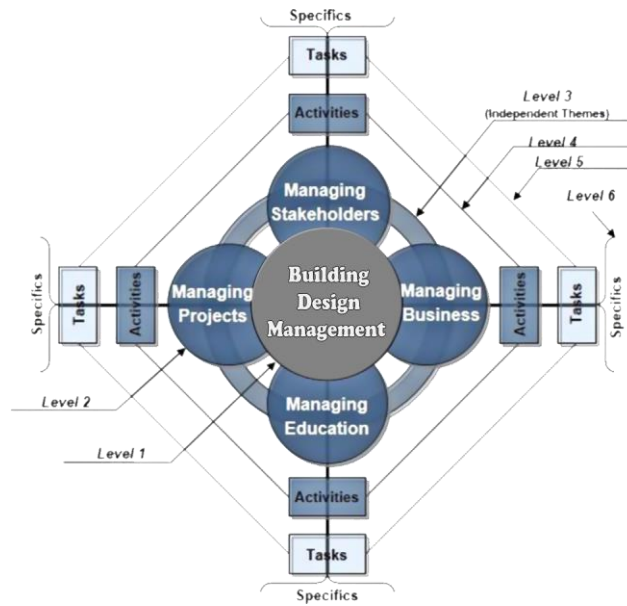


Figure 7. Building design management framework (Alharbi et al., 2015b)

3.1.2 Influencing Factor on the Success of Building Design Management

Whether being a person or an organization or any other representative, clients are among the success factors of BDM. The reason is rooted in the fact that the one who determines the budget, time, and scope of building design (Knotten et al., 2017). User involvement is a concept that could positively affect the process of BDM. It concerns all the clients' needs, both mentally and physically. User involvement is one of the most important factors in the building design briefing process. The briefing process in BDM deals with a thorough understanding of occupants that needs to be logically addressed in the final building project (Emmitt et al., 2009). It also considers the evaluation of design proposals and how the needs are addressed, starting from the predesign stage to the final building product interactively. The advantages of comprehensive briefing in BDM includes making sure about understanding the needs and their associated facilities, earning experience, and learning from the acceptance and ignorance (P. A. Jensen, 2011). Kim, Cha, & Kim (2016) reviewed the existing methods for the implementation of the user involvement process in building projects and their challenges and potentials. These methods include; 1.architectural programming, 2.quality function deployment, 3.post-occupancy evaluation, 4.ergonomic design, 5.evidence-based design, 6.workplace planning, and 7.user simulation. As a result, they proposed a new framework for user involvement in BDM while still reporting a gap of 1.inefficiency of direct user involvement in some methods, 2.lack of user involvement in renovation. Their proposed solution for these two existing gap is also a virtual

design and construction theme. Communication in BDM as a success factor could be interpersonal or network interaction while concerning the structure of meetings coordination and integration (Sinclair, 2011). It also could happen in different distances and content, such as face to face and/or telephone communication to drawings and models. Communication management also is dependent on information management in information systems, which could substantially help collaboration in design for value creation (Emmitt et al., 2009).

On the other hand, decision making is one of the most challenging parts of BDM (Knotten et al., 2017). Decisions in building design stage substantially influence all the other stages of building project, including construction and exposure and demolition. Special attention and awareness is needed during the building design decision making (de Paula & Melhado, 2018). Moreover, buildings are the outcomes of the decisions in different stages of a building project. Logical and productive building designs are dependent on on-time decisions for creating a flow of the work; otherwise, they may fall in trouble of wasting time and quality (Emmitt & Ruikar, 2013). The more technology and human knowledge increase, the more decision making becomes complex and deterministic and needs advanced tools (Kostas Terzidis, 2006). In section 4, tools for building design decision making are explained.

Another critical success factor of BDM is the significance of the design process in the pursuit of health, safety, and environmental consideration for sustainable building (Knotten et al., 2017).

As another factor influencing the success of BDM, Interface management deals with the efficient and productive/responsive connection with a different specialist in the BDM in various steps of building design. It involves the management of the interdisciplinary nature of BDM (Knotten et al., 2017).

The knowledge of building a designer is the important power of that designer. Feedback and lessons from the previous work and users enrich the designers in the briefing process (Knotten et al., 2017). Knowledge sharing and cooperation, and competitions in BDM are important pillars which could be implemented through productive communication and relationships among the membership to shape the knowledge management in the process of BDM (Ghobadi & D'Ambra, 2012). Regarding the knowledge management in the context of sustainability, Martins, Rampasso, Anholon, Quelhas, & Leal Filho, (2019) conducted a review article to detect the current gaps and future research opportunity. Based on their study, the majority of knowledge management basics in sustainability should be formed at the university level to prepare future experts for successful sustainable knowledge management. They indicated that current gaps in knowledge management for

sustainability are related to themes, strategies, and objectives. They added that action research and quantitative researches are missing in this area.

There is a necessity for control in any design process, like building design, to ensure the quality and logic of the consequent product. This is achievable in a performance evaluation process that could be implemented via ensuring the achievement of design objectives (Knotten et al., 2017). Building design could be evaluated in the process of design and after that from the perspective of various intellectuals, users, disciplines, to name just a few. In the context of SBD, building design would be evaluated according to SBDP (Brophy & Lewis, 2011).

The responsibility of risk management in the context of BDM is to decrease the portability and impacts of negative occurrence and vice versa. BDM can implement risk management in two ways. The first way is to address uncertainties in the design procedure as the second way is ensuring that the negative and positive risks are acknowledged risks by the design team. All the successes factor are for reducing the harmful risks of BDM (Knotten et al., 2017).

Finally, as the last critical success factor of BDM, “Team Management” is defined as transforming a group of people proper for organizing BDM to a team in which all the related disciplines could work together to thrive a necessary part of success in building projects (Knotten et al., 2017). In this regard, Mohammed, Hamilton, Tesler, Mancuso, & McNeese(2015) investigated the team's mental mode to improve BDM. It is an agreement that concentrates on time, speed, a sequence of tasks. Figure 8 shows these Influencing success factors of BDM in summary. However, these ten success factors may not necessarily be relevant to BDM, yet implementing them in BDM could substantially improve the building design process (Knotten et al., 2017).

Key Success Factors of BDM									
Client	Communication	Decision Making	HSE Focus	Interface Management	Knowledge Management	Performance Evaluation	Planning	Risk Management	Team Management

Figure 8. Key success factors of building design management
Adapted from (Knotten et al., 2017)

3.2. Sustainable Building Design Management

Attentions to sustainability increase sensitivity to the procedure in which projects are planned, implemented, and managed (Ali et al., 2016). The decisions during building design influence the overall building performance. That is why the design stage is worth focusing on. This stage determines whether the building incorporates sustainable development or not. A managing group and factors for SBD reduce the deficiencies associated with the implementation of sustainability in building processes since many of the barriers for SBD impeded in managerial factors. According to this, management in building design firms is a supporting element of the sustainable building (de Paula & Melhado, 2018).

In a review of design and sustainable project management, Ali, Boks, & Bey (2016) showed that although the project management literature and technique could potentially improve sustainable design, there was a big gap between these two concepts (project management and sustainable design). Several significant attempts that are conducted to investigate the Sustainable Building Design Management (SBDM) are reviewed in the article by de Paula & Melhado (2018). The managerial processes to be related to sustainability in building design firms represented in

Figure 9 (de Paula & Melhado, 2018). It covers strategic planning, performance evaluation, planning and controlling the design process, information system, business management and marketing, people management, financial management, and organizational management.

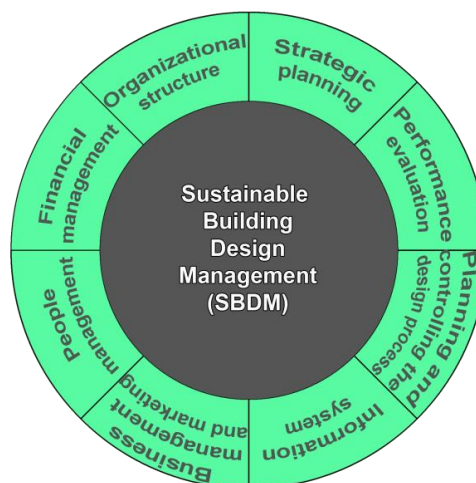


**Figure 9. Sustainable Building Design Management Components
(de Paula & Melhado, 2018)**

3.2.1 Strategic Planning

This section includes project schedules and planning to achieve the firm's objectives while taking into account the firm's position in the market. Also, it addresses strengths, weaknesses, threats, and opportunities in sustainability-related projects. (de Paula & Melhado, 2018).

Strategic planning is an organization's procedure to define the strategy and deciding the allocation of the resources to follow this defined direction. It also could include the control of the implementation of this directed strategy. Strategic planning indicates how the aims will be achieved through the managing of the resources. It is an analytical process and needs synthesis procedures. It could be formal or informal and is iterative. The results of strategic planning are 1) the answer to the question of "how to document and communicate?", 2) finding out the strategies to success following the policies, and 3) answer to the question of "how to implement them?". Strategic planning could be updated regularly. There are several tools and approaches to strategic planning. As such are; PEST analysis (which stands for Political, Economic, Social and Technological and take into account a bigger boundary around the projects including politics, economic, technologies and so forth) and SWOT analysis (which deals with Strengths and Weaknesses, Opportunities and Threats) (Mintzberg & Quinn, 1996; Rumelt, 2011).

3.2.2 Organizational Structure

In general, the organizational structure is about how the activities and their associated task will be allocated. It then takes into account coordination and supervision. The final objective of organizational structure is to meet the organization's aim. It determines to whom the responsibility and decision making will be allocated and how much their activities and tasks form the environment of the organization. It could be a visual perspective for the individuals to imagine their or others' position in the overall organization structure (Weber, 1948). In the context of SBDM, organizational structure deals with the relationship between the structure of the firm and the implementation of sustainable building design strategies (de Paula & Melhado, 2018).

3.2.3 Financial Management

Financial management is a managerial ability that lets the practitioner control profits and risk as well as planned investment (de Paula & Melhado, 2018). Loans, exchange equities, and ratios are three main components in which financial management should deal with them. Distribution of the profits,

hedge and mutual funding, production circulation, and handling the foreign exchange sharp fluctuations are all conducted by this type of management. The people who are responsible for financing should be aware of the kind of capital required to be able to pump the money through the asset. Furthermore, increasing the value of the firm stock is another responsibility of financial management.

The purposes of the company or organization could be achieved while applying efficient money management. It should note that budgeting the capital budget and assets could be for the long term while allocating the short term resources is managed (“Business Finance and Financial Management,” n.d.).

3.2.4 People Management

As de Paula & Melhado (2018) indicated, people management concerns the development of employment policies and planning for education and training and the spread of information in building design firms. It considers the people's information about the issue under consideration and the management regarding the increase in the awareness of it. People management also considers the roles and their associated responsibility as well as the people profiles.

3.2.5 Business Management and Marketing

Business management is one of the BDM components. In SBDM, business management and marketing refer to the activities that concentrate on the preparation of technical agreements and the development of implementable marketing strategies and their associated tools (de Paula & Melhado, 2018).

The empirical applications of the marketing orientation, methodologies, and approaches of organizations, as well as the handling of a corporation's resources and instructions, are all considered in marketing management. Also, the economic criteria are utilized for the analysis of the industry in which the corporation operates. Market competitors are analyzed comprehensively while obtaining their past performance to gather their strengths and defects. These include costs, profits, professions, etc. It is worth mentioning that market research should be done regularly to update the new position of competitors and demands. Various methods, for example, qualitative, quantitative, experimental, and observational, are applied by the marketers to perform market research:

Qualitative marketing research, such as focus groups and various types of interviews; Quantitative marketing research, such as statistical surveys; Experimental techniques such as test markets; Observational techniques such as ethnographic (on-site) observation (Kotler & Keller, 2006; Porter, 1998).

3.2.6 Information System

In the context of BDM, information system concerns receiving and storing the information. Besides, it manages internal/external communication and coordination, information flow, file management, and any information, consulting, and tools related to sustainability (de Paula & Melhado, 2018).

3.2.7 Planning and Controlling the Overall Design and Service Process

An aggregation of services as well as planning, controlling, and monitoring of the design is managed in this part. This SBD managerial component provides procedures and tools to support the design process and mapping it. It manages the entrances of new/change activities, studies, research, solutions, consultant, objectives, agents, and tools in the design process. All in all, It deals with the ways, tools, and solutions for controlling the design steps (de Paula & Melhado, 2018). Moschetti, Brattebø, Skeie, & Lien (2018) indicated that building projects not only affects the environment but also influences the economy and society as well. Considering sustainable measures in building design could improve the environmental impacts; however, these measures need to be addressed in the business side through business models. One the results among their findings that quantitative analysis can strongly improve business models in building projects. This way SBD could provide cost effective environmental and social benefits.

3.2.8 Performance Evaluation

This component of SBDM issues the performance assessment. It is responsible for comparing the design with the sustainability goals in building design firm. Performance evaluation in SBD accounts for evaluating sustainable designs and clients' needs, environmental objectives (de Paula & Melhado, 2018).

3.3. The role of Designers in Sustainable Building Design Management

SBDM is one of the most complex and challenging types of management because designers need to manage the creativity and logic behind it as well as doing the ordinary management job (Knotten,

Svalestuen, Hansen, & Lædre, 2015). In this regard, the role of the designer in the process of SBDM is prominent and crucial influencing.

The BDM is not a linear process which filling and permitting the next level but an iterative and compliance of the design to the building codes, etc. which needs management from the redesign till construction and after that to be controlled to check whether the criteria are fulfilled or not and how to get the feedback. Also, the activities and tasks are not filing and passing in nature. Most of the duties last in the duration of BDM (Rekola et al., 2012). The role of a sustainable building designer follows the procedure above.

Rekola, Mäkeläinen, & Häkkinen (2012) studied the crucial role of the designer in the process of SBDM. They analyzed the existing finished building project and interviewed their chief designer. They informed about the challenges of SBD for designers and how the designers dealt with them. The results showed that there is not any sufficient definition for this critical role and its associated tasks and duties. However, in practice, they found out the role of being more of a technical supervisor. Moreover, the authors stated that experience, charisma, and power are the ingredients of an excellent chief designer that let her/him bring up SBD alternatives in different situations (Rekola et al., 2012).

The perspective of the designer is a pivotal key role that is used to extract the hidden side of BDM/SBDM. According to this, Chan, Qian, & Lam(2009) relied on survey methodology to find out the marketing and business aspect of SBDM from the perspective of the building designer. They used the finding as to the initial step towards developing marketable SBD. Also, Shi, Tian, Chen, Si, & Jin (2016), reviewed SBD optimization. The information objectives, procedures, variables, simulation tools, etc. were collected from the perspective of designers.

The power of a building designer is her/his knowledge and ability (Rekola et al., 2012). In the context of SBDM, the building designer needs to be well equipped to the relevant knowledge and tools as well as the logic and theory behind them (Loonen et al., 2017).

Finding out about the sustainable solutions out of SBD information and experiences and how to create them are among the challenges and tasks of sustainable building designers. The integration of sustainability specialists and guidelines as a reference to the design team to followed is the responsibility of the chief designer in the process of SBDM. The key influencing factors that determine a competence chief designer is having creativity while conducting her/his responsibilities and leadership. Also, one of the other essential duties of designers is to provide users with sufficient

information to use the products and the logic behind choosing them. It could affect the occupant's attitude and habits towards the buildings (Rekola et al., 2012).

To empower the decision making and knowledge of building designer, consideration of a time-effective manner which fits the scope of the designer capability to grab them is essential. In this regard, Loonen, Favoino, Hensen, & Overend (2017) asserted the necessity of user-friendly and less conflicting models in favor of designers. Alana et al., (2019) and Ariosto et al., (2019) concentrated on the role of building designers in sustainable heritage building protection. They explained that the differences between modern occupants and the old physical properties of heritage buildings are the major problem in protecting these spaces for sustainable development. In this regard, they provided the designer with a framework and the aspects of designer interference in physical, social, and economic community development and revitalization. It finally helps the building owners to make optimal choices in terms of financial issues and energy efficiency through viable retrofit alternatives with the help of sustainable building designer.

In order to improve the process of SBD, Kanters, Horvat, & Dubois (2014) indicated that besides user-friendly and advanced tools for SBD, the designer should also be well educated to be able to accelerate the process of SBD successfully and productively.

On the other hand, an SBD/SBDM is an outcome of an interdisciplinary/collaborative process between intellectuals, which means a good designer needs to know how to do the teamwork and collaborate with others. As such Xu, Li, Wang, & Huang (2019) showed that there is a concentration on collaboration between designers and stakeholders (contractors). An evolutionary game model is proposed to underlying the logic behind the collaboration of designers and contractors. Primarily, the potential barriers and drivers of this communication and collaboration are detected out of the literature. After that, a model was used to analyses what designers and contractors decide on different occasions. The results indicated that the condition in which there is a decrease in collaboration cost and increasing the collaboration benefit is the optimal one. In addition to being collaborative, a sustainable building designer should be creative. Knotten, Svalestuen, Hansen, & Lædre (2015) pointed out to the importance of creative minds in the process of SBDM. They stated that this is what makes differences between SBDM and other kinds of management.

3.4. Summary of Chapter 3

Any decision in building design processes affects the overall life cycle of the building project, including design, construction disposal, and demolition. According to this, it is vitally important to pay attention to this process as a determining stage in the sustainability of building projects. Sustainable building design management helps to manage the process of sustainable building design. Any success factor in building design management would affect sustainable building design management as well. Building design management, project management, stakeholder management, business management, and education management are essential components of implementation.

The components of sustainable building design management are strategic planning, organizational structure, financial management, business management and marketing, information systems, planning and control design processes and aggregative services, and performance evaluation. The building designers have an influencing role in the success of sustainable building design management processes.

CHAPTER 4

TOOLS FOR SUSTAINABLE BUILDING DESIGN MANAGEMENT

In addition to heterogeneous logic and branches of sustainability, decision-making processes are critical. Decision-making in sustainable projects is complex. This complexity is embedded in the fact that there is a need to involve different associations, including politicians, designers, experts, stockholders, clients, etc. in the building planning process. Implementing dialog and improving project procedures between actors, each with different backgrounds and understanding of sustainability, are challenges. Here, sustainable management tools are solutions to facilitate the process. They help create a common framework to come up with a language to create a shared sustainable mindset for sustainable practices (Emmitt et al., 2009).

Even though SBD and SBDM are vital for achieving sustainable buildings, there are no identified exclusive superior approaches, techniques or tools in SBDM as a baseline for SBD firms (Ahmad et al., 2016). However, this could be in part because BDM is a creative process (Knotten et al., 2015), and each building project is unique (Emmitt et al., 2009). For SBDM, a combination of system and techniques are needed. These combinations could be logically achievable by optimization (Ahmad et al., 2016).

One of the international attempts to promote SBD among designers and engineers from all over the world is the United States of America Solar Decathlon Competition. The management and tools parts are the determining factors of competing in this competition; there is no specified rule, technique, approach, or system to follow in the guideline. The guideline just tells the general points and requirements. It keeps the responsibility of SBDM flexible and open to redefine by the designer teams while welcoming any kind of innovation, each, to the best of its ability and to increase the efficiency of SBDM with green targets. (US Department of Energy, 2020).

There is no exact determined/specified approach for design and control of the sustainable buildings. However, despite the existence of all the limitations and barriers in applications, optimization processes are significant in seeking efficient SBD/SBDM (Lu et al., 2015). On the other extreme, the optimization process faces complexity in SBD while encounters the variety of design criteria, variables, constraints, and objective functions. This shows the necessity of a programmatic approach to make this decision making easier for designers daily in a more holistic approach rather than the detailed one to take advantage of the benefits out of SBD (Ahmad, Thaheem, & Anwar, 2016).

Aiming to facilitate the optimization for the allocation of systems and techniques to initiate the process of SBD for designers and actors of the SBD process, Ahmad et al. (2016) ranked available systems and techniques based on their priorities in semi-arid climate conditions. The authors validated the workability of their proposed framework in an SBD case study. They also proposed workflow for the SBD (Figure 10).

The flowchart begins with project requirement collection and continues with climate consideration and its associated assessment of available systems and techniques. Passive design is the third step of this flowchart. If sustainability targets are not met, this step will be refined using the reselection of sustainable building systems and techniques. The success of this step is the active design. Finally, renewable energy consideration for SBD continue until the possible sustainability is achieved; otherwise, a return to a revision regarding the selection of sustainable building systems and techniques is proposed. As is evident, the sustainable building systems and techniques are the critical roles of refinement towards achieving the most out of SBD targets. An integrated approach in SBDM could substantially minimize the confusion and effort in vain and increase efficiency (Ahmad et al., 2016).

There are plenty of techniques, approaches, and systems besides technologies, which in combination could help to make the building design more sustainable. Some of them are unique in terms of functionality and mutually exclusive. An optimal selection between these systems and techniques in SBDM is of high significance (Ahmad et al., 2016).

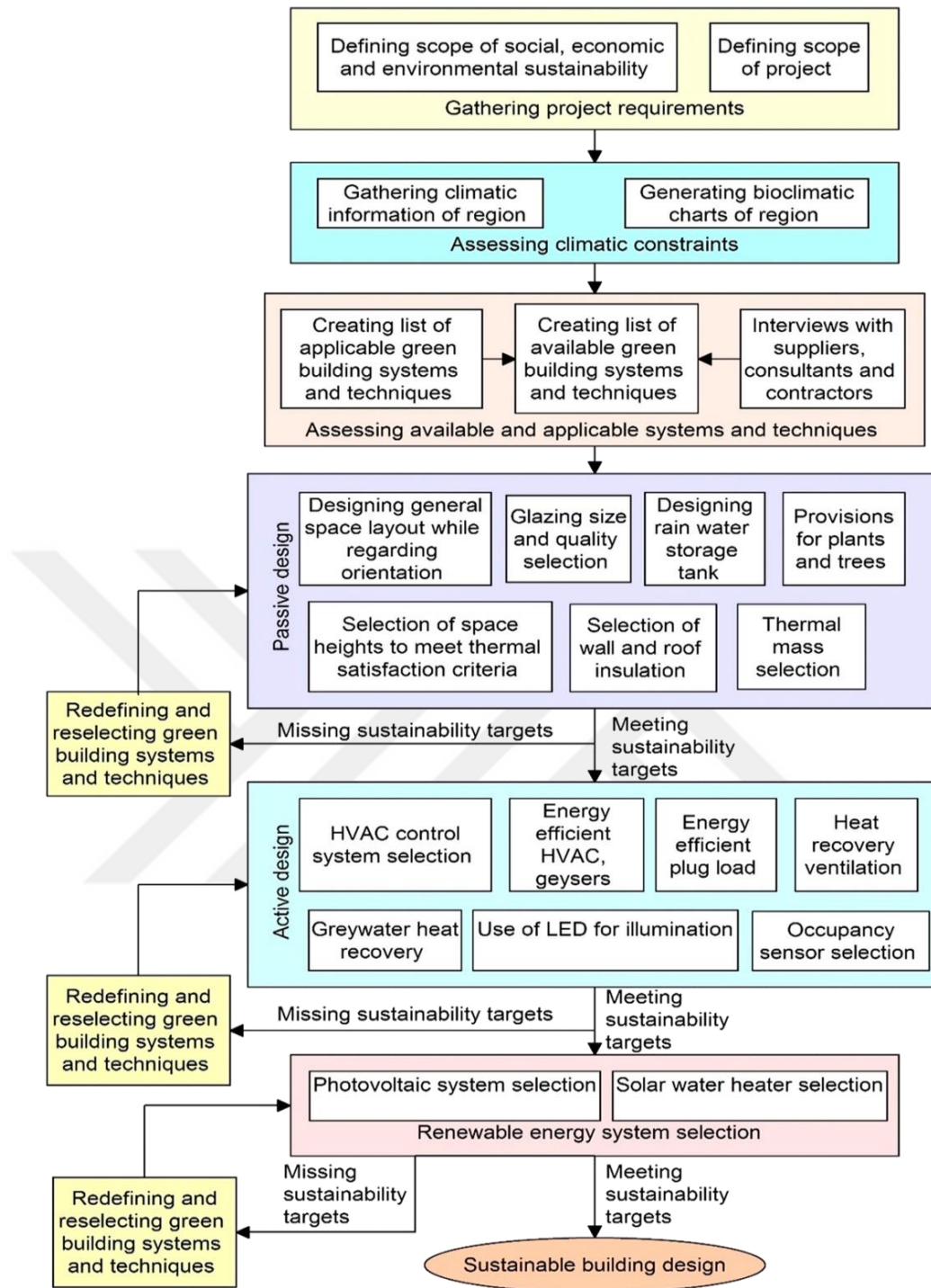


Figure 10. A workflow for sustainable building design (Ahmad et al., 2016)

Ahmad et al. (2016) found out that the SBDM participant priority between the three pillars of sustainable development is the economic and social ones. They also found that among the green building system and techniques, more weights are for heat recovery ventilation and indoor luminance quality finishing materials (Figure 11)

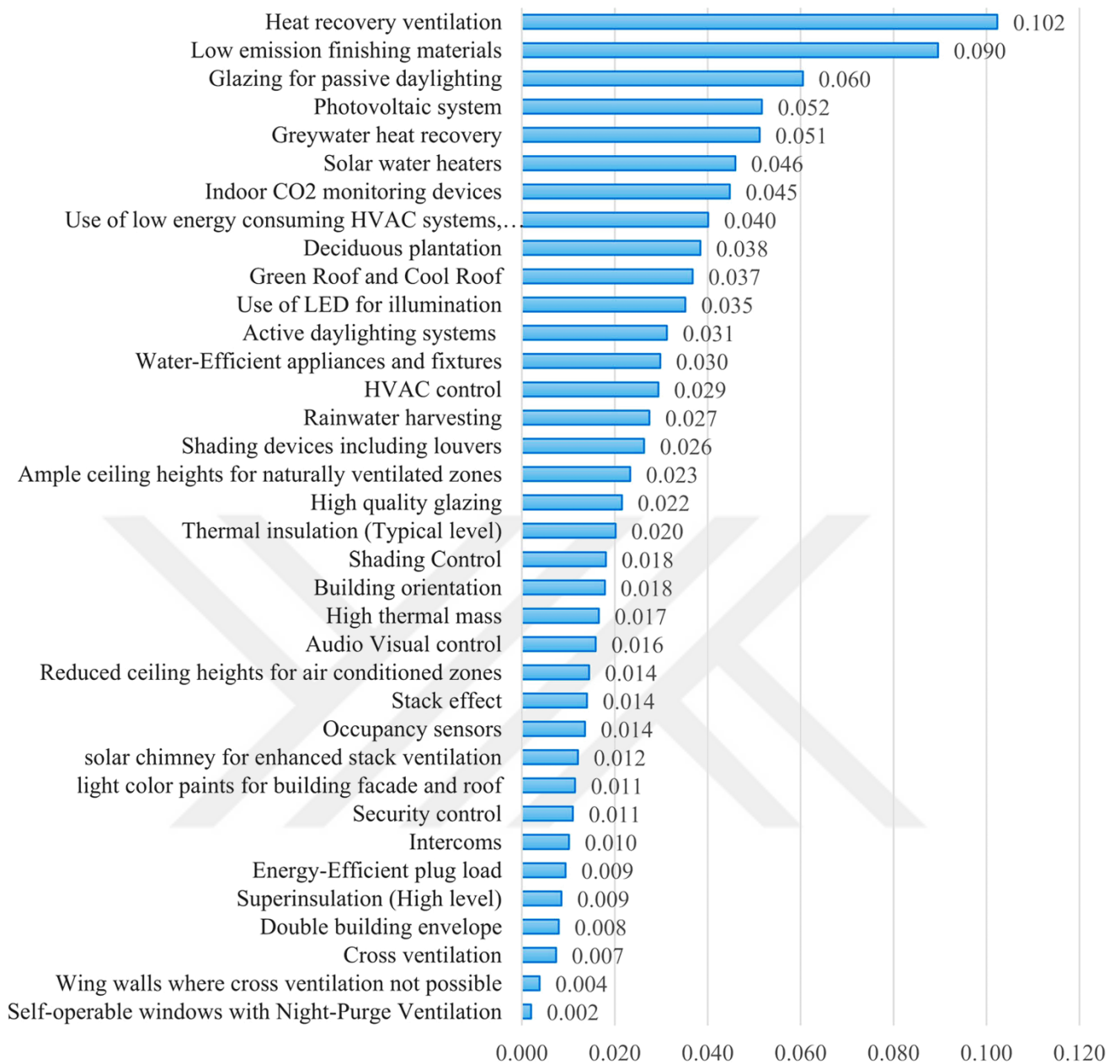


Figure 11. Comparison of different green-building systems and techniques
(Ahmad et al., 2016).

Optimization processes are determined to be the best approach for SBDM. Wang, W., Rivard, H., & Zmeureanu, R. (2005) found alternative solutions for satisfying conflicting criteria and design objectives; they introduced the multi-objective optimization model as a solution. The best economic and environmental performance alternatives were their final goals in the process of SBDM. To implement their method, they used a genetic algorithm (W. Wang, Zmeureanu, et al., 2005). Wang, et.al. (2005) introduced a simulation-based optimization process a responsive opportunity to find the best available SBD alternative solutions. They introduced the simulation-based optimization as a way to overcome trial and errors drawback. They indicated that reusing any defined particular

optimization code for any other SBDM processes is one of the essential advantages of this approach. They tested their framework to come up with an optimal trade-off between life cycle cost assessment and life cycle environmental assessment in an SBDM process (W. Wang, Rivard, et al., 2005).

Process tools are the umbrella of tools and techniques (J. O. Jensen & Elle, 2007) and are the introduction of allocating Sustainable Building Design Management Tools (SBDMT).

Process, calculating (design evaluation (Brophy & Lewis, 2011)), assessment, and monitoring are the four categories of SBDMT (Emmitt et al., 2009; J. O. Jensen & Elle, 2007).

SBDM tools and techniques are ever developing and have many overlaps; face challenges and complexity. These systems are either additive or substitutive.

In their book "Green Project Management" Maltzman & Shirley (2011) represented techniques and tools for managerial fields along with the building design. Beyond that it was considered to follow the market potentials and opportunities. They pointed to the easily achievable moods and behaviors like traveling, group, personal and office behaviors. The followings are essential techniques and tools in summary: Green traveling; for work through public transportation or online group meeting via computer or mobile-based applications like Skype, providing bicycles in the surroundings for the employer to use. Green data transferring and storage; using hardware and internet applications for storing the information, having a virtual library. Green educations; study online, study with a laptop rather than paper-based books and desktops. Green personal behaviors teach the children to save money through green behaviors, used washable staff green talking and greeting, propose your ideas to others.

4.1 Process Tools

Process tools help answer, 'How to manage a building process and sustainability policies'? They also clarify phases such as stakeholder involvement considerations, different types of other tools to be used, and the way to analyze situations. Frameworks, checklists, environmental rating, and assessment, policies, standards, and strategies are among these tools (Emmitt et al., 2009; J. O. Jensen & Elle, 2007).

Building codes are a set of building rules. They specify standards for building affairs. In order to achieve building permissions from the local council, the buildings should follow the building codes. To become a law, building codes should formally be enacted by the government or authority. Building codes aim to provide the minimum level of standards in building-related affairs such as health, safety, energy conservation, structural and installations integrity, and so on. In Canada, the National Research Council is responsible for publishing the national codes. In the United States of America, International Commercial or Residential Code (Known as ICC/IRC), mechanical, electrical, and energy codes (International Energy Conservation Code (IECC)) are among the principal codes. United States Green Building Code (USGBC) also provides the green building codes and promote sustainability in buildings (USGBC | U.S. Green Building Council, n.d.).

On the other extreme, frameworks are the main structure behind any system. There is a concentration on efficient/innovative frameworks for any system and procedure like SBD. Building Information Modeling (BIM) is a well-known framework in building projects. The main advantage of BIM is its ability to foresee the results of the decisions while doing the project. Utilizing BIM provides an opportunity for the project managers to see the progression of the project, which allows them to allocate time and budget efficiently. Finally, the control of the projects is easy while applying BIM, which leads to a successful project giving profit to the stakeholders. It might need high cost and more time to educate the operators for performing the BIM (Fazli et al., 2014).

In recent years the significant potential of BIM for improving the SBD is proved through literature and practices. The progression of SBD using BIM is one of the hottest subject matter of sustainable building development. Ahmad, Aibinu, & Thaheem, (2017) developed a conceptual framework using BIM and an iteration design to come up with the best possible combination of building procedure, systems, material, and technique selection alternatives. This proposed framework is a way to strengthen the SBD decision making. The name that the authors proposed for this framework is BIM-DIT, which stands for Building Information Modeling and Design ITeration.

Standard means a level of quality, a measure, or norm while comparing it in an evaluation process. There are different kinds of standards. Like, AHRI (Air-Conditioning, Heating, & Refrigeration Institute): (AHRI) is a voluntary, nonprofit organization containing the manufacturers of refrigeration, air conditioning, and heating products (AHRI, 2020); ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers; international organization of 50,000 people with chapters around the world. IEC, the International Electrotechnical Commission, is a nonprofit organization that improves and provides standards relating to the electrical technologies. Geneva,

Switzerland, is the main center of IEC standards, which reach over 150 countries. It plays an important role of coordinating efforts performed in various countries while unifying them, such as the development of various units of measurement and the standardization of the modern form of the metric system; ISO -The International Organization for Standardization-, is a non-governmental organization established in 1947. The ISO 9000 family of standards for quality management is a popular ISO product. The mission of ISO is to promote the development of standardization to facilitate the international exchange of goods and services, and to establish cooperation in the spheres of intellectual, scientific, technological, and economic activity. ISO maintains a searchable online catalog of international standards. To use this standard efficiently, the users should read the tutorial included in the catalog. Various examples of ISO standards are ISO 9000 - Quality Management, ISO 22000 - Food Safety Management, ISO/IEC 27000 - Information Security Management Systems, ISO 31000 - Risk Management (*ISO - International Organization for Standardization*, n.d.). In each step of SBD, standards could shed light on the quality management process.

Government Based Regulations are necessary for each country and region to provide its policy standards to achieve sustainable development (Olawumi & Chan, 2018). Each country is exclusive in its strategies to provide human beings in interior/exterior space with comfort and thrifty energy consumptions (Brophy & Lewis, 2011).

A process of approving that a specific product has passed the quality control and performance tests while meeting qualification criteria given in regulations or specifications is called product certification. Among the instances of product certificates are the Safety Equipment Institute for protective headgear, the U.S. Environmental Protection Agency Energy Star program, the International Commission on the Rules for the Approval of Electrical Equipment Product Safety Certification Body Scheme (IEECE CB Scheme), MAS which stands for Materials Analytical Services Certified Green Indoor Environmental Quality (IEQ) program, and the Green Guard Environmental Institute Indoor Air Quality program. Certification plans are ordinarily composed to incorporate both the execution test strategies that the item must poses, as well as the criteria that the item must meet to be certified. The sensitive industries, which a failure has adverse effects on the health and wealth of the people are pioneering utilize the product certification. The product certificates could be used in the process of SBD to ensure acceptable qualities.

4.1 Design Evaluation and Calculations Tools

Calculating outcomes out of environmental problem solutions is the responsibility of design, evaluation, and calculation tools. Such are Life Cycle Assessment (LCA), social and financial tools, and simulations tools (Emmitt et al., 2009; J. O. Jensen & Elle, 2007). Tools for evaluating the design are those that predict the building energy performance based on geometry, materials, orientation, users, and any other boundary conditions of design based on neighborliness and weather data of the region. They are the tools which propose and inform the designer for the best combination of decision and alternatives. They help designers like specialists in specific fields such as material and mechanical installation, which decrease the time for steadying the field. These assistants are based on mathematical calculations or practical relationships while following the standards and rating systems. Although these tools facilitate designing with sustainable principles, they are not immune to the disadvantages. The disadvantages fall with the fact that they may face inaccuracy or misleading due to using assumptions that are for any kind of reason far from reality. Awareness and understanding of the logic behind the assumptions, simplifications in the contexts of theoretical analysis methods are necessary for the potential designers that use these tools (Brophy & Lewis, 2011).

Zapata-Lancaster & Tweed (2016) reported some of the challenges of using calculation and evaluating tools during the building design process. Among these challenges are the ambiguity related to the best time to begin using the calculation and evaluating tools and the possible gap between the theoretical results of the simulations and the real results. They stated that the use of experimental results and comparing them to the simulation result is a right solution. To compare the software tools in terms of satisfying the requirements Østergård, Jensen, & Maagaard (2016) conducted a table comparison using checkmarks. In this comparison, the kind of user/expert support, level of design stage support, interoperability, complexity, objectives, and parametric simulation support and quality are compared in four groups of SBDM software tools (Figure 12).

Software	A. Users		B. Design stage				C. Interoperability	D. Core complexity	E. Objectives						F. Parametric sim.					
	Architects	Engineers	Conceptual	Preliminary	Detailed	Management			Energy	Thermal	Daylight	Air Quality	LCA	LCC	Cloud	I/O Configurable	UA	SA	OAT	Optimisation
BPS (own engine)	Be10 (ISO 13790 monthly) ²	(A) E		✓			Standalone	Low	✓	(✓)					✓					
	BSim	E		✓	✓		Standalone	High	✓	✓	✓	✓							(✓)	
	DOE2	E			✓		Standalone	Medium	✓						✓					
	EnergyPlus (E+)	E			✓		Standalone	High	✓	✓		✓			✓					
	EPC (ISO 13790 hourly)	(A) E	✓	✓			Standalone	Medium	✓						✓					
	ESP-r	E			✓		Standalone	High	✓	✓		✓			✓					
	IDA-ICE	E		✓	✓		File exchange	High	✓	✓	✓	✓			✓				✓	
	iDbuild	E	✓	✓			Standalone	Medium	✓	✓	✓	✓							✓	
	IESVE	(A) E		✓	✓	✓	File exchange	High	✓	✓	✓	✓	✓	✓						
	Radiance	(A) E		✓	✓		Standalone	High			✓				✓					
BPS (external engine)	VELUX Daylight Visualizer	A E	✓	✓	✓		File exchange	High			✓									
	A+E3D	A	✓	✓			Integrated	Be10	✓	(✓)	(✓)									
	Daysim	(A) E	✓	✓	✓		Run-time	Radiance			✓				✓					
	DesignBuilder	(A) E		✓	✓		File exchange	E+, Radiance, jE+	✓	✓	✓	✓		✓	✓					✓
	eQuest	E		✓	✓		Standalone	DOE2	✓											
	N++	E	✓	✓	✓		Separated	E+, jE+, GenOpt	✓	✓		✓			✓				✓	✓
	OpenStudio	E		✓	✓	✓	File exchange	E+, Radiance	✓	✓	✓	✓		✓	✓					
	Riuska	E		✓	✓		File exchange	DOE 2, own engine	✓	✓	✓						✓	✓		
Plug-in	Sefaira	A	✓	✓			Run-time	E+, Radiance	✓	✓	✓				✓		(✓)	(✓)		✓
	DIVA for Rhino	A (E)	✓	✓	✓		Run-time	Radiance			✓									
	Green Building Studio	A (E)	✓	✓			File exchange	DOE2	✓						✓					
	HoneyBee (GH)	A E	✓	✓	✓		File exchange	OpenStudio, E+, Radiance	✓	✓	✓			✓						
	jEPlus (+ JESS)	E		✓	✓		Run-time	E+, DesignBuilder, N++	✓	✓	✓	✓		✓	✓	(✓)	(✓)	✓		
	Parametric Analysis Tool	E		✓	✓		File exchange	OpenStudio	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Glue	Solon	(A) E		✓	✓		File exchange	Green Building Studio	✓						✓		(✓)	✓		
	Dynamo	A E	✓	✓			-	-												
Grasshopper (GH)	Grasshopper (GH)	A E	✓	✓			-	-												

Figure 12. A comparison between current building simulation supporting decision making (Østergård et al., 2016)

As is evident, the results show an acceptable scope of success among the parametric plugins tools. One of the contemporary SBD tools for environmental consideration is the Grasshopper parametric design tool and its associated plugin. Grasshopper plugin is a parametric tool that allows for geometric coding via creating controllable parameters in which all the design process is parametrically updatable in any step in the design process. Ladybug, Honeybee, butterfly, and so forth are the environmental plugins that could connect to the grasshopper environment and let for further analysis through simulation and optimization. Energy Plus, Radiance, OpenStudio, and Daysim are among the simulation engines that allow for simulations and analysis of daylighting, comfort, and building energy efficiencies considerations (“Grasshopper Algorithmic Modeling for Rhino,” n.d.; “Ladybug Tools | Ladybug,” n.d.) Figure 13 shows the combination of some of the current combination of these environmental analyzing tools and applications and their associated simulating engines. Galapagos and Octopus are also among the optimization components in grasshopper, which follows the Genetic algorithm optimization (Rutten, 2013).

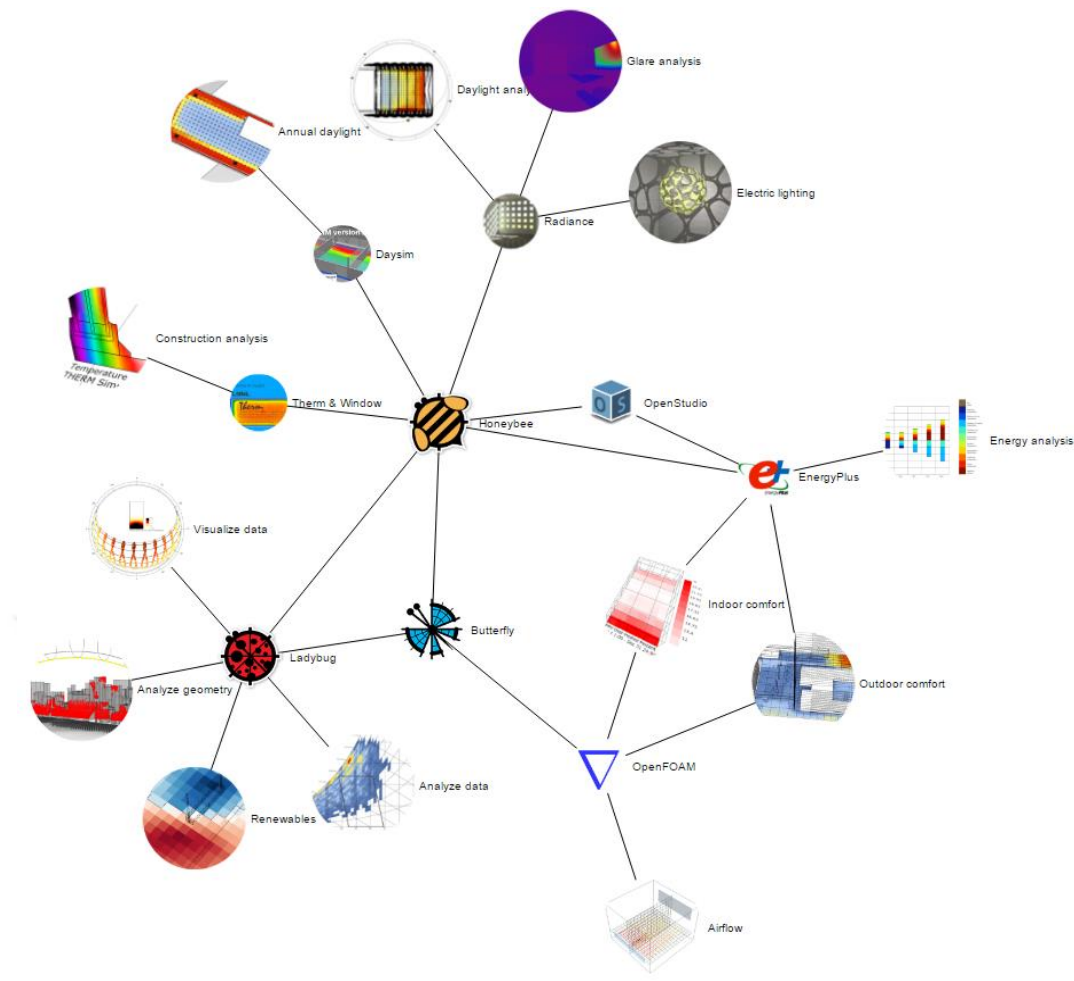


Figure 13. A sample set of environmental analysis tools for sustainable building design (Food4Rhino, n.d.)

4.2 Assessments Tools

According to Olawumi & Chan, (2018) each country and region should provide its policy standards to achieve sustainable development. However, it is seldom feasible to apply all the aspects of sustainable development at once. The sustainable development evaluation is a complicated activity since it needs an understanding of many aspects of sustainability as well as their interactions. Therefore sustainable development assessment needs the evaluation of many individual elements, influencing factors, and activity (P. Roberts, 2006).

For weighting the environmental aspects of sustainability, assessment tools are used. These tools help to figure out the advantages and disadvantages of different solutions. This group of tools covers the

multi-criteria assessment tools, evaluation procedures, surveys, and public discussions (Emmitt et al., 2009; J. O. Jensen & Elle, 2007).

There are several rating system tools for assessing the SBD, which help designers with interdisciplinary SBDM. As such are LEED, BREEAM, SBtool, CASBEE. In the following, each is briefly explained. Consequently, they are compared with one another in terms of the scope of fulfilling the SBD assessment.

LEED stands for Leadership in Energy and Environmental Design and is originated from the United States of America's Green Building Council (USGBC). (Figure 14).

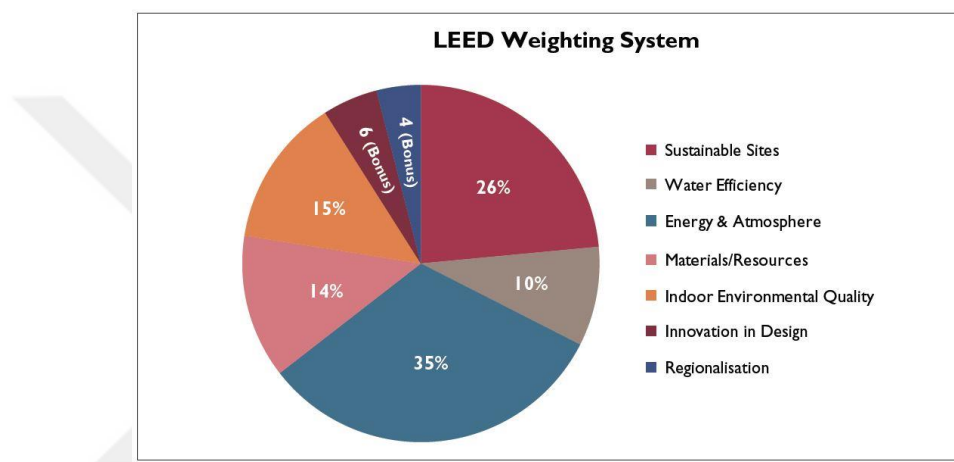


Figure 14. Leadership in Energy and Environmental Design attributes (Brophy & Lewis, 2011)

It is an international certification system for buildings. It deals with 7 fields in its weighing system including, sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, innovation and design process, and regional environmental priorities (Leadership in Energy and Environmental Design (LEED), 2015; Zarghami et al., 2018).

BREEAM (Building Research Establishment Environmental Assessment Method) was developed in the United Kingdom in 1990. The objective of this assessment tool is to assist designers and production in identifying and minimizing the destructive environmental impacts of buildings. The scope of BREEAM supports covers offices, homes, multipurpose developments, industrial units, retail units, courts, prisons, and schools in an updating manner.

BREEAM supports to cover the design and post-construction stages in a building project. The weighting system of BREEAM is based on points that are awarded to each of the criteria attributed to

this rating tool. Based on the total credits out of each criterion, the building performance (design or construction) could be attributed as pass, good, very good, excellent, or outstanding. The categories of these criteria include management, health and wellbeing, energy, transport, water, material, land use, ecology, and pollution. Figure 15 shows these criteria and the weight attributed to each of them in the BREEAM system (BREEAM, n.d.; Brophy & Lewis, 2011).

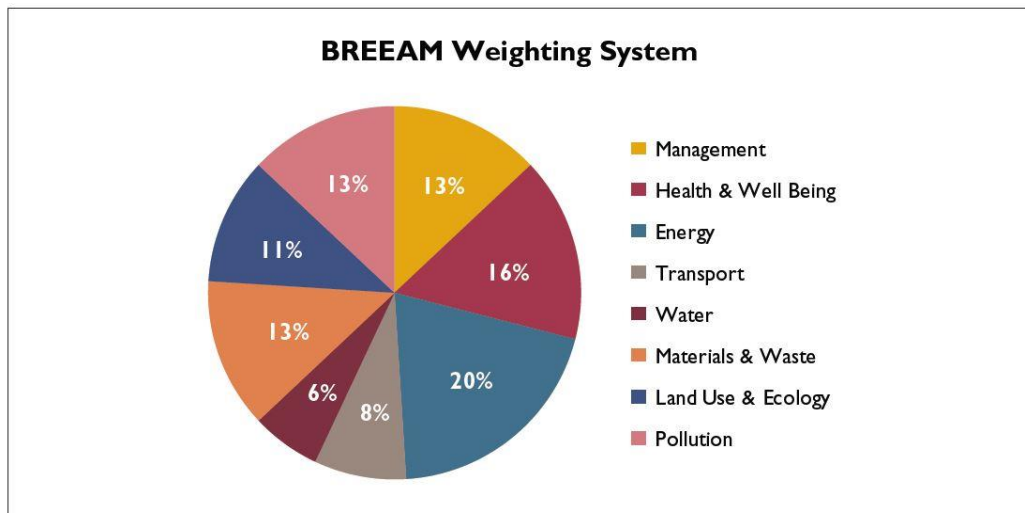


Figure 15. BREEAM which stands for (building research establishment environmental

As a generic framework, SBtool is an assessment tool for rating the sustainable building projects. SBtool could consider regions, building types, and context factors. It also could be used as a briefing material to show the sustainability requirements to the staff, managers, and competitors. The scope of this system could be modified to be narrower or broader. It contains eight indicator weighting approach based on national references. These categories are site selection, service quality, environmental loadings, indoor environmental quality, cultural and perceptual aspects, energy and resource consumption, project planning and development, and economic and social aspects. The weighting factors differ from building to building. SBtool was developed by International Initiative for a Sustainable Built Environment (iiSBE) before 2002 (*SBTool | International Initiative for a Sustainable Built Environment*, n.d.).

CASBEE stands for (Comprehensive Assessment System for Built-Environment Efficiency). It is a comprehensive assessment system for built environment efficiency, which is developed in Japan in 2001. The range of CASBEE support covers a predesign stage to the post design stage. Its utility includes existing buildings, construction, and renovation projects. CASBEE assessment concept is related to make a proportion based on environmental load (L) and the quality of building performance

(Q). See Figure 16. Through a mathematical process, L and Q make an indicator on how the building is environmentally efficient. More amount of this indicator reports a better building in terms of environmental efficiency. Subsequently, based on the indicator, the building falls upon one of the predefined categories from C (Poor), B-, B+, A, and S (Excellent). See Figure 17.

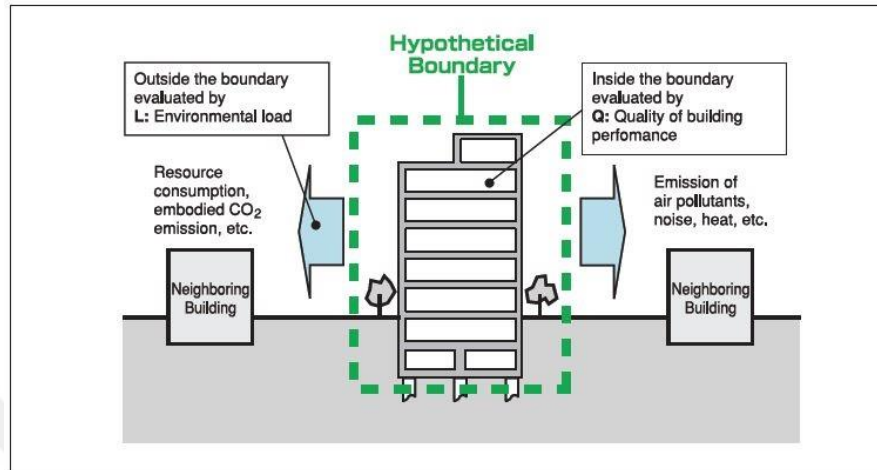


Figure 16. The definition of Q and L

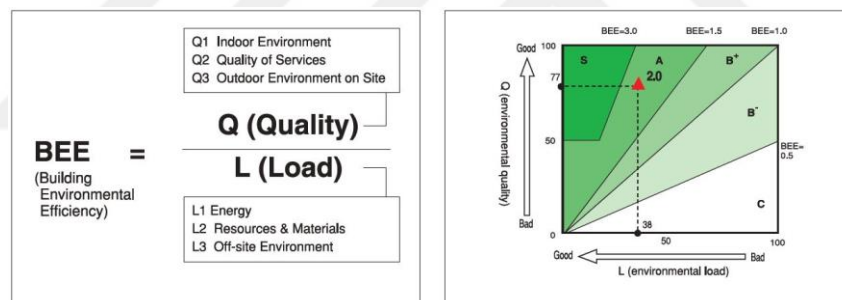


Figure 17. The mathematical process to define the indicator of CASBEE

In conducted a there is a comparison between these well-known SBD assessment tools. They conducted a comparison between the well-known Sustainable building design assessment tools that were presented earlier. The summary of their comparison is briefly presented in Figure 18. The results show that LEED includes a broader scope of sustainability support; however, it still does not cover management, economic, and social aspects sufficiently. While in contrast with others, it well covers integrative processes. The advantage of SBtool over others is the economic and social aspect coverage.

The assessment tools are ever-developing/ improving. In a new attempt, Mahmoud, Zayed, & Fahmy (2019) concerned the lack of comparability among the different countries' sustainable buildings while

considering the regional variation. To address this gap and develop a shared language of assessment tools among regions, they developed a new assessment model using a multilevel weighting scheme. This model was implemented using BIM modeling and energy simulation as well for cases in Canada and Egypt. Building sustainability Index (BSI), building sustainability assessment ratio (BSAR) are new the new expressions added to this model to reflect the amount of sustainability and the perception of sustainability from region to region. The advantages of this model to the related industry are i) measuring the existing building sustainability, ii) possibility of comparing SBD in a different region, iii) determining the weak side of sustainability which need more concentration, and iv) developing an integrated sustainability assessment framework as an initial step towards a comprehensive global assessment tool.

		LEED v2009	BREEAM 2014	SBtool 2011	CASBEE 2014
Country		USA (1998)	UK (1990)	Canada (1998)	Japan (2001)
Scope		New build, Refurbishment, Existing building	New build, Refurbishment, Existing building	New build, Refurbishment, Existing building	New build, Refurbishment, Existing building
Sustainable Categories	-Sustainable Site	✓*	✓	✓	✓
	-Location and transportation	✓	✓	-*	-
	-Water Efficiency	✓	✓	✓	✓
	-Energy Efficiency	✓	✓	✓	✓
	-Materials	✓	✓	✓	✓
	-Indoor Environment Quality	✓	✓	✓	✓
	-Innovation and Design Process	✓	✓	-	-
	-Regional Priority	✓	✓	✓	-
	-Integrative Process	✓	-	-	-
	-Management	-	✓	✓	-
	-Land Use and Ecology	✓	✓	-	-
	-Waste	✓	✓	✓	✓
	-Cultural and perceptual aspects	✓	-	-	-
	-Project planning and development	✓	-	✓	✓
	-Service quality	✓	-	-	-
	-Economic and social aspects	-	-	✓	-

Figure 18. A comparison between for well-known assessment tools
(Zarghami et al. 2018)

On the other extreme, sustainable development needs ways and tools to measure human's activity impact on the products. Preparing product and services are always associated with detrimental environmental impacts like pollution and resource depletion. The entire effects of any products on the environment should be well recognized in all the stages of their life span from design to demolition. Life Cycle Assessment (LCA) is the chosen phrase for this performance. Buildings are human productions that are among the most influencing on the environment. Therefore, life cycle assessments of buildings are of high importance. It helps the designer to have a well conscious of

designing and choosing between alternatives ways for a sustainable build environment (Ingrao et al., 2018).

Ingrao et al. (2018) thoroughly explained how LCA could be used to obtain sustainability. They introduced the LCA as a tool to direct the designer to a sustainable building. On the other extreme, Su, Li, & Zhu (2019), defined the LCA as a tool for quantifying the performance of the building and environmental impacts. Highlighting the necessity of whole building LCA, Ingrao et al. stated that it helps for a substantial decrease in energy consumption and saving the resources while decreasing the detrimental impact on the environment. A whole building life cycle includes material productions and infrastructures, including transportations and design and all the energies consumed for the other procedures, construction periods, installations, operations, maintenance, and demolition (Ahrinet, 2019). See Figure 19.



Figure 19. Entire building life cycle
(Ingrao et al., 2018; *Suspended ceilings in their environment*, 2017)

LCA is a difficult-to-implement process because there are many factors such as stakeholders. These specific buildings' characteristics have influence (Hernandez et al., 2019). However, these complexities are gradually being addressed through innovative frameworks and investigations. A Building Information Modeling (BIM) based approach is used as a framework to structure the process of LCA by Cavalliere, Dell'Oso, Pierucci, & Iannone (2018). The idea was then checked through a case study. The results indicated that BIM could well promote LCA while providing more ease of implementation of data processing as well as more data reliability while saving more time. Despite

the difficulties and distances with a mature status, LCA is an excellent reliable method for decision making during the design and comparisons not only for individual practices but also for standards and regulation definer and policymakers (Hernandez et al., 2019).

4.3 Monitoring Tools

Choosing between indicators and benchmarks for monitoring and policy formulation on sustainability is well-feasible by using monitoring tools (Emmitt et al., 2009; J. O. Jensen & Elle, 2007). These tools are used in existing buildings for almost technologies consideration and involving people's behaviors and feedback (users, caretaker, residents, etc.). Monitoring tools are often implemented by intermediary people like local departments and green guides. These tools are also usable for post-occupancy evaluation in sustainable buildings (Emmitt et al., 2009). However, still insufficient, these tools are getting advanced (Bonilla et al., 2018; Laprise et al., 2018). There are several examples of these tools for improving SBD facilitation, as such is a virtual building energy management system. It records and reports energy-related parameters, including demands, cost, and carbon footprint. It is intranet-based, and the output/information, including the location of this system, is achievable via the internet both in text and graphic. The functionality and accuracy of this monitoring tool were tested (Bonilla et al., 2018). Figure 20 shows the deploying status of this system which is connected to the building infrastructure and several examples of text and graphical statistical reports of building energy performance.

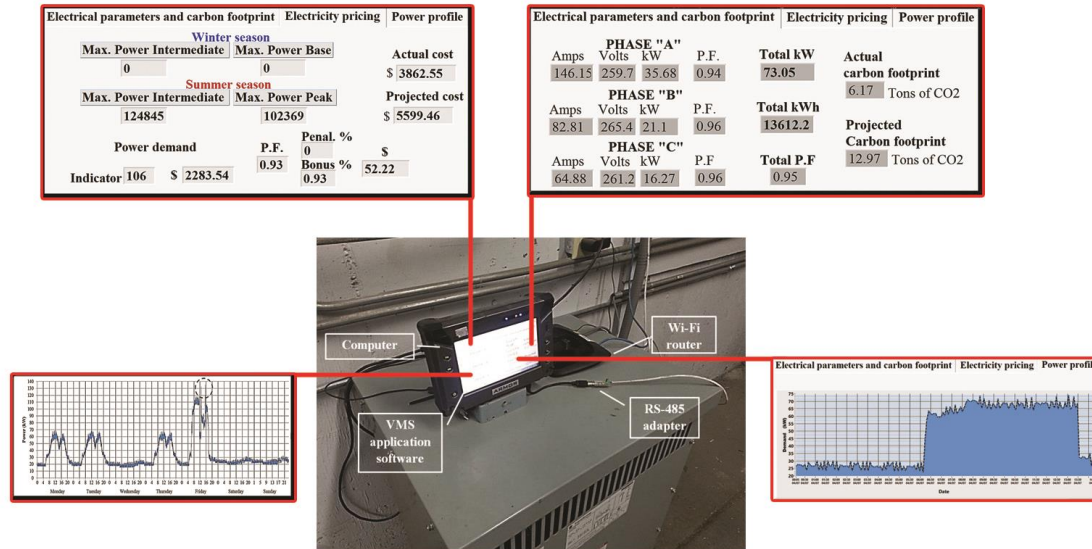


Figure 20. A new monitoring tool is known as the Virtual Energy Management System (Bonilla et al., 2018)

In another attempt Göçer et al., (2015) developed a color code data collection for filling the gap of the SBD process. This new system enhanced post-occupancy monitoring and evaluation for receiving feedbacks out of building performance.

Pointing out to the lack of continuous and dynamic behavior in sustainable transformation, Laprise et al., (2018) developed an operational monitoring tool to facilitate the mollification towards sustainable neighborhoods. The name of this tool is **SIPRIUS+**. It included criteria and their associated indicators indicator system, checklists, assessment reference steps, and sources and finally calculating outputs. This tool was capable of conducting continuous monitoring of social, environmental, and economic aspects of a neighborhood under consideration. A test application of this tool was conducted in three European countries, Belgium, France, and Switzerland, for proof of usability.

4.4 Summary of Chapter 4

SBDM decision-making is a complicated process, as many actors and factors are involved in different stages of the project. Moreover, it is not straightforward to engage in an understandable and optimal dialog and a proper workflow between input elements and experts to extract a desirable outcome. Sustainable building design management tools are the solution.

There is no specified global approach, technique, or system for SBDM due to the sake of creativity and flexibility. However, a clear framework and approach should be specified before the project on which the required tools could be specified.

Sustainable building design management tools are included in four categories, including process tools, design evaluation, and calculation tools, assessment tools, and monitoring tools. Sustainable building design management tools are being developed/improved.



CHAPTER 5

DESIGN OF THE RESEARCH

5.1 Case Study Area, Iran

Iran is a country located in western Asia, in the middle-east with around 82 million population and 1,648,195 km² territory area. The country has a pioneering civilization. There have been numerous regimes that have governed the country for ten to hundreds of years. It has a diverse climate, including arid, semi-arid and subtropical forests along the Caspian Sea and in the north. There are various ethnic groups with different languages in Iran. Concerning energy, Iran ranks second in gas reserves and third in gas production. The country ranks fourth among countries with oil reserves.

Historians stated that Iran's architecture goes back to the seventh millennium BC. The guiding motif of Iranian architecture is its cosmic symbolism. UNESCO listed Iran as a seventh rank country among the most archaeological ruins and attractions from archaism (Ardalan, Bakhtiar, & Nasr, 2000).

According to the Koppen climate categories, Iran has several climate categories and is a multi-climate country. One of the most common climate types which are prolific in more than half of the country area is categorized as "B". B stands for hot arid climate conditions. This climate type has two types BW and BS. The former stands for desert biome-dry tropical climates while the latter stands for the steppe-dry mid-latitude climate. Tehran is situated in this second type of climate condition and in terms of microclimate conditions, is poor in precipitation. Therefore it is categorized as BSks. BSks stands for a region with a hot arid mid-latitude climate in which the precipitation is low (Soflaei et al., 2016).

Tehran is the capital of Iran. I have approximately 10 million populations. Tehran features a continental-influenced Hot-summer Mediterranean climate. The weather in Tehran is mostly

influenced by desert and Alborz mountain range in southern and Northern parts, respectively. Normally the weather is mild in spring and autumn, somewhat cold in winter with a hot summer.

Tehran's main expansion was started from the late 18th century while playing a significant role in society (Tehran Environment & Geography, n.d.; "The Style of Tehran" Library of Congress Information Bulletin," n.d.). The location of Iran in a worldwide map and the location of Tehran in Iran are represented in Figure 21.

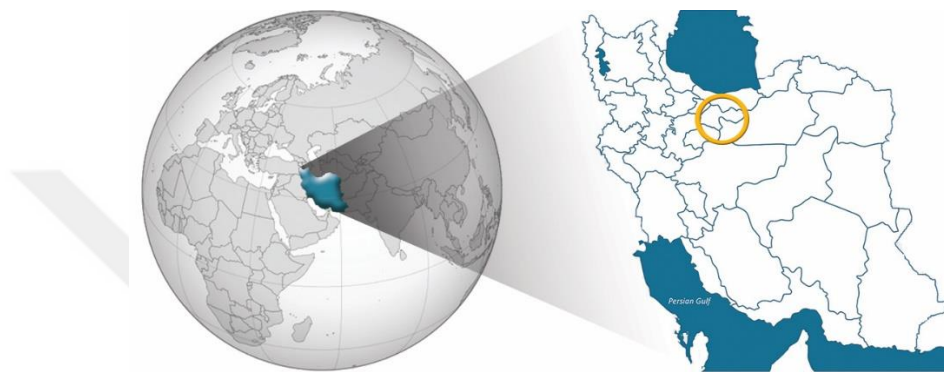


Figure 21. Iran, Tehran Location in the world

5.1 Sustainable Development Approach in Iran

A review of the articles on sustainability and sustainable development in Iran clearly shows that there is a non-sufficient effort towards sustainability. The implementation of sustainable development has been slow due to the abundance of fossil fuels in this country (Gorjian et al., 2019).

The energy consumption in Iran is around 450% more than the global average. Iran is enriched with oil and gas that it is one of the leading exporters in the world. On the other hand, this country also has the potential of solar energy. There is a not enough tendency of the government and policymakers for the deployment of the photovoltaic technology in Iran, due to the lack of budgets specified to it, low industrial growth, problematic governing rules, and lack of sustainable development (Gorjian et al., 2019).

Renewable energy resources cannot be easily avoidable for a country like Iran. At the same time, it is enriched with different kinds of energy reserves, such as gas and oil. The water resources are scarce in comparison to its large area. New technologies can be developed based upon the available materials in the country as well as local industries since they would be more economical and help

improving local production. However, performing this task is somewhat challenging since the private sectors are inactive in the country, and the system of pricing is not well established (Jahangiri et al., 2018). Technology is required to be improved while shifting from fossil fuels to renewable energies. Iran has low prices for petroleum productions, which demotivate the system to invest in renewable energies. On the other hand, air pollution is another problematic issue considering the heavy usage of fossil fuels (Jahangiri et al., 2018).

Recent research shows that in Iran, environmental issues are among the least important, considering economic development. Therefore the social index deviates from the environmental one. Specifically, for Iran, it is required to concentrate more on the subsystem interactions (Mamipour et al., 2019).

Jahanshahi et al. (2019) specified that the young people and the students were among the people who used a bicycle sharing system more often.

5.2 Building Sector in Iran

Housing/dwelling and the governmental buildings compose the two dimensions of the construction industry in Iran. The collapse of stated authority, coupled with the populist convictions and spontaneous popular land occupations, led to the dramatic expansion of cities. Tehran doubled in size within two years. However, only a small fraction of this geographic expansion was confiscated private land. The rest, more than 90 percent of the total distributed, had been public land. From 1979 to 1993, nearly half a million hectares of predominantly public unoccupied land was converted into private and cooperative residential property. New stated institutions like the Urban Land Organization and the Housing Foundation played a crucial role in this massive transfer of property. By the mid-1980s, more than 60 percent of all urban residential land transactions were being allocated by the stated (*MERIP*).

This large-scale transfer of mostly public land, coupled with the absence of enforceable regulation, transformed Iran's urban geography. Between 1979 and 1982, 75 percent of all new construction in Tehran occurred outside the formal city limits, where satellite villages were transformed into sprawling suburbs. Remarkably, by 1986 urban housing stock had doubled, and housing ministry surveys showed that more than half of all urban dwellings in the entire country had been built after the revolution. It was private individuals who built these 2.3 million new units. The stated merely transferred the public land into private; its share of investment in housing construction (affordable or otherwise) was less than 2 percent of the total after the revolution (*MERIP* |, n.d.).

The concentration of material used in Iran is, for most rely on cement industry, ceramic, float glass, steel, tiles, and stone (Iran Daily | No:6249 | Date:1398/4/31, n.d.). Producers and providers in Iran are required to have either ISO 9000 certification, European Union Standards (EN, BSI, DIN, ANFOR, UNI, NNI, ON, IBN, IPQ, DS, NSF, SEE, SIS, NSAI, ELOT), North America National Standards (ANSI, ASTM, AGI, API), Japan National Standard (JIS) or International Standards (ISO, CODEX, ITU, IEC) to be allowed to export (National Standard Organization of Iran, n.d.).

5.3.1 Sustainable Building Design Approach in Iran

Lack of efforts to promote sustainable development in Iran includes contemporary sustainable building design as a subset of sustainable development paths as well (Gorjian et al., 2019). Iran is one of the countries which is well known for a rich history and achievements in traditional sustainable building design (Gorjian et al., 2019). However, after 1960 the municipal modernization shifted to a new sphere. The reasons behind it are the entering of foreign currencies to the country from the international construction investors, increasing the oil price, and the development budget. As a result, obsolete housings, which replaced with luxury houses later, were not available anymore to the middle class. Reformers and citizens exposed to these reforms have been among the people who hastened the modernization process in Iran. The process started through the idea of modernization by architects, bankers, and so forth made contributions to breaking the conventions (Habibi & De Meulder, 2015).

Zarghami et al. (2018) indicated that to improve the building standardization in Iran; the Iranian construction practitioners can become familiar with the common indicators of SBDMT, which have the potential to be used as an evaluation process while developing the local assessment tool. Also, the national Environment Impact Assessment (EIA) regulation system can be revised to address the shortage of sufficient penalties for EIA serious violations. There are currently several problems with EIA in Iran. Such as lack of public participation, screening, and alternative methods, and the incompetent operators. Learning about EIA would increase environmental protection (Khosravi et al., 2019). Iran is one of the countries which needs improvement in building project management (Fazli et al., 2014). Fazli et al. (2014) proposed BIM which plays a vital role in accomplishing the project on time and budget, as a solution for improving the management problems in building projects in Iran.

Passive design strategies could substantially help to return sustainability to the buildings and neighborhoods in terms of environmental aspects of sustainable development (S. Wang et al., 2016). The passive design strategies of Tehran include; 1. Air motion and ceiling fans, 2. Evaporative cooling, 3. Earth involvement design, 4. Humidifying the entering air, 5. Flat roofs, 6. Central

courtyard capable of managing daylight and wind, 7. Passive solar heating from the most exposed surfaces, 8. Decreases in the opening and high mass construction, 9. Open plans for more natural ventilation, 10. External shadings, 11. High performance double and low emissive glass windows except for south-oriented skins, 12. Optimized north opening (glazing) for daylight and cross ventilation, 13. Well oriented and shaded opening for natural summer ventilation, 14. Stack ventilation (like Badger houses), 15. Light color materials and cool roofs, 16. Protecting west oriented skins from sun, 17. The different set back temperature in day and night, 18. Internal heat gain and insulation through tightening the space for cold periods, 19. Letting activities zone for wintertime, 20. Protected external space from sun and wind (Milne Murray, Climate Consultant 5.4 - Energy Design Tools - UCLA.edu n.d.).

5.3.2 Sustainable Building Regulation in Iran

Iran is very rich in nonrenewable energy sources; also, it has a high potential for renewable energy. (SUNA) that stands for the Persian translation of the organization of new energies in Iran, is the renewable energy organization which is responsible for renewable energy considerations in the country (“Suna,” n.d., www.suna.ir). Also, (SATBA) that stands for renewable energies and electric energy efficiency of Iran in the Persian language, is an organization for energy efficiency in Iran. Ministry of Energy is also responsible for making policies in energy conservation. Riazi & Hosseyni (2011) reviewed the current building energy policies, standards, and regulations in Iran. They asserted that Iran strongly needs to improve its current policies for sustainable building sectors.

In Iran energy conservation plans are included in two, three, four, and five-year period plans, regardless of the fact that how much and to which level of quality these plans are implemented. Among these plans are promoting sustainable development, equipment technical standard preparations, laws for importers, fund allocations for research on energy efficiency, preparation building design and construction regulation, preparation of existing building standards, energy efficiency educations (Riazi & Hosseyni, 2011). Figure 22, Figure 22, and Figure 24 represent CO₂ production in Iran, energy resources of Iran, energy used categories in Iran's buildings. As is evident, in the building sector in Iran, buildings are responsible for 38% of energy consumption, and 66% of this energy is natural gas. Also, 61% of Iranian energy consumption in Iran is for heating and cooling.

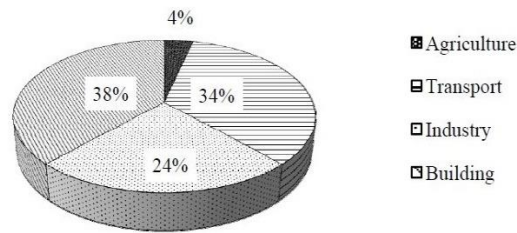


Figure 22. CO₂ production in Iran
(Iran Energy Ministry, n.d.; Riazi & Hosseyni, 2011)

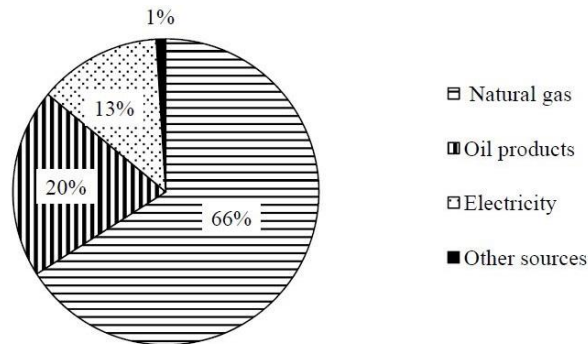


Figure 23. Energy resources of Iran
(Iran Energy Ministry, n.d.; Riazi & Hosseyni, 2011)

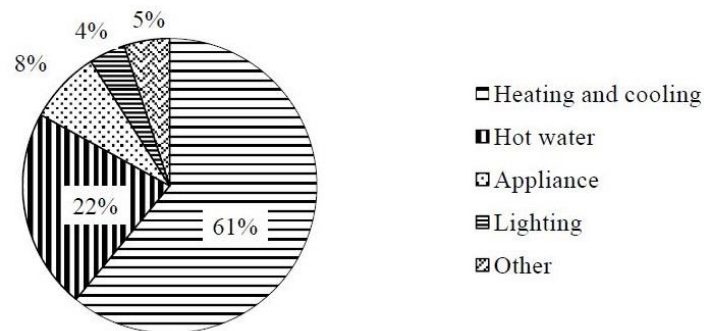


Figure 24. Energy used categories in Iran's buildings
(Iranian Fuel Conservation Company, 2012; Riazi & Hosseyni, 2011)

Iran construction engineering organization (IRCEO) is a technical organization, which is responsible for publishing the building regulation, monitoring, educating the engineers, implementation of engineering regulation in building engineering fields and increasing the people's information regarding building engineering. To do these, this organization cooperates with other related organizations in the country (IRCEO, 2020). This organization has representation in every province

in Iran, such as Tehran Construction Engineering Organization (TCEO, 2020). Building regulations in Iran are published in 22 parts. Table 1 shows a list of building regulations in Iran.

Table 1. Iran ministry of Roads and Urbanism, building national regulations
(Ministry of Roads and Urban Development, 2011)

No	Year (Last date of updates and modification)	Law Name	Content
1	2013	Part 1	Definitions of words and phrases
2	2007	Part 2	Official Organizations
3	2013	Part 3	Part 1 Building Protection against Fire
4	2013	Part 4	General Necessities of Buildings
5	2013	Part 5	Building Materials
6	2013	Part 6	Building Statistical Loads
7	2013	Part 7	Building Foundation
8	2013	Part 8	Design and Construction of Masonry buildings
9	2012	Part 9	Design and implementation of reinforced concrete buildings
10	2013	Part 10	Design and Implementation of Steel Structured Buildings
11	2013	Part 11	Industrial Design and Construction of Buildings
12	2013	Part 12	Safety and Human Protection while Constructing
13	2005	Part 13	Design and Implementation of Buildings Electrical Installations
14	2012	Part 14	Mechanical Installations
15	2013	Part 15	Elevators and Electrical Stairs
16	2012	Part 16	Hygienic Installations
17	2010	Part 17	Natural Gas Piping
18	2011	Part 18	Insulations and Acoustics Settings
19	2010	Part 19	Energy Saving in Buildings
20	2007	Part 20	Signs and Symbols
21	2012	Part 21	Passive defense
22	2013	Part 22	Maintenance

The only mandatory published framework for sustainable development in building design in Iran is part 19, which concentrates on building energy efficiency. The introduction of this part highlights the point that 42% of energy consumption in Iran is by the building sector, which is expected to increase in the near future if no measure is taken into consideration. Buildings are divided into groups based on their application and their annual energy demands. In order to unify the calculation results and ease of decision and comparison, technical data for materials and skins are added. According to these, following the experience of advanced industrial countries, the policymakers in Iran establish the 19th part in 1970, which is for most concentrated on thermal insulation. This caused the addition of a

guideline for this part for the ease of use among the users in 1978. After that, in 1981, a newer version of part 19th emerged with that included daylight, mechanical installations consideration in a different section of the code. In the third edition of the code, most of the concentration is on simplification of the content of the book for more ease of use among users in the majority of sections. A primitive shading provision for each region based on the angle of solar radiation, highlighting the application of scheduled and controllable installation systems, adding some newer production available at the country such as double glass and high-performance windows. Information for calculating thermal bridge is the commandments of the third editions of this part (Ministry of Roads and Urban Development, 2011).

Part 19 is defined in five sections and 11 appendixes. The sections concentrate on energy efficiencies and calculations requirements. The content of these sections is in the scope of Iran's capacity and available technology and resources (National Building information of Iran, the Ninetieth part, 2011).

Updated standards and regulation provision for SBD plays a vital role in the realization of energy conservation. Given this, Zarghami et al. (2018) conducted research to come up with recommendations to improve the thermal behavior of windows through the next version of part 19. They highlighted the deficiencies of the Iranian regulation for building energy efficiency. In the context of an article, they customized the Leadership in Energy and Environmental Design (LEED) standard for Iran as a new sustainable assessment tool. In another attempt, this adaptation was conducted with BREEAM and LEED together (Omran & Marsono, 2016). Moslehi et al. (2017) published a book in Persian which teaches how to thoughtfully be aware of the energy loads in buildings. DesignBuilder software was used as a case study tool to teach the principles.

In addition to the chapter ninetieth of building regulations, the Department of Environment in Iran has published several laws on environmental protection. It has collected all of the regulations and published them by the name of "human's environmental laws, regulation criteria and standards" (Iran Department of Environment, n.d.). Even though the regulations dealt with air and acoustic pollution, neighborhoods, and land use, it did not include building design, natural parks, and forests in general. Building affairs considerations are conducted under the surveillance of municipals' rules and regulations (Riazi & Hosseini, 2011).

Institute that controls the quality of products and procedures in Iran is the Institute of Standards and Industrial Research of Iran (ISIRI), founded in 1960. It is a governmental institute in Iran which is responsible for standardization and certificate. It is an Iranian representation of the International

Organization for Standardization. Providing standardization of experts, management system, and environmental management system certification are among the many responsibility and duties of ISIRI. It also is responsible for uplifting the standard levels by conducting research. ISIRI institute has provided the standards for building design and products such as material thermal insulation, electrical system, piling, building information models, life cycle costing, sealing, glass quality, sloping, accessibility in design, flood resistance, construction resistance, disables consideration in public, structural joints, durability of material and systems in environmental testing (National Standard Organization of Iran, n.d.).

5.3.3 Examples of SBD Practices in Iran

Figure . shows Zahiroleslam house, which has been registered as national monuments, and it is intended to restore it (*Zahiroleslam house, hamshahri*, 2014). According to Professor Amir Mansouri, who was graduated in a doctor of philosophy in history and is a publisher of several books on the renovation of old construction and aesthetics in building design, etc. (Mehr news agency, 2018), 99% of Tehran construction has been suffered from lack of identity. He concluded that, one of the biggest problems of the city, in terms of construction, was uncompromised copying of western building design and construction, which did not match the community and climate. Highlighting the lack of identity in Tehran construction, he pointed to similar construction for needy families, which were restricted by building design regulations. He stated that buildings affect our behaviors and lifestyle: bewildered building design and construction cause bewildered lifestyles. As a solution, he pointed to preliminary knowing our identity from a philosophical point of view, "what" we are? "Who" we are? What is our history? He consisted of the fact that identity comes from the environment and history. The building design should follow these two when looking at the future.

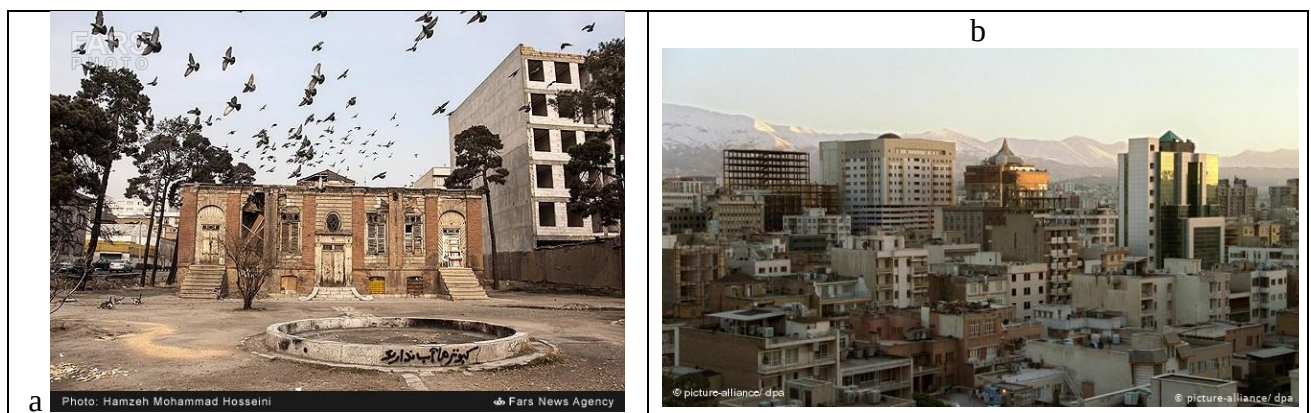




Figure 25-A. Sustainable building design practices in Iran, The contrast between traditional and contemporary buildings in terms of SBD

a,c,d Zahiroleslam house, Tehran (Zahiroleslam house, hamshahri online, 2014)

b. View of Tehran city turbulent building design without identity (Mehr news agency, 2018)

Another example of the traditional housing system in Tehran is Kakhe-Golestan is a palace (Figure 26). The history of Kakhe-Golestan goes back to 1580, which has undergone several additional construction and changes after that. Nevertheless, it has many of the socio-environmental SBDP of Iran housing (Milne, n.d.; Soflaei et al., 2016, 2017). As such, principles are the form, orientation, windcatcher, dome-shaped roof and ceiling, ornaments, vegetation, humidification, material selections, etc.

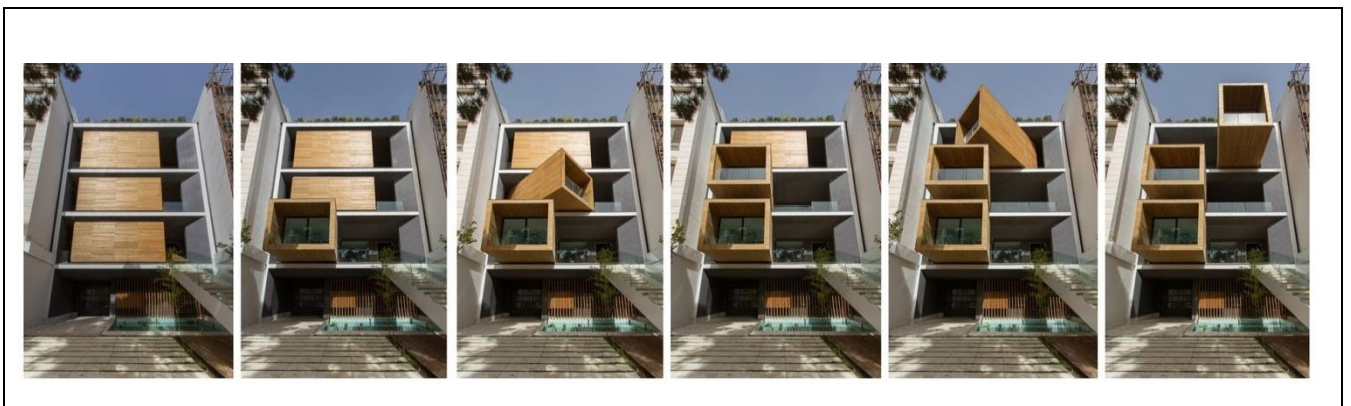




Figure 25-B. Sustainable building design practices in Iran, Kakhe-Golasan building

(Milne, n.d.; Soflaei et al., 2016, 2017)

There are many criticisms regarding Tehran's' contemporary building design, including meaningless imitation of the western country style of design, lack of identity and reflection of Iranian identity and sense of self, lack of implementation of new housing technologies, high weight construction, and lack of energy efficiency. However, still, there are some contemporary SBD examples in Tehran. Khaneye-Sharifiha 2013 by Next-office building design company is among these. Their design won an international award in 2014. (*Sharifi-Ha House/Next Office–Alireza Taghaboni, 2014*). The chief designer relied on traditional Iranian building design culture. The designers started with the flexibility concept and ended with a changeable building envelope. The building was both introvert and extrovert because of the climate condition of north Tehran, which is moderate in summer and cold in winter. A closed and shrank volume with a minimum window to wall ratio in winter and transparent, deep balconies in summer (Soflaei et al., 2017). Adding to its climate-based design, this building has a high-performance installation for human comfort (*Sharifi-Ha House/Next Office–Alireza Taghaboni, 2014*).



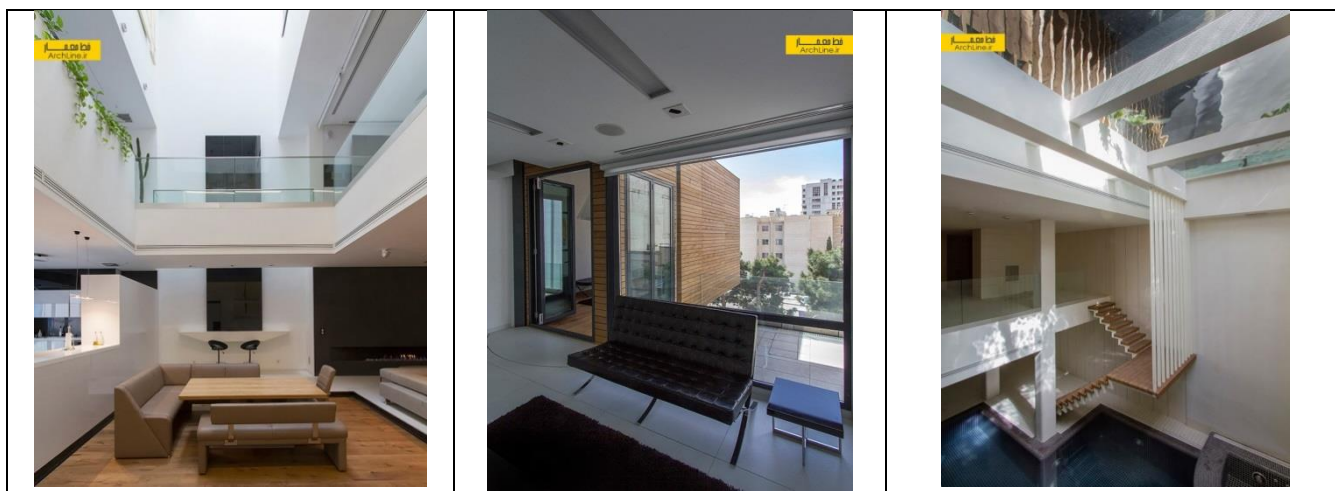


Figure 25-C. Sustainable building design practices in Iran, Khaneye sharifiha, a new sustainable building design practice in Tehran, Iran (Sharifi-Ha House / Next Office–Alireza Taghaboni, 2014)

5.3.4 Education in Iran Regarding SBD

In Iran, academic programs in building design take place at the high school, undergraduate, and graduate levels. Also, architecture and energy is a new major of study that is added to Iran's university education system during graduate periods. This new major of study, which is much more related to SBD, is just taking place during a master's period at limited universities.

In order to find clues of influence of the education system on SBD and SBDM in Iran, the syllabus of ordinary building design major or Memari in Persian in four different periods of high school, undergraduate, and graduate levels was explored course by course. The result of this review showed that in high school, in second-grade basics of technical layout design and application of computers in building design and understanding the construction materials are provided among the core courses besides studio and spatial layout drawing (Ministry of Education (Iran), 2020). In third grding elements and details, and computer used in building design. In this grade, they become acquainted with historical buildings as well. All of these courses are provided at a high school level associated with general courses. The general courses include religious and Quranic education, sport, Arabic courses, mathematic, Persian literature, and geography. Except for mathematic, in the third grade of high school other than these general courses, the contemporary history of Iran is also included in their courses (Ministry of Education (Iran), 2020).

In the undergraduate level of building design major (Mohandesi Memari), there are 53 courses including general, basic, main, specific, and elective courses and thesis. Architectural designs are provided in five sections in different semesters. Neither architectural design courses nor any other

courses specifically focus on sustainable architecture definition and principles in general. However, there are courses related to construction and material (statics (main), construction and materials site (main), the strength of materials and steel structures (main), concrete structure (main)), which address the structural details and residency, urbane consideration (site management and organization (special), analyzing urbane spaces (main)) which covers the basics of urbane design and management. And basics of environmental courses (human, nature, and architecture (basic), adjustment of environmental conditions (main)). Regarding the English language, there is a rudimentary course as a general English tutorial and an elective technical English language related to architecture (National Education Evaluation Organization, 2020).

At the graduate level, in the master period of building design major (Arshade memari), in architecture-architecture (memari-memari) major students pass twelve courses, including basic and special. While basic courses are elective and changeable based on student selection, special courses are not changeable and are mandatory to pass. The special courses are architectural design one and two, Modern structure, an advanced method of construction, architectural and physical planning, location theories, and thesis. As is evident, none of the courses especially include SBD for clarification and teaching.

In Master of building design and energy (Arshade Memary Energi), there are mandatory and elective courses as well. Mandatory courses are Architectural design and energy (one and two), urbane design and energy, Islamic thought in architecture, architecture-climate-comfort, and passive and active systems. Were thought thoroughly and adequately, these courses can cover the basics of two first sub-categories of energy consideration in SBD, still, regarding the last subcategory (renewable energies consideration in design) there is insufficiency (National Education Evaluation Organization, 2020).

In the Ph.D. Level of ordinary building design major (Doktora memari), there are no mandatory courses. Instead, there are main, special, and compensatory courses from which the students should pass nine main credit courses, nine credits special courses, and ten credits compensatory courses. Eighteen credits are considered for the Ph.D. thesis, which will select based on the availability of professorship and the student's wills (National Education Evaluation Organization, 2020).

From the main courses list, there are two "climate and architecture" and "environment and architecture" which are relevant to SBD. In special courses list, there are space psychology and climate course categories, including architecture based on climate, architecture, and contentment in energy, architecture and new energies, and natural ecosystems and artificial environment that are well

relevant to SBD. All of which is taught thoroughly and adequately could compensate part of SBD principles for the students (National Education Evaluation Organization, 2020).

All of these show that there is insufficiency regarding SBD/SBDM/SBDMT in the education system in Iran, especially for the undergraduate level. Also, in the Ph.D. level, all the courses relevant to SBD/SBDM/SBDMT are elective, which means there are no mandatory rules to learn these principles (National Education Evaluation Organization, 2020).

5.3 Data Analysis

5.4.1. Data Gathering and Formation of Survey

For the sampling process, the capital of Iran, Tehran, was selected as there are numerous and heterogeneous building design companies in the city. Several sustainable building design firms were detected in the city (Babbie, 2011). In order to collect the data for this study, first of all, the respondents were specified using a snowball sampling method (Babbie, 2011). The reason behind this attempt was the lack of official information on SBD firms in Tehran, Iran.

The participant firms were selected based on their willingness to participate and their experience in SBD practices. The firms were named as letters from A to M for the sake of keeping the identities uncovered and protecting privacy (Babbie, 2011). Table 2 shows the characteristics of the firms, including their scale, years of operation, owner's education, owners' major.

For explaining the firms' scale from a descriptive point of view, the number of members was taken as follows. 1-5, 2-10, 11-15, 16-20, 21, and more are considered as very small, small, medium, large, and very large, respectively.

Table 2. Participant firms' characteristics

	<i>Scale</i>	<i>Years of operation</i>	<i>N. of projects</i>	<i>Owner's education</i>	<i>Owners' major</i>	<i>Firm</i>
A	Small	10 years (Since 2010)	28	Graduate(master)	Architecture	Partnership
B	Medium	18 years (Since 2002)	12	Graduate(ph.d.)	Architecture	Partnership
C	Very small	10 years (Since 2010)	9	Undergraduate(bachelor)	Architectural engineering	Sole proprietorship
D	Small	15 years (Since 2005)	14	Graduate(master)	Architecture & energy	Corporation

E	Very small	5 years (Since 2015)	25	Graduate(ph.d.)	Architecture	Corporation
F	Medium	10 years (Since 2010)	10	Graduate(ph.d.)	Architecture	Corporation
G	Medium	8years (Since 2002)	2	Graduate(ph.d.)	Urban design engineering	Partnership
H	Very small	3 years (Since 2017)	3	Graduate(master)	Architecture & energy	Sole proprietorship
I	Medium	7years (Since 2002)	7	Graduate(master)	Architecture	Partnership
J	Small	4 years (Since 2016)	4	Graduate(ph.d.)	Architecture & energy	Joint nature
K	Small	7 years (Since2013)	7	Undergraduate(bachelor)	Architectural engineering	Corporation
L	Very large	20 years (Since 2000)	11	Graduate(ph.d.)	Civil Engineering	Partnership
M	Very large	30 years (Since 1990)	8	Graduate(ph.d.)	Civil Engineering	Partnership

For studying the SBD, SBDM, and SBDMT, methods and approaches in building design firms, a survey questionnaire was prepared. The survey questionnaire was based on the areas of concentrations in the literature and the associated readiness, willingness, and barriers evaluation.

Table 3 shows the categorization of the questions. For each set of questions in this taxonomy, the source of inspiration was provided. A structured survey questionnaire was created following the structure of contingency questions, rating questions using a Likert scale, multi answers questions, and open-ended questioned following the structures introduced in Babbie's research method book (2011) and Groat & Wang, (2013). For this thesis face to face interviews, telephone, Skype, What's app application, and e-mails were the tools to collect the information.

Table 3. A summary explanation of the categories of the survey questions and the source of inspiration

<i>Category of the questions</i>	<i>source of inspiration and confirmation</i>
Part one: asks about SBD practices in the firms.	(Sassi, 2006)
Part two: asks about BDM as a base for SBDM and finally asks about SBDM.	(Alharbi et al., 2015a, 2015b) (de Paula & Melhado, 2018)
Part three: questions the consideration of SBDMT	(J. O. Jensen & Elle, 2007)
Part four: asks about SBDM barriers, reediness, and willingness	(Juan et al., 2016)

In the Appendices section, the survey questionnaire, is provided.

5.4.2 Data Analysis

5.4.2.1 Qualitative Analysis

For qualitative analysis of survey results, first, a text format of the results was prepared for coding. software tool, Nvivo was intended to use however as it had a problem with the language of the text (Persian), it was decided to do the coding manually. In order to analyze the output data of findings, Vensim software is used to manage the mind maps, cause trees, uses trees, and loops. This way, not only did the relationships between the thematic opinions of the survey results become evident, but also the most mentioned keywords showed up. For each mind map, a legend was prepared that included thick green arrows showing the relationship between subcategories and main headings, thin green arrows showing reported contributors or causes of improvement, and thin red arrows showing reported obstacles.

5.4.2.2 Quantitative Analysis

For the quantitative part, Excel charts were used as well as atrial python data analysis coding for calculation and visualization. The information that shows which firms pointed to which thematic information was presented in appendices in Table 21 and Table 22.

Python visualization was used for Figure 27. Sustainable building design principles implementation. Excel charts were used for section 6.5 that focuses on the Evaluation of Reediness of BDM, SBDM, and SBDMT, SBDMT and section 6.6 that concentrates on the Evaluation of Willingness and Acceptance of Adopting BDM, SBDM, and SBDMT.

While developing the Iranian sustainability assessment tool, the international ones indicated above can be assessed to make an analogy. As the verification process, different categories should be considered for an assessment process. For instance, energy efficiency does not have many differences in all the appraisal tools for worldwide concerns. It is worth noting that there are five assessment categories; Including energy efficiency, water efficiency, sustainable site, materials, and resources, and indoor environment quality (Zarghami et al., 2018).

Appendix 1 shows the code formation and content of respondents' firms speeches.

5.4 Limits and Limitations of the Study

Regarding the shortcomings of this research, it is worth mentioning that the number of respondents was following the scope of this research and allocated time for conducting the research. However, more respondents might have provided more generalizability of the results; also, lack of building design firms with SBD practice made it challenging to find the eligible respondents. The other limitation was the fact that reaching out to the respondents was difficult due to their limited time and workloads. Moreover, lack of municipal and policymakers respondents and educators is the other limitation of this study that might be covered in future work.

5.5 Summary of Chapter 5

Chapter 5 elaborates on data design of this research in terms of data collection and data analysis. For data collection, the respondents were specified using a snowball sampling method. Totally thirteen firms were selected for the open end questionnaire interview. Firms scale, years of operation, number of projects, owner's education, owners' major are specified in this study.

For qualitative analysis of survey results, after code formation, Vensim software is used to manage the mind maps, cause trees, uses trees, and loops. While for quantitative analysis, Excel charts were used as well as atrial python data analysis coding for calculation and visualization.

Among the limitations of this study are the number of respondents was following the scope of this research and limited time and high workloads of respondents which made it difficult and challenging to collect information. Moreover, lack of municipal and policy makers respondents and educators is the other limitation of this study.

CHAPTER 6

SURVEY RESULTS

For evaluating SBD, SBDM, and SBDMT implementation in building design firms in Iran, first, the overall relationships between sustainable development, sustainability, SBD, BDM, SBDM, and SBDMT and their subcategories were studied. Second, Tehran, Iran's case study environment and conditions regarding SBD regulation, and education system were studied. Third, based on the literature review relations and logic, a survey questionnaire was constructed. Finally, after choosing the participants who had shown practicing SBD in their building design firms, the interviews were conducted to collect the information, and the data were analyzed. In the following subsections, first, a discussion on findings of the literature review is provided. After that, the results of interviews and recommendations are presented.

Most of these mentioned obstacles and contributors are interwoven causes and effects of each other, which are strongly interrelated and affect each other. That is why the story of the situation of SBD/SBDM/SBDMT in Iranian building design firms out of managers' expression was representable.

In the following, there are 6.1. Evaluation of Sustainable Building Design Principles (SBDP), 6.2. Evaluation of Building Design Management (BDM) 6.3. Evaluation of sustainable building design management (SBDM), 6.4. Evaluation of Sustainable Building Design Management Tools (SBDMT), 6.5. Evaluation of Reediness of BDM, SBDM, and SBDMT, 6.6. Evaluation of Willingness and Acceptance of Adopting BDM, SBDM, and SBDMT, 6.7 .

Figure 26 shows the SBD categories and subcategories.

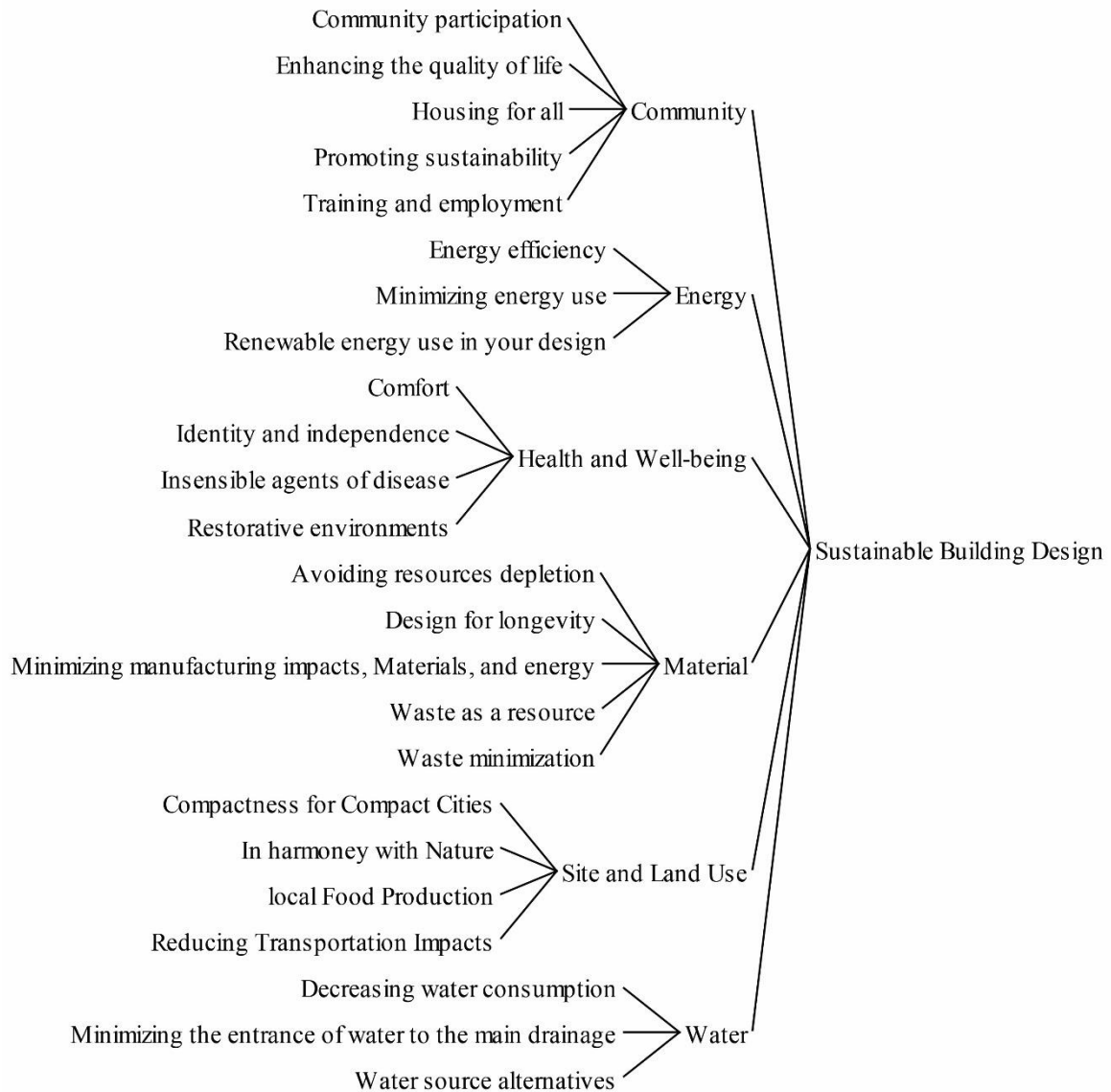


Figure 26. Sustainable building design categories and subcategories

6.1 Evaluation of Sustainable Building Design Principles (SBDP)

In order to be able to evaluate the SBD in building design firms in Iran, obstacles and success factors in implementing SBDP for each subcategory were surveyed. Figure 29 shows the SBD principles implementation

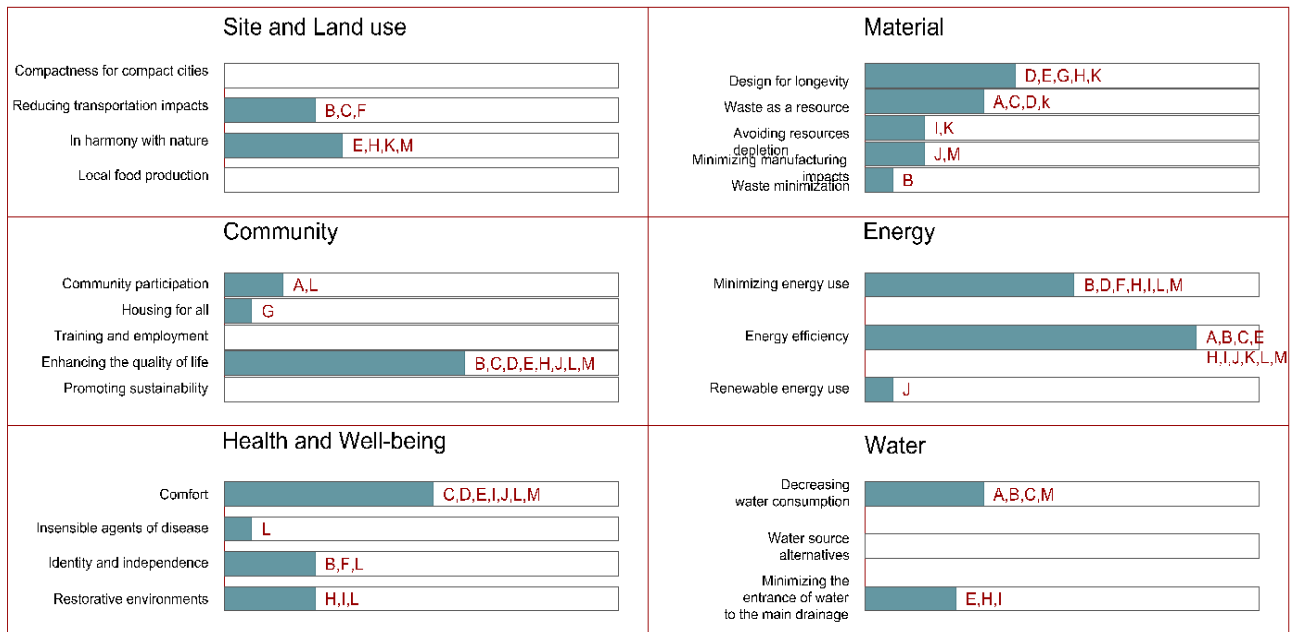


Figure 27. Sustainable building design principles implementation

6.1.1 Site and Land Use

Regarding the first category of SBDP, site and land use, less attention was given to compactness for compact cities, reducing transportation impacts, and local food production according to the interviews.

... Sustainable building design principles does not have anything to do with the compactness of cities... (A, B)

...I did not know that the more compact a city is, the more sustainable it is... (D)

As the respondents reported, the obstacles for implementing compactness for compact cities were as following phrases: disallowance by higher authority; governance, financial loss, improper informative education systems, lack of acceptance of sustainable principles among people and by the government, lack of regulation and penalties, lack of informative notification, lack of knowledge, lack of motivation, lack of people's priority, and misunderstanding.

...for a proper site and land, isn't it enough to follow the municipal limitations and rules?... (A)

...is the compactness for compact cities the same as traditional narrow alleys?... (C)

Among the obstacles for this item, governance disallowance, misunderstanding and lack of knowledge were the most mentioned reasons. Municipal regulations have rules for the density of construction, proportions, and height of each building that the constructors should obey. Lower than that threshold can be built. For the item “compactness for compact cities” the respondents did not violate it due to the regulations.

...I think high rise buildings cannot bring sustainability... (B)

On the other hand, building up less area of construction than the thresholds brings financial loss for the stakeholders since the prices are based on constructed interior areas.

...so we can increase the height of buildings to increase the sustainability... (D)

The participants reported that they paid attention to living interior spaces, yards, and parking spaces for each family or floors. Violating these predefined measures would end up with municipal penalties, including monetary fines or destruction. Designing less than the allowable areas also would cause stockholders' dissatisfaction due to financial loss when selling.

For the unawareness of implementing building design in harmony with nature, respondents reported an improper informative education system. While, for the success factors in implementing this item, user interests were pointed, and especially the women's interest in harmonious design with nature was highlighted. Women in Iran spend more time in houses and the women's softer emotions and insight for nature might be the reason for the women's interest in harmonious design with nature.

Half of the respondents specified that they tried to design in harmony with nature. Moreover, their definition of this harmony was various, including the best view to outside, allocating garden place, and excavation procedure.

One of the respondents declared that his team usually paid attention to the main lines of the master plan and followed them in their design. Also, there was a point to daylight and shading consideration using ladybug plugin of grasshopper and weather file data while considering site and land use.

For lack of local food production consideration in building design, they reported obstacles including improper informative education systems, lack of acceptance of sustainable development principles among people and by the government, lack of governmental regulation and penalties, lack of informative notification, lack of knowledge,

...It is the first time I hear that local food production is of interest to SBD... (H)

lack of people's priority, traditional design dominance, the traditional designers who were not updated but had influencing key role in decision making and teaching. Lack of knowledge and lack of acceptance among people and by the government were among the most cited items for the shortcoming in implementation of SBD.

...local food production needs maintenance, and people do not like being in trouble... (E, H)

Odor, maintenance, feeling of unfashionable or being insane, and time-consuming process of gardening were the causes that people and government do not like local food productions.

...people might think o local food production as something unfashionable and insane...(I, K)

...local food production is a time consuming for people and government...(J)

On the other extreme, all respondents attributed the local food production as one of the SBD principles which were related to the residence. Maintenance, gardening ability, time, and hygienic issues were among their probable responsibilities. These items might cause many occupants to reject local food productions despite their advantages. This might raise the technical issues for facility managers and technical designers to provide technical ease of gardening, automatic gardening and facilitating maintenance, to name just a few. Also, there might be an emergence of new job opportunities for building caretakers if there were not enough related technologies available.

...occupants should like the process of local food production and have time to do so...(All)

...children as the next generation need to learn sustainable behaviors... (A, H)

Concerning reducing transportation impacts, they reported obstacles including disallowed by govornance, improper informative education system, lack of knowledge, lack of motivation, and misunderstanding.

...For transportation issues, there should be trees for dealing with pollution; it does not have anything to do with SBD... (I)

Regarding reducing transportation impacts, some respondents pointed to the shortest and easiest way of allocating entrance to parking and access to streets.

In summary, Table 4 and Table 5 show respondents' stated phrases as obstacles and success factors in implementing sustainable site and land use, respectively.

Table 4. Obstacles in implementing sustainable site and land use

<i>Theme</i>	<i>Categories</i>	<i>Subcategories</i>	<i>Obstacles</i>	<i>Firms</i>
SBD	Site and land use	Compactness for compact cities	Disallowed by governance	D, E, G, H, J
			Financial loss	B, E,
			Improper informative education systems	D, H, J
			Lack of acceptance among people and government	B, H
			Lack of governmental regulation and penalties	D, F,
			Lack of informative notification	B, J,
			Lack of knowledge	A, B, C, D
			Lack of motivation	I, L
			Lack of people's priority	B, F,
			Misunderstanding	A, B, C, D, E, I, J, M
	In harmony with nature	Improper informative education systems		B, F, I
	Local food production	Improper informative education systems		C, H, I
			Lack of acceptance of SBDP among people and by the government	C, E, H, I, J, K, M
			Lack of governmental regulation and penalties	B, H,
			Lack of informative notification	D, E, I,
			Lack of knowledge	A, B, D, H, J, K, M
			Lack of people's priority	B, C, E, I,
			Traditional design dominance	F, J, K,
			Traditional designers who are not updated but have influencing key role in decision making and teaching	H,
	Reducing transportation impacts	Disallowed by governance		C, D, E, G, I, J,
			Improper education systems	H,
			Lack of knowledge	D,
			Lack of motivation	L
			Misunderstanding	B,

Table 5. Success factors in implementing sustainable site and land use

<i>Theme</i>	<i>Categories</i>	<i>Subcategories</i>	<i>Success factors</i>	<i>Firms</i>
SBD	Site and Land Use	Compactness for Compact Cities		
		In harmony with Nature	Attractive for Costumers	G, K, M
			User interests	B, G, H, K
		Local food production	The importance of Occupant's behavior	All

6.1.2 Community

The problem among the participants for answering this question was that they did not fully understand the content of this principle, or they thought that it was not entirely their responsibility. Among these items were training and employment and promoting sustainability.

...a sustainable training and employment need governmental supports and implementation... (A, H, J)

...Architects can't provide people with training and employment through their design; this is a responsibility of the education system and municipals...(C)

...architectural firms are not in charge of doing anything for sustainable training and employment...(D,E,M)

Most of the participants reported that in this category of SBD they practiced enhancing the quality of life through their building design. Also, very few participants specified that they adopted measures regarding community participation and housing for all. For this principle of SBD, they pointed that they used no tools. They just considered the physical proportion such as width and height of doors and other building elements for housing for all items out of Noifert standard or municipal regulation.

Regarding the obstacles of lack of community participation, the participants' firms reported improper informative education system and lack of informative notification, lack of knowledge; for lack of considering housing for all they reported misunderstanding and lack of knowledge; for lack of consideration of training and employment principle, they pointed lack of knowledge, lack of governmental regulation and penalties, known as out of the scope of their duties, and disallowed by governance. For lack of consideration of promoting sustainability, lack of knowledge, known as out of the scope of their duties, improper informative education systems was stated. The two items, “out

of scope of their duties” and “disallowance by the governance” were among the most cited cause of this shortcoming.

On the other extreme, for the success factors in implementing community participation community, the respondents reported the importance of occupant's behavior for community participation and, creativity, knowledge of physical proportions, potential of site, social science and understanding occupant aspects and needs, spending time on design and user interests for enhancing the quality of life.

Creativity was among one of the most cited items that respondents referred to as an important characteristic of a building designer who would like to enhance the quality of life. As another most cited item for this principle was spending time for design or, in other words preventing rush during design for enhancing the quality of life.

In summary, Table 6 and Table 7, respectively, show respondents’ stated phrases as obstacles and success factors in implementing a sustainable community.

Table 6. Obstacles in implementing sustainable community

<i>Theme</i>	<i>Category</i>	<i>Subcategory</i>	<i>Obstacles</i>	<i>Firms</i>
SBD	Community	Community participation	The improper informative education system	A, I, J,
			Lack of informative notification	A,
			Lack of knowledge	D, G, M
	Housing for all		Misunderstanding	A, B,
			Lack of knowledge	A, D, E,
	Training and employment		Lack of knowledge	A, G,
			Lack of governmental regulation and penalties	A,
	Promoting sustainability		Known as out of the scope of their duties	A, C, D, E, H, J, M
			Disallowed by governance	A, C, D, E,
			Lack of knowledge	
			Known as out of the scope of their duties	E,
			Improper education systems	B,

Table 7. Success factors in implementing sustainable community

<i>Theme</i>	<i>subcategories</i>	<i>Subcategory</i>	<i>Success factors</i>	<i>Firms</i>
SBD	Community	Community participation	The importance of Occupant's behavior	D
		Enhancing the quality of life	Creativity	C, E, F, J
			Knowledge of physical proportions	A
			Knowledge of potential of a site	B, M
			Understanding occupant aspects and needs	A, J
			Spending time	F, H, K
			User Interests	E

6.1.3 Health and Wellbeing

Regarding health and well-being, the participant had a better understanding of this principle of SBD compared to the previous ones.

...Compactness brings a sense of depression and is in contrast with quality of life...(E)

Their definition of this category and its subtitles was more inclined to those of literature. Most of the participants closely knew the comfort definition and items they pointed to physical comfort out of proportion, thermal comfort, visual comfort, and acoustic comfort. Also, they paid attention to mental comfort to some extent. They manually and traditionally dealt with this part or followed the local standard for window size or shading. 15% of respondents used simulation tools, including energy plus, Designbuilder, and grasshopper plugins for visual and thermal comfort consideration.

For lack of comfort consideration, the respondents reported traditional design dominance and designers who were not updated and also had influencing key role in the decision making in governance and teaching. Several respondents reported that older designers who had influencing decisions in critical positions did not use design evaluation tools, and preferred traditional design methods.

On the other hand, as for the success factors for comfort in SBD, ubiquitous and easy to use software and indices, availability of partial local standards, and availability of Persian tutorials were reported.

Insensible agents of disease was known for the participants. They were careful not to design anything that would promote mental and physical diseases.

...I know bad design may cause disease, we as a team critically pay attention to this...()

...Compactness might bring daylight availability issues... (J)

According to the respondents, identity and independence was defined as privacy issues, a reflection of self and activity of the occupants on building design and consideration of physical dimension and promotion for the activities that take place at homes and was spacious enough for their task and needs. These were the things that they followed when they designed. Lack of knowledge was the cited cause of shortcomings in implementing identity and independence in SBD.

...Why people need a sense of identity in their home?... (K)

They also knew the restorative environment; however, they declared no critical attempts to provide them in their design due to strict municipal regulation of the following privacy. They thought this was more connected to open balconies and nature connection and interior design. 23% of respondents reported that they tried to consider this item according to the potential of the site. For the last two items, they did not use any tools. Lack of knowledge and restriction due to the rules were reported as the obstacles for this item. Restriction due to the rules was the most cited item. Several respondents stated that restrictions of the rules and lack of flexibility among them did not let for providing restorative environments like open space greenery, getting together spaces, pools, etc. For lack of consideration regarding insensible agents of disease, they reported improper informative education systems, lack of financial priority, and lack of knowledge, lack of proper tools, or knowing them.

In summary, Table 8 and Table 9, respectively, show respondents' perceptions as obstacles and success factors in implementing sustainable health and well-being.

Table 8. Obstacles in implementing sustainable health and well-being

<i>Theme</i>	<i>Category</i>	<i>Subcategory</i>	<i>Obstacles</i>	<i>Firms</i>
SBD	Health and well-being	Comfort	Traditional design dominance traditional	K
			Designers who are not updated but have influencing key role in decision making and teaching identity	K

Identity and independence	Lack of knowledge	A, D, H, I, J
Insensible agents of disease	Improper informative education systems	
	Lack of financial priority	B, D, F
	Lack of knowledge	C, I
	Lack of proper tools or knowing them	J
Restorative environments	Lack of knowledge	C, D
	Restriction due to the rules	C, E, J, K, M

Table 9. Success factors in implementing sustainable health and well-being

<i>Theme</i>	<i>Category</i>	<i>Subcategory</i>	<i>Success factors</i>	<i>Firms</i>
SBD	health and well-being	Comfort	Ubiquitous and easy to use software and indices	I
			Availability of Partial Local Standards	B
			Availability of well-known Persian tutorials of tools	I, J

6.1.4 Materials

The understanding of the respondents regarding the fourth principle of SBD, material consideration, was not fully complete. Even though it is still much more than the first two principles, each respondent followed one, two, or more items of material consideration in the process of SBD. For most, they paid attention to design and select materials for longevity and waste as a resource. For minimizing manufacturing impacts, materials, and energy, they much more took into account the budget rather than sustainability. For example, they used local material because the cost of transportation to the construction site was less than remote materials. They declared that sometimes the users and stakeholders emotionally selected materials as a mere luxury and beauty or in contrast for a lower cost. This could override the designer and managers' decisions. Convincing these kinds of stakeholders was overwhelming.

Two of the respondents reported that they considered minimizing manufacturing impacts, materials, and energy. Besides, two of the respondent stated that they knew the problem of depletion of resources.

...Yes, yes, I know resource reduction is a problem and we consider on the prevention. I do not like to buy xxx (a particular stone) because I have witnessed that the mountains in this area are destroyed because of the excavation and mining of this material. However, our technical knowledge and information regarding this is not much. We should study long hours to understand what to do, which is not very logical to delay other parts of the design for one particular part... if there was a local updatable tool or a catalog with the information needed for simulation and other considerations of the material, it would be rewarding. If there was a tool which includes all the material in Iran and their characteristics it would be very helpful, you know like a library with filtering based on characteristics such as closeness... there might be something like this, but I do not know, as a firm we have not heard of it yet. For each design, we spend many times to find out the materials, their information... Actually this is the government's responsibility, to enhance a tool like that...()

Among the items of material consideration, less attention was given to minimizing the waste. Moreover, as for tools for this part, the respondents reported design-builder, energy plus, met, grasshopper tools, sensitivity analysis, and optimization.

In general, for lack of considering avoiding resources depletion, emotional selection, lack of knowledge, lack of proper tools, or knowing them, and limited budget was reported. For lack of design for longevity, emotional selection, lack of financial profit, lack of people's priority, lack of proper tools, or knowing them, a limited budget was reported. For lack of minimizing manufacturing impacts, materials, and energy, emotional selection, improper informative education systems, lack of knowledge, lack of proper tools or knowing them, and for lack of using waste as a resource, lack of proper tools, or knowing the respondents reported them. Also, for lack of consideration regarding waste minimization, lack of proper tools, or knowing them was reported.

In summary, Table 10 and Table 11, respectively, present respondents who stated their obstacles and success factors in implementing sustainable material use.

Table 10. Obstacles in implementing sustainable material use

Theme	Category	Subcategory	Obstacles	Firms
SBD	Material	Avoiding resources depletion	Emotional selection	A,
			Lack of knowledge	B, G,
			Lack of proper tools or knowledge	F, J,
			Limited budget	G, L, M

Design for longevity	Emotional selection	A,
	Lack of financial profit	A, H, I
	Lack of people's priority	F,
	Lack of proper tools or knowledge	J
	Limited budget	A, K, L
Minimizing manufacturing impacts, materials and energy	Emotional selection	B, L
	Improper education systems	K,
	Lack of knowledge	B, E, I
	Lack of proper tools or knowledge	
Waste as a resource	Lack of proper tools or knowledge	J
Waste minimization	Lack of proper tools or knowledge	J

On the other extreme, as for the success factors in implementing material consideration in sustainable building design, financial priority was mentioned for avoiding resource depletion. User interest was reported for a design for longevity, and financial profit and limited budget were reported for minimizing manufacturing impacts, materials, and energy. Also, financial profit and limited budget were mentioned for waste as a resource. Moreover, financial profit was mentioned for waste minimization.

As is evidence, financial profits are a strong success factors for implementing sustainable material consideration in SBD.

Many respondents noted that limited budget encouraged them to used waste as a resource. Providing more facilities such as tools or organization for doing this technically and optimally would be rewarding and welcome according to them.

Table 11. Success factors in implementing sustainable material use

<i>Theme</i>	<i>Category</i>	<i>Subcategory</i>	<i>Success factors</i>	<i>Firms</i>
SBD	Material	Avoiding resources depletion	Financial priority	K
		Design for longevity	User interests	A, M
		Minimizing manufacturing impacts, Materials, and energy	Financial priority	I
			Financial profits	B,
		Waste as a resource	Financial profit	A,
			Limited budget	A, B, G, L, M
		Waste minimization	Financial profit	I, M

6.1.5 Energy

Three subcategories of energy consideration as one of the pillars of SBD were evaluated in the respondents' point of view toward which the most attention was taken among the SBD principles. There was a weak understanding of the differences between "minimizing energy use" and "energy efficiency". Almost all the respondent thought they were the same. After clarification, 84% of the respondent reported that they paid intense attention to energy efficiency, and 53% declared that they considered minimizing energy use in their building design. As a tool and reference, they referred to the energy efficiency code of Iran. They declared that most of their attempts concentrated on this part in their SBD projects using many tools, including Design builder, Grasshopper tools, Ansys fluent, and many other simulation and analysis tools.

Even though the respondents had an adequate understanding and awareness of renewable energy use in a design, they seldom used them. As for a reason, they pointed to the high budget need for these kind of investments and too long payback time. Also, they noted that the market was not still providing many prolific installation and maintenance of renewable energy use.

...When people occupied the designer is not around to force the energy-efficient behavior, the occupant then themselves should manage the process...(H, J, K, M)

The clients thought of them as far illogical due to their budget and ease of using grid energy supply. Only one of the respondents noted using such an installation in their design. Lack of tools was reported for this item among the respondents.

In general, lack of English language skills for using tools, skill, and information, traditional designers who were not updated but had influencing critical roles in decision making and teaching were reported for a shortcoming in energy efficiency. Ease of using cheap grid energy was reported for lack of minimizing energy use.

...people prefer grid energies rather than renewable onsite energy sources...(B, D)

Ease of using cheap grid energies, high initial costs, lack of acceptance among people and government, lack of people's priority, lack of prolific installation equipment and services, long payback time, and stakeholder rejection were reported as the lack of renewable energy consideration in SBD. Figure 28 shows the obstacles in implementing energy considerations in sustainable building design.

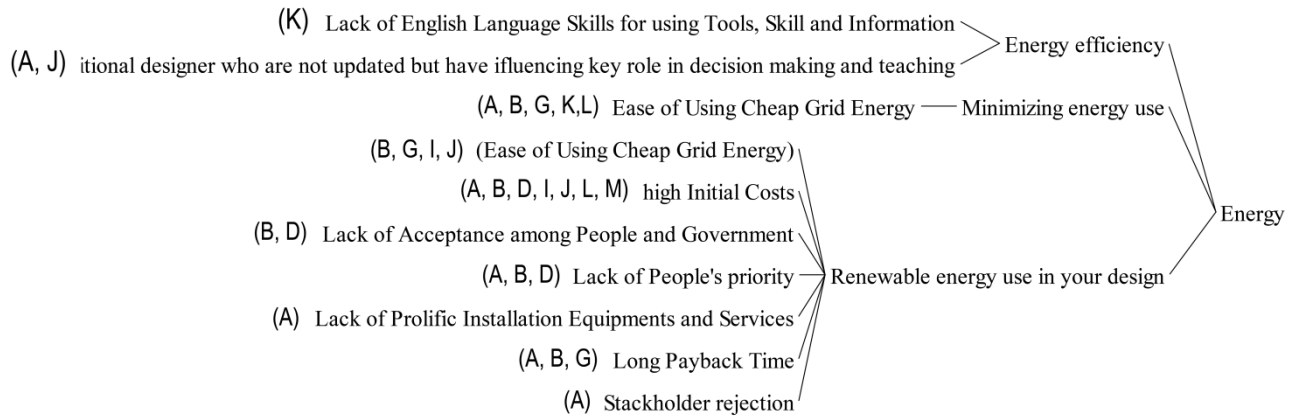


Figure 28. Obstacles in implementing energy consideration in sustainable building design

on the other hand, as the success factors of implementing energy consideration in sustainable building design, for energy efficiency, the existence of local code, the importance of occupant behavior and occupant training were reported. For minimizing energy use, the existence of local code, the importance of occupant's behavior, and occupant's training were reported.

...children, as the next generation needs to learn sustainable behaviors... (A, H)

...people will partly practice what they learn, while they will not be informed they might not know what is right or wrong, then they choose an easy lifestyle which is not always sustainable...(B)

Figure 29 shows the overall success factors in implementing energy consideration in sustainable building design.

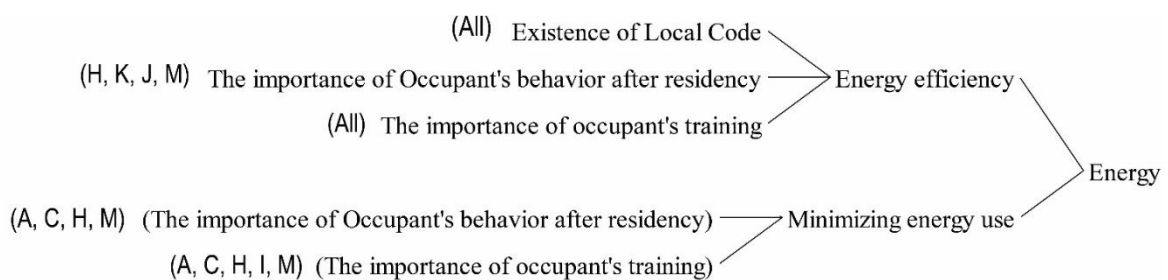


Figure 29. Success factors in implementing energy consideration in sustainable building design

6.1.6 Water

Four out of thirteen respondents reported that they not only did not consider water consideration in their design but also had no idea how to do it. They explained that they did not know any tools, standard, or design technique for this matter.

...I have heard of the water sources alternatives and gray water, I know about them; I know which tools would provide water efficiency in the design but I have not tried it in reality since they are time-consuming and costly; also, the stakeholders do not prefer adopting them. Also, we need specialized experts, equipment, installation, and trying to adopt the system can delay construction. Moreover, we may need maintenance...(A, E)

Nevertheless, three out of thirteen respondents noted minimizing the entrance of water to the main drainage, especially in the construction period. However, they did not clarify how. Furthermore, 38% of the respondents reported that they paid attention to decrease water consumption while designing wet spaces, cleaning areas, and dry spaces via keeping in mind piping consideration. They did not know any special tools, sources, or standards. They thought decreasing water consumption was the responsibility of the occupants rather than the building designer.

In general, as the obstacle for consideration of water in SBD, for decreasing water consumption, improper informative education systems, lack of governmental regulation and penalties, and lack of knowledge were reported. For minimizing the entrance of water to the main drainage, improper informative education systems, known as out of the scope of their duties, lack of governmental regulation and penalties, and lack of knowledge were reported.

For lack of water source alternatives, financial loss, high initial costs, improper informative education systems, lack of acceptance among people and government;

...people think that alternative water sources like gray water have a religious problem...(A)

...people might think alternative water sources are not hygienic... (M)

lack of English language skills for using tools, skill, and information, lack of governmental regulation and penalties, lack of informative notification, lack of knowledge, lack of people's priority, lack of prolific installation equipment and services, long payback time and stockholder rejection were reported. On the other hand, the importance of occupant behavior was reported as a success factor for decreasing water consumption.

...there should be public training in a sustainable lifestyle."(All)

...if the occupant knows how to decrease how to minimize the entrance of water to the main drainage...(D)

Furthermore, for mitigation of water use, the importance of occupant's training and occupant's behavior were highlighted. In summary, Table 12 presents respondents stated phrases as obstacles in implementing sustainable water management.

Table 12. Obstacles in implementing sustainable water management

<i>Theme</i>	<i>Category</i>	<i>Subcategory</i>	<i>Obstacles</i>	<i>Firms</i>
SBD	Water	Decreasing water consumption	Improper informative education systems	H, K,
			Lack of governmental regulation and penalties	H,
			Lack of knowledge	A,
		Minimizing the entrance of water to the main drainage	Improper informative education systems	
			Known as out of the scope of their duties	A, I
			Lack of governmental regulation and penalties	K
			Lack of knowledge	A
		Water source alternatives	Financial loss	A, C, F, L, M
			High initial costs	A, C, E, J
			Improper education systems	J
			Lack of acceptance among people and by the government	A, C, M
			Lack of English language skills for using tools, skill, and information	F
			Lack of governmental regulation and penalties	K,
			Lack of informative notification	B,
			Lack of knowledge	
			Lack of people's priority	A, C,
			Lack of prolific installation equipment and services	A,
			Long payback time	B, C, E,
			Stockholder rejection	C, I,

6.1.7 Most Mentioned Keywords as Obstacles and Success factors in Implementing SBD

The most mentioned items in general for lack of consideration of SBD reported by participants are presented in Figure 30 to Figure 35. These items are included in Figure 30. Items that are affected by lack of knowledge, Figure 31. Items that are affected by improper informative education systems, Figure 32. Items that are affected by lack of informative notification, Figure 33. Items that are

affected by lack of peoples' priority, Figure 34. Items that are affected by lack of proper tools or know, Figure 35. Items that are affected by lack of acceptance among people and by the government.

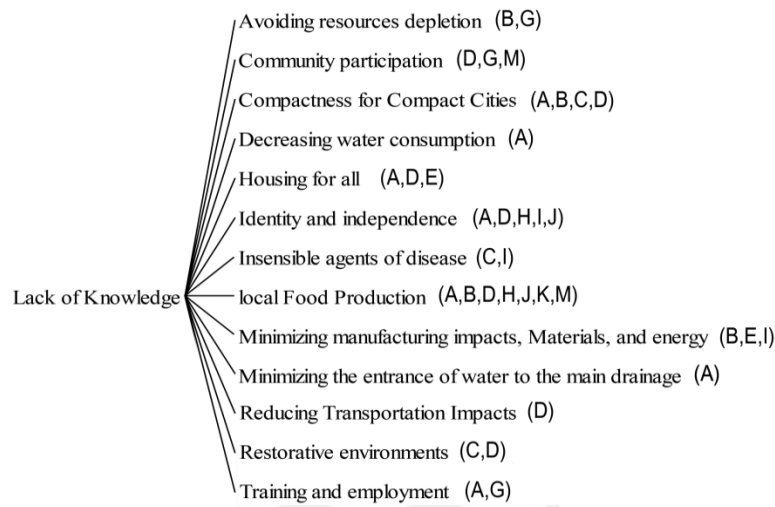


Figure 30. Items that are affected by lack of knowledge

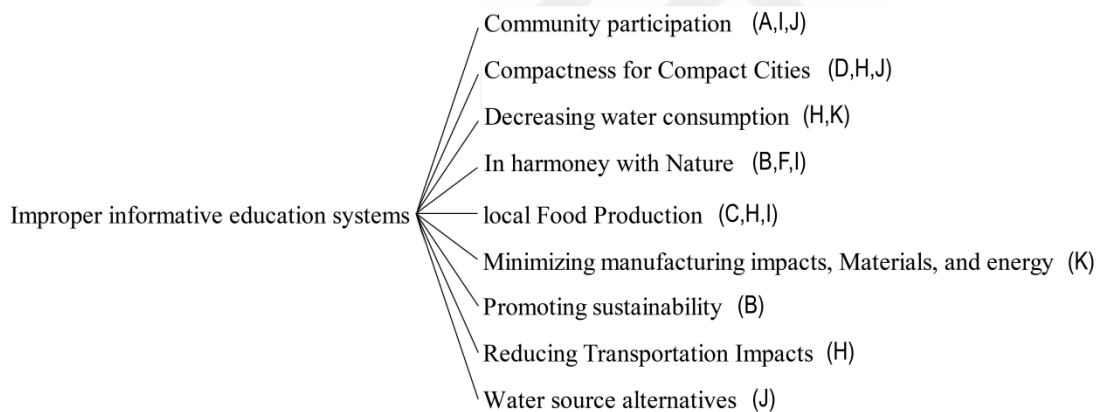


Figure 31. Items that are affected by improper informative education systems

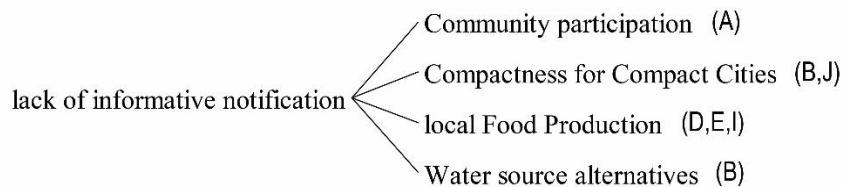


Figure 32. Items that are affected by lack of informative notification

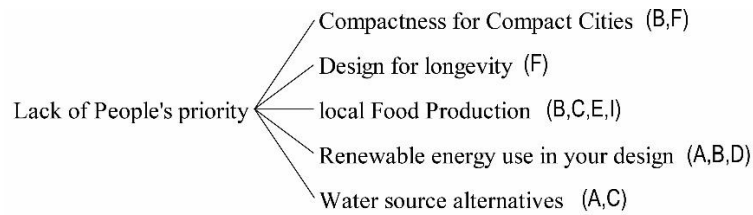


Figure 33. Items that are affected by lack of peoples' priority

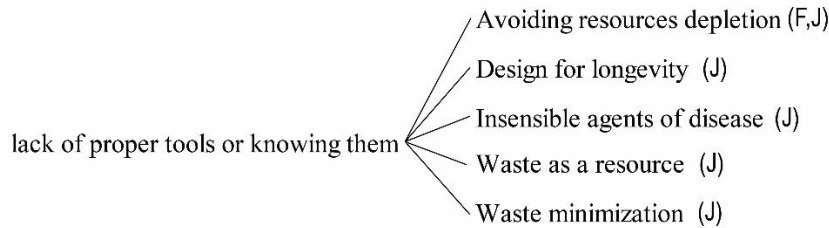


Figure 34. Items that are affected by lack of proper tools or knowledge

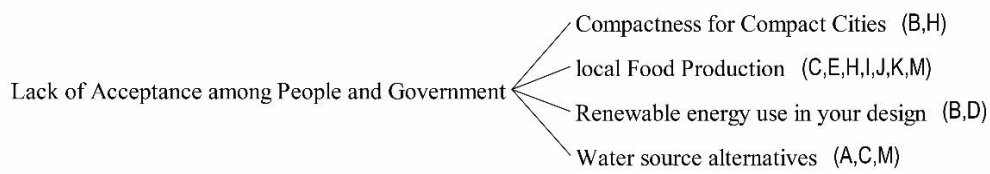


Figure 35. Items that are affected by lack of acceptance among people and by the government

On the other hand, in Figure 36. Items affected by occupants' behavior , Figure 37. Items affected through training occupants show the most mentioned contributors to implementing SBD.

In these two mentioned items, the managers held people accountable and responsible for SBD and thought it did not happen unless they will become taught properly and after that contribute their knowledge in their lifestyle and daily behaviors.

The significant role of occupants' behavior in supplementary to efficient design, operation, retrofit towards energy efficiency at low cost was also highlighted by Hoes et al., (2009); Hong et al., (2015). The importance of this factor is since the occupants of the buildings tend to spend 80%-90% of their time inside the buildings (T. Roberts, 2016), and they seek quality and comfort in their indoor environment beyond a mere survival status (Citherlet et al., 2000).

Also, The importance of teaching the occupants for sustainable building was reported by Rekola et al. (2012). They explained the need for teaching the occupants how to use the buildings and

technologies, getting feedback from the users, or post-occupancy valuation in the operation stage of building the life cycle. Knowledge would increase by learning the principles of sustainable buildings while understanding a more efficient operation of the building. The more care the inhabitants give to the usage of their building, the possible success would be for a sustainable design method (Sassi, 2006; Sodiq et al., 2019). Besides, educating people towards sustainable water consumption is essential to accomplish water saving (Sassi, 2006).

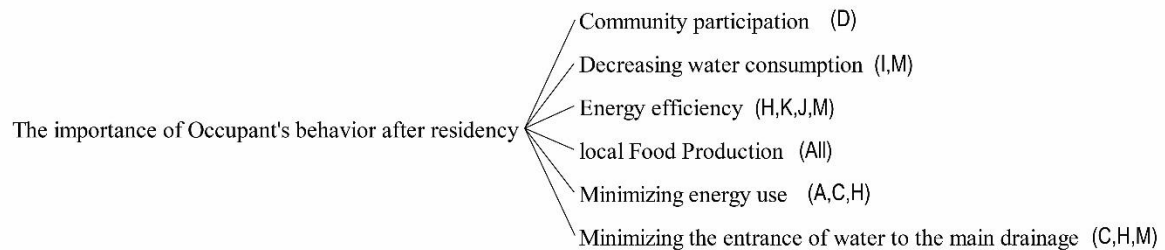


Figure 36. Items affected by occupants' behavior

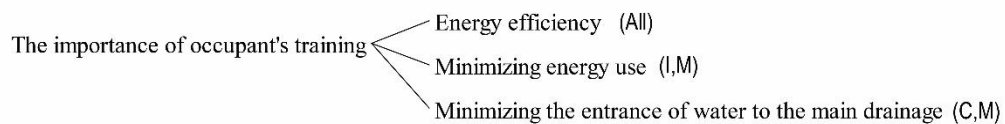


Figure 37. Items affected through training occupants

Overall, Figure 38. The overall mind map of obstacles in implementing sustainable building design.
 Figure 39. The overall success factors in implementing sustainable building design.

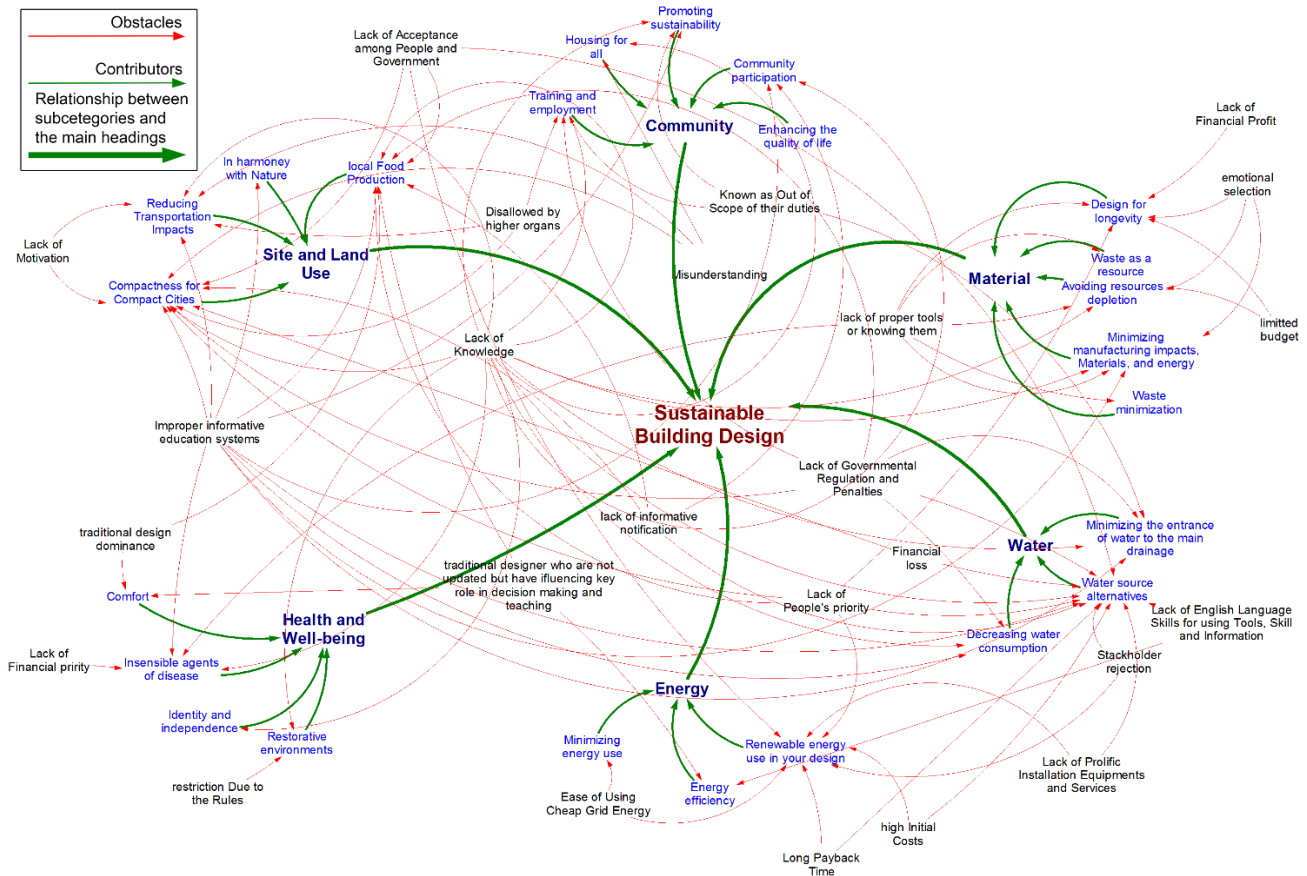


Figure 38. The overall mind map of obstacles in implementing sustainable building design

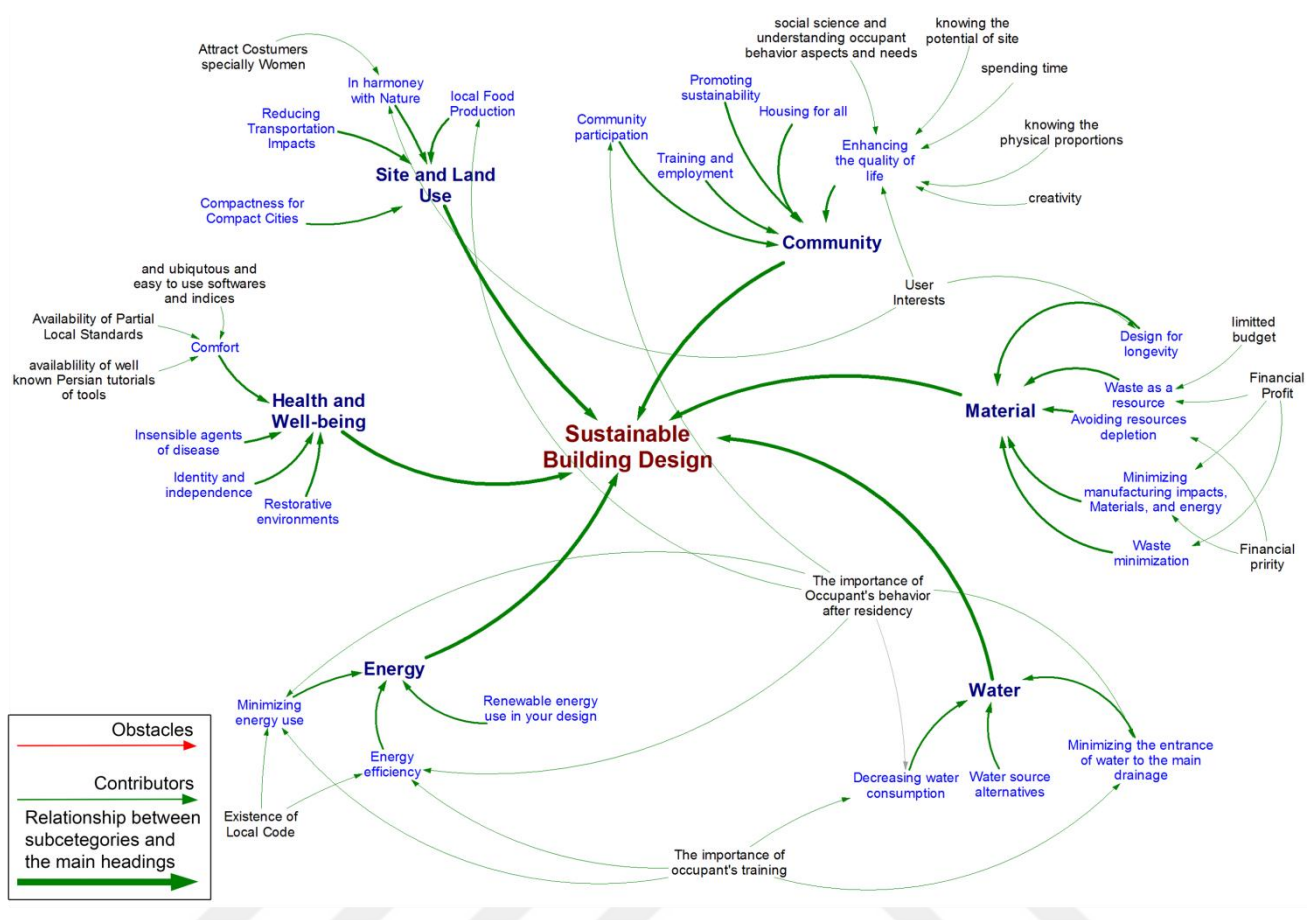


Figure 39. The overall success factors in implementing sustainable building design

6.2 Evaluation of Building Design Management (BDM)

6.2.1 Project Management

Emotional conflicts, filtering (like telegram), insufficient consideration, and lack of decision-making tools or knowledge about them were reported as the obstacles for project management. Assigning correct person to each task, flexibility for partial changes, following up the deadlines of the individual tasks and paralleling tasks, graphic design for conveying results for customers and staffs, high-quality environment for exchanging information and saving and searching, high-quality informative connection between the employees and experts and collaboration, high team workability, knowing the rules, rights, and ethics, not to fail the customers' needs, optimization, optimization power of passing from negligible, prediction of possible occurrences and predefined solutions and alternatives, preventing redundant or valueless detailed conversation among experts, success in finding and

receiving project, well defined agreements between customers, stakeholders and employers, well defined time table, well defining the projects, well justifying the stakeholders and client (a powerful justifying briefing), well understood project definition among the project members were reported as the success factors in implementing project management.

Among these items assigning a correct person to each task, preventing redundant or valueless detailed conversation among experts, success in finding and receiving project was the most cited success factors for BDM in Iran. Most of the respondents indicated that assigning a correct person to each task played a significant role. A proper tool for identifying these people and their profession and experience speedily could facilitate this. Respondents spoke about a harmful situation in which interdisciplinary projects when an expert tended to talk in detail, the technical language to others would delay the process and violate the agendas, cause redundancy and valueless conversation among members. Most of the participants declared that in an SBD projects, finding a project to do was one the most difficult, one of the reasons why SBD was not an primary issue for most in Iran.

....indeed, the first step for the SBD project is finding one...(E, H, J)

...there is not always an SBD project available if a firm could find one; it is a success...(K)

6.2.2 Stakeholder Management

For stakeholder management, emotional conflicts, lack of proper tools, or knowing them were reported as obstacles. While, Knowing the rules, rights, and ethics, Not to fail the customers' needs, patience, Preventing redundant or valueless detailed conversation among experts, well defined agreements between customers, stakeholders and employers, Well justifying the stakeholders and client (Powerful justifying briefing) were reported as success factors.

6.2.3 Business Management

Emotional conflicts were reported as an obstacle for business management in building design firm. While for success factor in business management, participants reported items including expanding salary on the project first then taking salaries and profit, not to fail the customers' needs, personal website, channel, or forum,

...The world has been changed to a world of virtual connection internationally, in this world, it is of importance to show yourself to be prosperous, this is for a large part possible in online platforms like personal websites...(C)

...for most, we find our employers and customers through our online platforms...(E)

...followers intensify the validity and reliability of SBD firms...(J)

...personal platforms are strong marketing, business, and information management...(K)

prediction of possible occurrences and predefined solutions and alternatives, preparing good graphical resume in which the strength ability and achievements are highlighted, teaching intensify learning and economic income, well-defined agreements between customers, stakeholders and employers, well defined time table, well justifying the stakeholders and client (a powerful justifying briefing)

6.2.4 Education Management

For education management, abusing informative information and tutorial in other businesses, filtering (like telegram), traditional designers who are not updated but have influencing critical roles in decision making and teaching were reported as obstacles.

...whenever we teach, we try first to learn something deeply...(A, J)

...lack of sustainable awareness among students and experts raises the idea of teaching for whom know the principles... (D, E)

While, consulting with professionals and experts, expending money and time for learning something new and helpful, which is in worldwide trend, high-quality environment for exchanging information and saving and searching, a High-quality, informative connection between the employees and experts and collaboration, teaching intensifies learning and economic income is considered as success factors.

The overall obstacle for BDM in Iranian building design firms is presented in

Table 13.

Table 13. Obstacles of implementing BDM in Iranian building design firms

<i>Theme</i>	<i>Category</i>	<i>Subcategory</i>	<i>Obstacles</i>	<i>Firms</i>
BDM	Business management		Emotional conflicts	E
	Education management		Abusing informative information and tutorial in other businesses	J
			Filtering (like telegram)	A, J
			Traditional designers who are not updated but have influencing key role in decision making and teaching	G,

Project management	Emotional conflicts	C, J
	Filtering	K,
	Insufficient consideration	C, G,
	Lack of decision-making tools or knowledge	E, G, J
Stakeholder management	Emotional conflicts	E, J, M
	Lack of proper tools or knowledge	J

The overall success factors for BDM in Iranian building design firms are presented in Table 14 and Figure 40.

Table 14. Success factors in implementing BDM in Iranian building design firms

<i>Theme</i>	<i>Category</i>	<i>Success Factors</i>	<i>Firms</i>
BDM	Business Management	Expending salary on the project first then taking salaries and profit	A
		Not to fail the customers' needs	C
		Personal Website, channel, or forum	A, S, E, J
		Prediction of possible occurrences and predefined solutions and alternatives	I, K, L
		Preparing an excellent graphical resume in which the strength ability and achievements are highlighted	D, J
		Teaching intensify learning and economic income	A, D, E, J
		Well defined agreements between customers, stakeholders, and employers	M
		Well defined time table	A, D
		Well justifying the stakeholders and client (Powerful justifying briefing)	J
Education Management		Consulting with professionals and Experts	A, C, D, I, L
		Expending money and time for learning something new and helpful, which is in a worldwide trend	H, J, K
		High-quality environment for exchanging information and saving and searching	C, J
		A high-quality informative connection between the employees and experts and collaboration	H, J
		Teaching intensify learning and economic income	H, J
PM		Assigning a correct person to each task	A, C, E, G, H, J, M
		Flexibility for partial changes	E, J
		Following up the deadlines of the individual tasks and paralleling tasks	B,
		Graphic design for conveying results for customers and staffs	J

	A high-quality environment for exchanging information and saving and searching	C, J
	A high-quality, informative connection between the employees and experts and collaboration	C, J
	High team workability	B, C
	Knowing the rules, rights, and ethics	L, M
	Not to fail the customers' needs	E, G
	Optimization	J
	Power of passing from negligible	I, J
	Prediction of possible occurrences and predefined solutions and alternatives	F, G
	Preventing redundant or valueless detailed conversation among experts	C, D, J, F
	Success in finding and receiving project	E, E, H, K, J
	Well defined agreements between customers, stakeholders, and employers	F
	Well defined time table	A, D
	Well defining the projects	A,
	Well justifying the stakeholders and client	J
	Well understood project definition	A, M
Stakeholder Management	Knowing the rules, rights, and ethics	B, F
	Not to fail the customers' needs	H
	patience	F
	Preventing redundant or valueless detailed conversation among experts	C, D, J
	Well defined agreements between customers, stakeholders, and employers	B,
	Well justifying the stakeholders and client	G, I

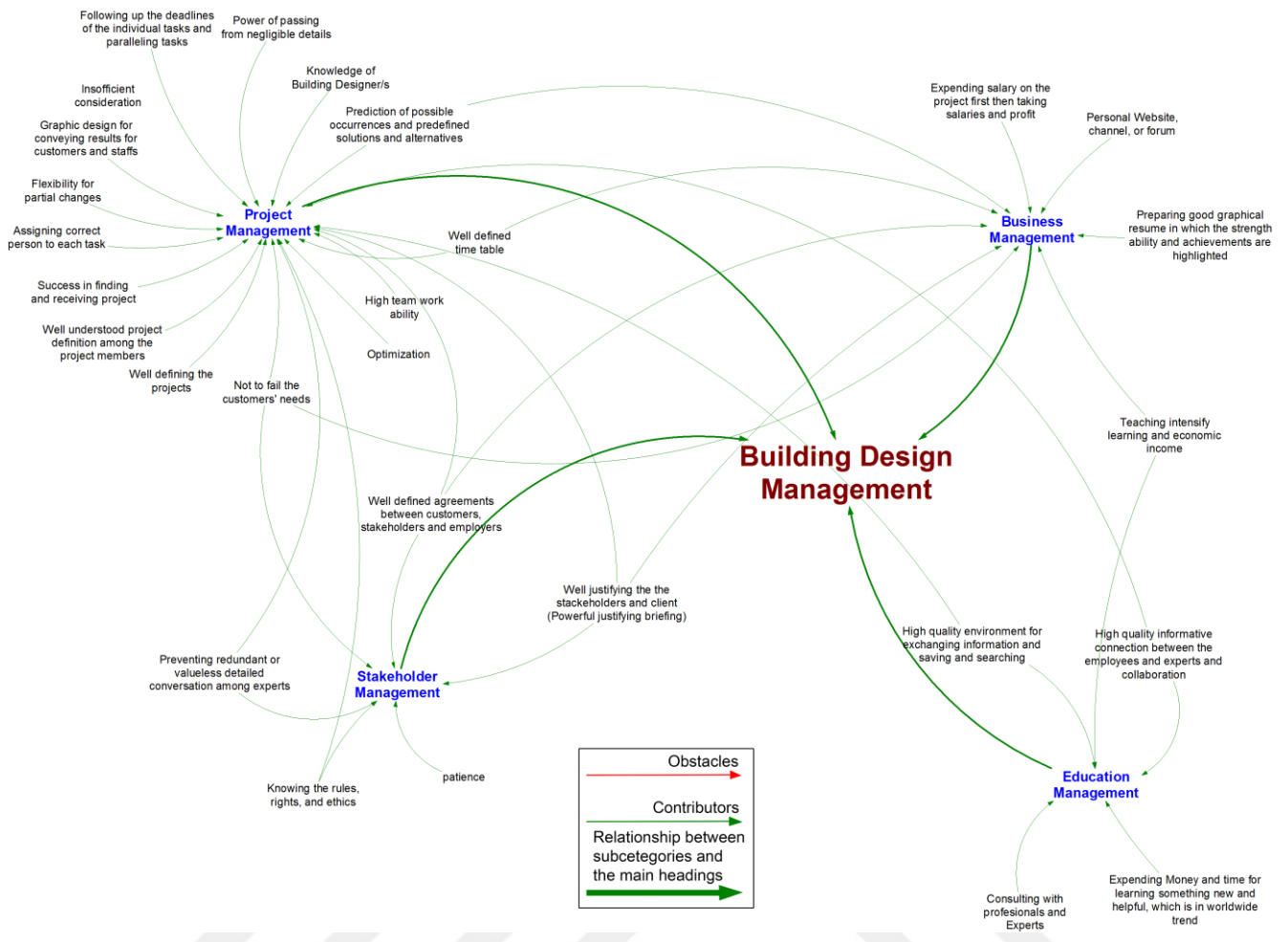


Figure 40. Success factors mind map in implementing BDM in Iranian building design firms

6.3 Evaluation of sustainable building design management (SBDM)

6.3.1 Strategic Planning

Lack of decision-making tools or lack of knowing them, lack of knowledge, lack of proper tools or knowing them, the similarity of rules in all the regions of a country, following up the deadlines of the individual tasks and paralleling tasks, understanding the nature of project are the obstacles of strategic planning. See Table 15 and Figure 41.

...In case I want to do monitoring an SBD, how can I convince the people to let me do so?...(M)

Mentioned success factors for this item are following up the deadlines of the individual tasks and paralleling tasks, understanding the nature of project, organizational structure, experience, graphic

design for conveying results for customers and staffs, high-quality environment for exchanging information and saving and searching, internship, interview, lack of decision making tools or lack of knowing them, personal website, channel, or forum, financial management, accompanying teaching to conducting project as for more salary, comparison of income and expenses, newborn discipline, success in finding and receiving project, people management, consulting with professionals and experts, expending money and time for learning something new and helpful, which is in worldwide trend, high-quality environment for exchanging information and saving and searching, high-quality informative connection between the employees and experts and collaboration, personal website, channel, or forum, teaching intensify learning and economic income, business management and marketing, finding and conducting students' project, increasing followers, personal website, channel, or forum, powerful resume preparing good graphical resume in which the strength ability and achievements were highlighted, providing beneficial contents for free to attract people, receiving feedback, information system, high-quality environment for exchanging information and saving and searching, High-quality informative connection between the employees and experts and collaboration, mobile phone banking, Planning and controlling the overall design and service process, careful review at each step, consulting related experts, continuous monitoring, entrusting work to experts. See Figure 42 and Table 16.

6.3.2 Organizational Structure

Emotional selection, financial priority, lack of decision-making tools or lack of knowing them, lack of experienced experts, low salaries, traditional designers who were not updated but have influencing key role in decision making, and teaching were the mentioned obstacles for organizational structure. See Table 15 and Figure 41.

While, Experience, graphic design for conveying results for customers and staff, a high-quality environment for exchanging information and saving and searching), internship, interview, lack of decision-making tools, or lack of knowing them, personal website, channel, or forum were reported as the success factors. See Figure 42 and Table 16.

6.3.3 Financial Management

Accompanying teaching to conducting the project as for more salary and comparison of income and expenses were the respondents reported success factors for financial management. See Figure 42 and Table 16.

6.3.4 People Management

For implementing people management, filtering (like telegram), lack of knowledge, lack of proper tools, or knowing them, the misunderstanding was reported as the obstacles.

...People management is the same as only customer service management... (M)

While, consulting with professionals and experts, expending money and time for learning something new and helpful, which is in worldwide trend, a high-quality environment for exchanging information and saving and searching, a high-quality informative connection between the employees and experts and collaboration, personal website, channel, or forum, teaching intensify learning and economic income. See Table 15 and Figure 41.

Among the reported success factors in people management, having a personal website, channel, or forum are most cited. Such items show the importance of a changed atmosphere of traditional BDM with advanced information technologies and internet facilities. See Figure 42 and Table 16.

6.3.5 Business Management and Marketing

For business management and marketing, participants pointed to filtering (like telegram), lack of government support, and lack of proper tools or knowing them, the fact that SBD is a new discipline as the obstacles for business management. See Table 15 and Figure 41.

Expendung salary on the project first then taking salaries and profit, not to fail the customers' needs, personal website, channel, or forum, prediction of possible occurrences and predefined solutions and alternatives, preparing good graphical resume in which the strength ability and achievements are highlighted, teaching intensifies learning and economic income, well-defined agreements between customers, stakeholders, and employers, well defined time table, well justifying the stakeholders and client (a powerful justifying briefing), teaching intensifies learning and economic income was reported as the success factors in implementing business management regarding SBDM. See Figure 42 and Table 16. Several respondents highlighted the fact that SBD is a new discipline. This item is the most cited one for business management and marketing regarding SBDM.

...sustainble building design... many professionals still do not know the advantages, and that is why we do not tend to undergo this kind of design...()

Among the most cited items as success factors were personal website, channel, or forum and the fact that teaching intensifies learning and economic income, finding and conducting students' project, increasing followers, personal website, channel, or forum, powerful resume, preparing good graphical resume in which the strength ability and achievements are highlighted, providing beneficial contents for free to attract people.

Lack of educational systems and students, staff, and designers' English language ability to use the global resources have prepared a business opportunity for some designers and staff to teach SBD, SBDM, and SBDMT the others.

6.3.6 Information System

For information system, filtering (like telegram), lack of knowledge, weak hardware were reported as obstacles (See Table 15 and Figure 41) while a high-quality environment for exchanging information and saving and searching and a high-quality informative connection between the employees and experts and collaboration were reported as success factors. See Figure 42 and Table 16.

6.3.7 Planning and Controlling the Overall Design and Service Process

For planning and controlling the overall design and service process, lack of experienced experts, lack of local code appropriateness, lack of proper tools or knowing them, the similarity of rules in all the regions of the country, traditional designers who are not updated but have influencing key role in decision making and teaching, lack of decision-making tools or lack of knowing them were reported as the obstacles in implementing Planning and controlling the overall design and service process for SBDM. See Table 15 and Figure 41.

As for the success factors, the participants reported careful review at each step, consulting related experts, careful review at each step, continuous monitoring, and entrusting work to experts.

The importance of continuous review and check-in each step for preventing losing the chain of process and overwhelming correction, which destroys the other next steps. Also, several respondents stated that SBD needs consultants and experts in different fields rather than a designer who knew all the things. See Figure 42 and Table 16.

6.3.8 Performance Evaluation

Lack of knowledge, lack of local code appropriateness, lack of proper tools or knowing them, misunderstanding, the similarity of rules in all the regions of the country were reported as the obstacles of performance evaluation of SBD in Iranian firms. The insufficiency of local code for performance evaluation is also highlighted in (Zarghami et al., 2018). This item is among the most cited item by the participants. Also, Optimization results and simulation results were reported as the success factor for this item.

The overall obstacles in implementing SBDM in Iranian firms are presented in Table 15 and Figure 41.

Table 15. Obstacles in implementing sustainable building design management

<i>Theme</i>	<i>Category</i>	<i>Obstacles</i>	<i>Firms</i>
SBDM	Strategic planning	Lack of decision-making tools or knowledge	G,
		Lack of knowledge	B, H, I, J, M
		Lack of proper tools or knowledge	E, J,
		The similarity of rules in all the regions of the country	J
	Organizational structure	Emotional structure	B,
		Financial priority	B, F,
		Lack of decision-making tools or knowledge	J
		Lack of experienced experts	A,
		Low salaries	A, F,
		Traditional designers who are not updated/ have influencing key role	E, F, H,
	People management	Filtering	J
		Lack of knowledge	A, D, G,
		Lack of proper tools or knowing them	J
		Misunderstanding	A, M
	Business management and marketing	Filtering	J
		Lack of government support	C
		Lack of proper tools or knowing them	L
		Newborn discipline	A, C, J, M
	Information system	Filtering	A, D,
		Lack of knowledge	J
		Weak hardware	A
	Planning & controlling design and service process	Lack of experienced experts	A, J, K,
		Lack of local code appropriateness	E
		Lack of proper tools or knowing them	I, J,
		The similarity of rules in all regions	F

Traditional designers who are not updated/ have influencing key role		E
Performance evaluation	Lack of decision-making tools or knowledge	D, F, K,
	Lack of knowledge	F, G,
	Lack of local code appropriateness	B, E, F, J,
	Lack of proper tools or knowing them	B, D,
	Misunderstanding	B, C, F,
The similarity of rules in all the regions of the country		C

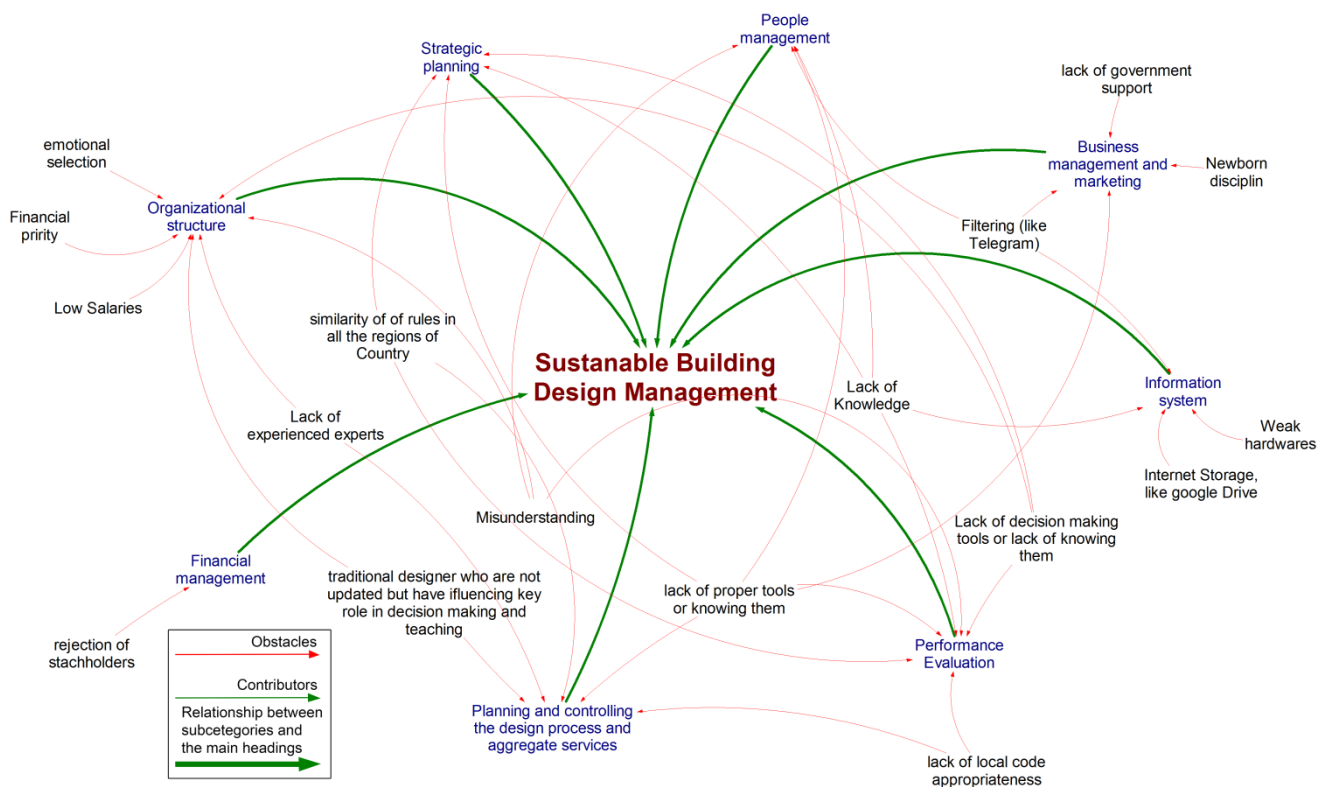


Figure 41. Obstacles in implementing SBDM mind map

The success factors in implementing SBDM in Iranian firms are presented in Figure 42 and Table 16.

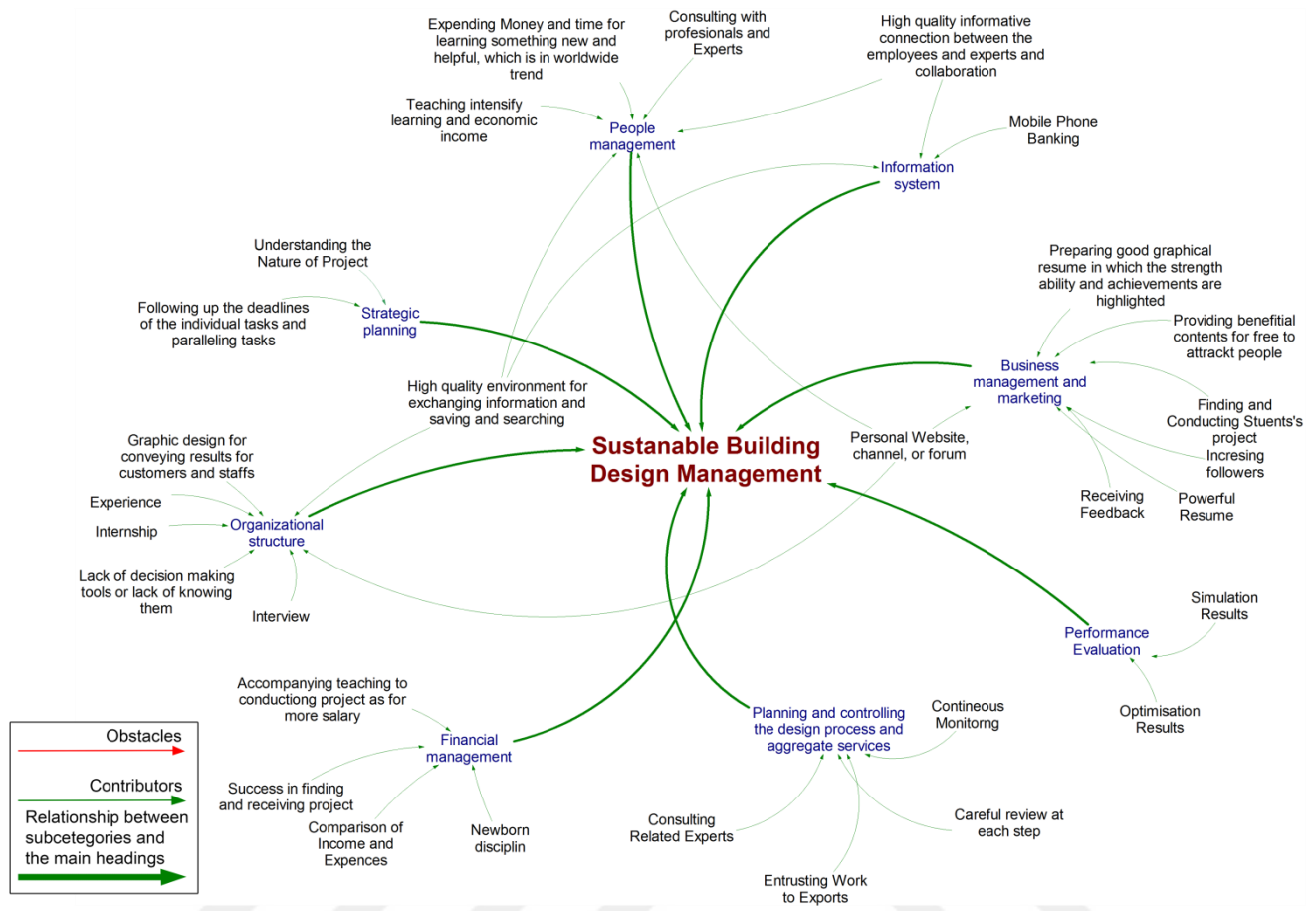


Figure 42. Success factors in implementing SBDM mind map

Table 16. The overall success factors in implementing sustainable building design management

Theme	Category	Success factors	Firms
SBDM	Strategic planning	Following up the deadlines of the individual tasks and paralleling tasks	G, L
		Understanding the Nature of Project	A, H
	Organizational structure	Experience	I, L
		Graphic design for conveying results	J
		High-quality environment for exchanging information and saving and searching)	J, L
		Internship	F, H
		Interview	C, M
		Lack of decision-making tools or knowledge	J
		Personal Website, channel, or forum	C, J
	Financial management	Accompanying teaching to conducting the project as for more salary	J
		Comparison of Income and Expenses	A,

	Newborn discipline	H, J
	Success in finding and receiving project	J
People management	Consulting with professionals and Experts	A, D
	Expending money and time for learning something new and helpful, which is in a worldwide trend	F, J
	High-quality environment for exchanging information and saving and searching	C, J
	A high-quality informative connection between the employees and experts and collaboration	C, J
	Personal Website, channel, or forum	C, E, J, K
	Teaching intensify learning and economic income	J
Business management and marketing	Finding and Conducting Students' project	A, C, D, E, J, K
	Increasing followers	C, E, J, K
	Personal Website, channel, or forum	C, J, K
	Powerful Resume preparing in which the achievements are highlighted	C, D, F, H, I, J
	Providing beneficial contents for free to attract people	C, E, J
	Receiving Feedback	E
Information system	High-quality environment for exchanging information, saving and searching	C, J
	The high-quality informative connection between the employees and experts and collaboration	C, H, J, K
	Mobile Phone or Internet Banking	E, G
Planning & controlling design and service	Careful review at each step	C, E, H
	Consulting Related Experts	A, D, F, H, K
	Continuous Monitoring	C, H, I, K, L
	Entrusting Work to Experts	A, D, I, L, M
Performance evaluation	Optimization Results	J
	Simulation Results	E, J

6.4 Evaluation of Sustainable Building Design Management Tools (SBDMT)

6.4.1 Process Tools

Confusion, difficult decision making, insufficiency of local process tools checklist, etc., lack of cost-effectivity, lack of English language skills for using tools, skill, and information, lack of government support, lack of governmental regulation and penalties, lack of knowledge, lack of motivation and

acceptance, lack of resources, time-consuming process of using tools, too complicated tools are the reported obstacles of implementing process tools in building design firms in Iran. See Table 17 and Figure 43.

...The problem with the tools is that we do not always know the logic behind the tools... (J)

Confusion and insufficiency of local process tools are among the most cited items regarding the obstacles of using process tools. The existence of a bunch of texts and information for process tools, lack of validity, and reliability among many of them, as well as lack of peoples' ability to discern good ones from bads, were reported as reasons for confusion while trying to followed process tools. As success factors in using process tools in Iran are using international codes, local codes, a manual combination of checklists, and optimization. See Table 18.

6.4.2 Design Evaluation Tools

Hardware limitations, high costs lack cost-effectivity, lack of English language skills for using tools, skill, and information, lack of governmental regulation and penalties, lack of knowledge, lack of motivation and acceptance, time-consuming process of using tools, too complicated tools, traditional design dominance, traditional designers who were not updated but had influencing key role in decision making and teaching were stated as obstacles.

...most of them teach in schools many unfashioned techniques... (E)

"They don't undergo learning new techniques and tools." (J)

"Hardware limitation" was the most cited obstacle in implementing design evaluation tools in Iran.

...SBDMT needs high ranked hardware, which is expensive...(C)

...Sometimes, the laptops become hot and soundly while using these tools...(E)

The other most cited item as an obstacle for these tools was traditional design dominance. As the success factors in using design evaluation tools, mentioned by the participants, were the previous customers' satisfaction and qualitative ranking.

6.4.3 Assessment Tools

Lack of cost-effectivity, lack of English language skills for using tools, skill, and information, lack of governmental regulation and penalties, lack of knowledge, lack of motivation and acceptance, partial using of international tools, time-consuming process of using tools,

...I had to keep my computer on for days because of the heavily running simulation... (J)

too complicated tools, traditional designers who are not updated but have influencing key role in decision making and teaching were stated as obstacles.

...they say whatever we say is insufficient...(A)

...they don't let new designers and ideas to grow...(K)

(See Table 17 and Figure 43). as a success factor, partial use of international tools was reported.

6.4.4 Monitoring Tools

Hardware limitations, high costs, lack of cost-effectivity, lack of English language skills for using tools, skill, and information, lack of facilities, lack of governmental regulation and penalties, lack of knowledge, lack of motivation and acceptance, lack of people contribution, lack of proper tools or knowing them, privacy issues, time-consuming process of using tools, too complicated tools were reported as the obstacles in using monitoring tools. See Table 17 and Figure 43.

...Monitoring needs many internets of things hardware connections and installation... (G)

High costs and lack of cost-effectivity are among the gaps in using monitoring tools, which worth researching to provide more facilities and solutions to ease the process of using them via more options and knowledge. POE could be conducted using these tools. On the other extreme, as success factors that let Iranian respondents to use monitoring tools are an online survey for receiving feedbacks and acting similar to monitoring for the BDM process. See Table 18.

Table 17. Obstacles in implementing sustainable building design management tools

<i>Theme</i>	<i>Category</i>	<i>Obstacles</i>	<i>Firms</i>
SBDMT	Process tools	Confusion	C, F, G, I, L,
		Difficult decision making	F, G, I,
		Insufficiency of local process tools, checklist, etc.	C, I, J, M
		Lack of cost-effectivity	F, G
		Lack of English language	E

	Lack of government support	H,
	Lack of governmental regulation and penalties	G,
	Lack of knowledge	B, H,
	Lack of motivation and acceptance	G, K,
	Lack of resources	C, E, I,
	The time-consuming process of using tools	E, G,
	Too complicated tools	C, I,
Design evaluation tools	Hardware limitations	C, E, G, J,
	High costs lack cost-effectivity	F, G,
	Lack of English language skills	B, G, M
	Lack of governmental regulation and penalties	G, J,
	Lack of knowledge	L
	Lack of motivation and acceptance	A, C,
	The time-consuming process of using tools	A, B, I,
	Too complicated tools	A, H, I,
	Traditional design dominance	A, B, E, J, K,
	Traditional designers who are not updated but have influencing key role in decision making and teaching	B, G,
assessment tools	Lack of cost-effectivity	F, L,
	Lack of English language skills	G, J,
	Lack of governmental regulation and penalties	H, J,
	Lack of knowledge	A, M
	Lack of motivation and acceptance	E, G,
	Partial using of international tools	E, G,
	The time-consuming process of using tools	A,
	Too complicated tools	I,
	Traditional designers who are not updated but have influencing key role in decision making and teaching	J
Monitoring tools	Hardware limitations	I,
	High costs	C, D, F, G, J, L
	Lack of cost-effectivity	C, D, F, G, M
	Lack of English language skills for using tools, skill, and information	F, L
	Lack of facilities	D, K,
	Lack of governmental regulation and penalties	D,
	Lack of knowledge	A,
	Lack of motivation and acceptance	E
	Lack of people contribution	C, E, G, J, M
	Lack of proper tools or knowing them	E,
	Privacy issues	A, H,
	The time-consuming process of using tools	A, G,
	Too complicated tools	C, G, J

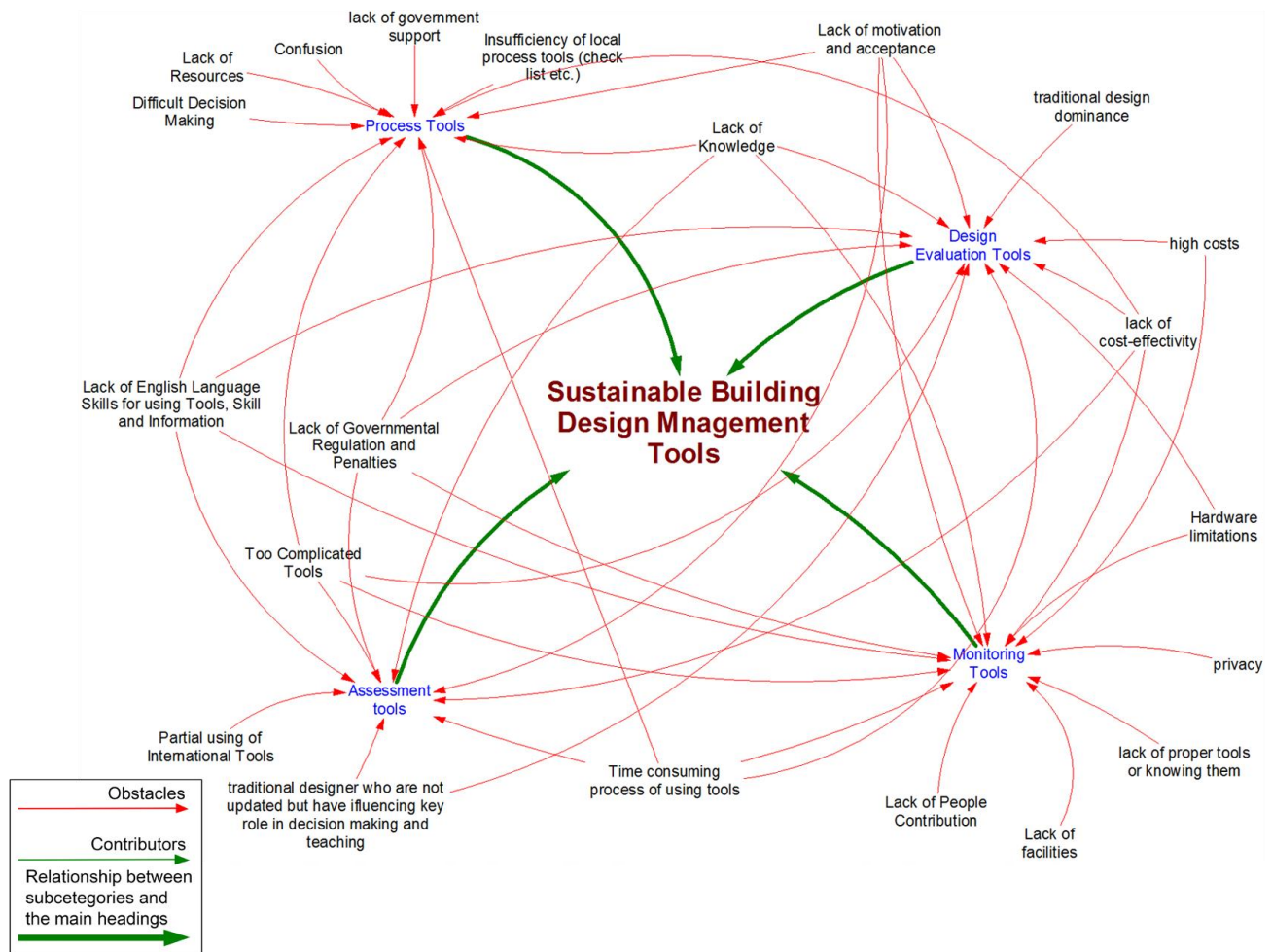


Figure 43. Obstacles for implementing sustainable building design management tools mind map

The overall success factors in implementing SBDMT in Iranian building design firms are presented in Table 18.

Table 18. Overall success factors in implementing sustainable building design management

Theme	Category	success factors	Firms
SBDMT	Process Tools	International Codes	D, F, G, J, M
		Local Codes	C, E, F
		Manual Combination of Checklists	B,
		Optimization	J
	Design Evaluation Tools	Previous customers satisfaction	D, E
		Qualitative ranking	C
	Assessment Tools	Partial using of International Tools	D, B, F, J

Monitoring Tools	Online survey for receiving feedbacks	J
	Similar to Monitoring for BDM Process	D

The overall relationship between sustainability, sustainable development, SBD, BDM, SBDM, and SBDMT is presented in Figure 44.

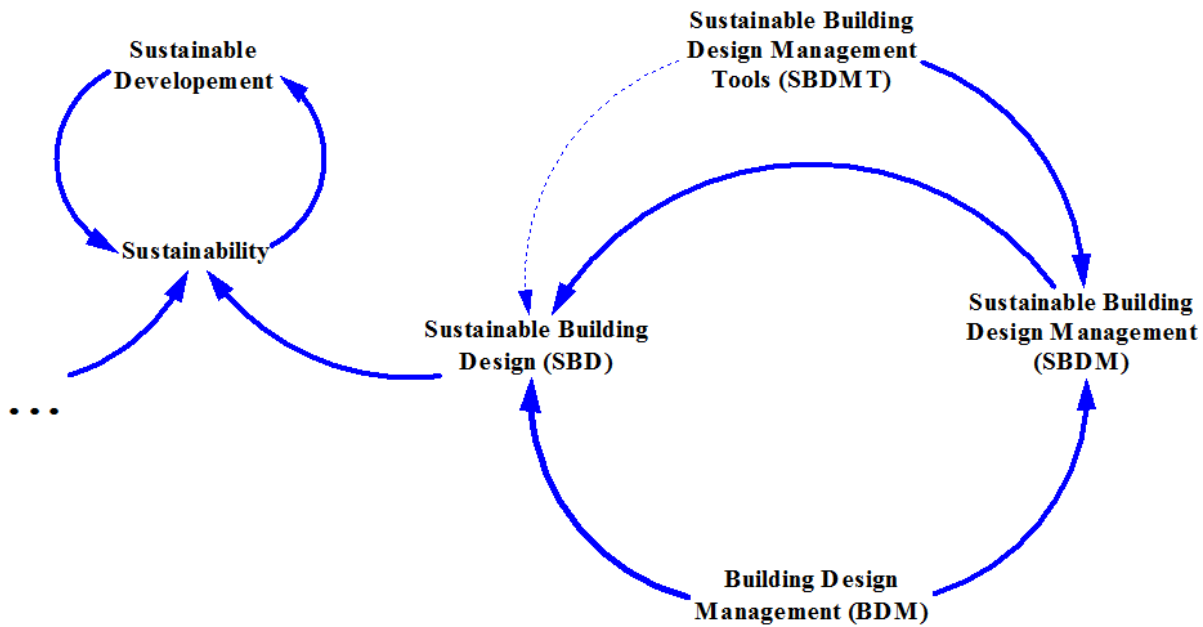


Figure 44. The overall relations among sustainable development, SBD, BDM, SBDM, and SBDMT

6.5 Evaluation of Reediness of BDM, SBDM, and SBDMT

6.5.1 Leadership

In the leadership level, seven of the respondent (managers) thought they needed to change towards SBDM. Three declared an intermediate need for this change. While one of them reported no idea about this change, one reported a little need for change towards SBDM. No one reported "no need" for change towards SBDM.

On the other hand, respectively, eight of the respondents declared that they had intermediate and four of the respondents stated that they had high power to change towards SBDM. While one of them declared no idea about possessing this power, one of them reported a little power for this change.

6.5.2 Business Performance

Regarding business performance, no one reported that the business side highly lets them take SBDM measures in their building design firms. Nine of the respondent reported an intermediate feasibility allowance of the business side for SBDM. While, two of respondent declared no idea of this issue, one of reported a little allowance of the business side for SBDM.

6.5.3 Organizational Culture

This part measured to what extent the respondent considered the organizational culture (both inside and outside) was ready to adopt SBDM.

Only one of the respondent stated that this readiness was high, one reported that it did not exist and one stated that he had no idea about it. Five declared that low, the other five reported an intermediate readiness. The population of those declared a low level of readiness was the same as those declared an intermediate level of readiness of organizational culture to adopt SBDM.

6.5.4 Operating Environment

Answering the question “how much do you think your company is ready for conducting SBDM in terms of operation (hardware, software, knowledge, database, etc.)?” most of the respondents reported an intermediate level of operational readiness. While four of them declared they had more than intermediate reediness for operating SBDM. No one declared low or no readiness for the operational readiness of adopting SBDM. However, one of the respondents stated that he had no idea of answering this question.

6.5.5 Workforce

Regarding the extent to which the respondents' current employees and staff or their future applicants had the ability for SBDM, no one reported no ability or low level of ability. More than half of the respondents reported that they thought their current or future employees and staff had an intermediate level of ability for doping SBDM While one of the respondents had no idea for this issue.

6.5.6 Technical Environment

Most of the respondents think that the supply management chain was supported in terms of technology, continuous training feasibility, colleagues. While a few of the respondents think this

support was at a high level for the supply management chain. On the other hand, two of the respondent could not talk about this issue because they did not have any idea about it. While two of the participants thought there was a highly supportive environment for the supply management chain for SBDM.

6.6 Evaluation of Willingness and Acceptance of Adopting BDM, SBDM, and SBDMT

From the technology transmission point of view, most of the respondents had no idea of whether they were using SBDM/SBDMT for workflow operation. However, most of them were strongly willing to adopt SBD, SBDM, and SBDMT experiences.

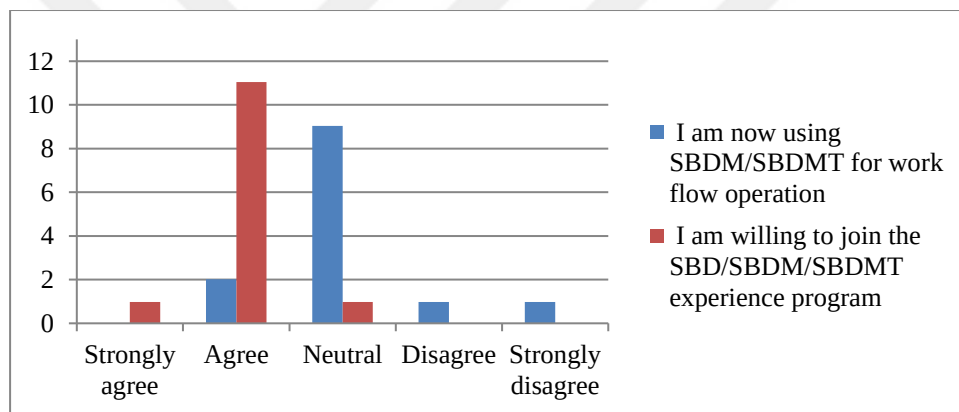


Figure 45. SBD/SBDM/SBDMT technology transmission

From the external environment, including conditions and factors influencing the forms' SBD/SBDM/SBDMT-related activities, adoption, opportunities, and risks, most of the firms acknowledged that SBD/SBDM/SBDMT are helpful to develop new types of business compared to the traditional kind of building design. Most of the firms were neutral about the fact that whether they were satisfied with the current process of building projects regarding SBDM or not. While the rest majority reported that they were not satisfied with that.

Many respondents thought that SBDMT was helpful toward the current process of building projects. No one reported that it was not helpful in this regard. Most of the respondents were strongly and moderately desire to used SBD/SBDM/SBDMT in the future process of building projects. Some of

the respondents reported that SBD/SBDM/SBDMT couldn't improve the efficiency of business communication, while many others have reported the opposite.

A few numbers of respondents thought that SBD/SBDM/SBDMT couldn't improve owner satisfaction. However, most of the managers reported that it can improve satisfaction among the owners. More than half of the firms' managers reported that they thought SBD/SBDM/SBDMT was helpful to solve construction disputes, while some of them were neutral about this. Many managers acknowledged the helpfulness of SBDMT outputs to clarify drawings. Firms' managers had a willingness to adopting SBD/SBDM/SBDMT. They stated that if they knew that the other competitors had adopted it they would have adopted it too.

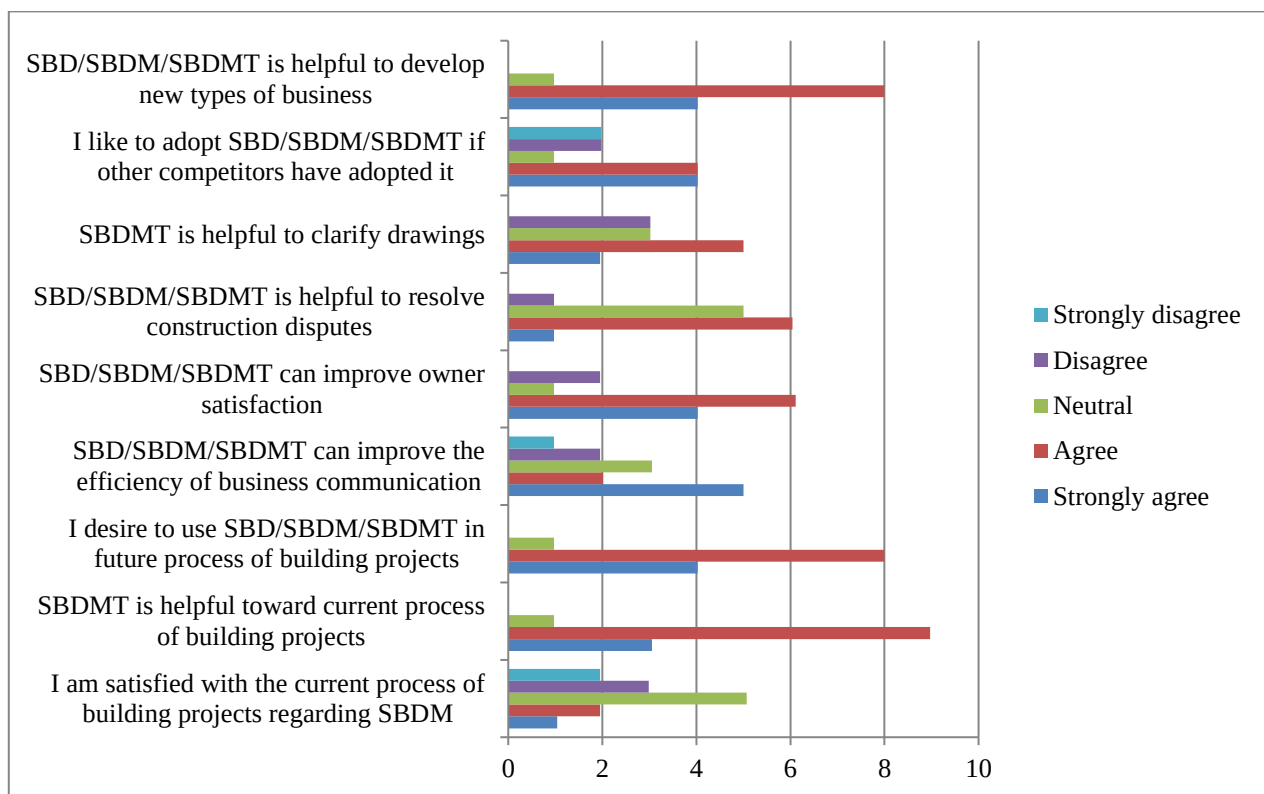


Figure 46. External environment: conditions and factors influencing the organization's SBD/SBDM/SBDMT-related activities, adoption, opportunities and risks

From the employees' issues (staff adoption for SBD/SBDM/SBDMT and workload reduction), there was a rather acceptable willingness in firms' owners.

The managers thought that most of the employees were willing to accept SBD/SBDM/SBDMT adoption. However, most of the managers think that it was easy to operate SBD/SBDM/SBDMT for employees; some of them think that it wasn't. On the other extreme, some of the respondents were

neutral about the fact that SBDMT could improve workload reduction over the long term while many others were positive about it. Figure 47. Employees: staff adoption of SBD/SBDM/SBDMT and workload reduction) status in Iran.

From the internal factors (improving workflow efficiency) perspective, there is an acceptable agreement with the use of SBDM and most of the managers were positive about adopting them.

More than half of the respondents stated that SBDMT could improve the efficiency of existing processes of SBD. And, even though none of the managers disagreed that SBDMT could improve the exchange of quality drawings, most of them were neutral about it and a few of them thought it could improve the exchange of quality drawings. Moreover, most of the respondents believed that SBD/SBDM/SBDMT can improve communication quality.

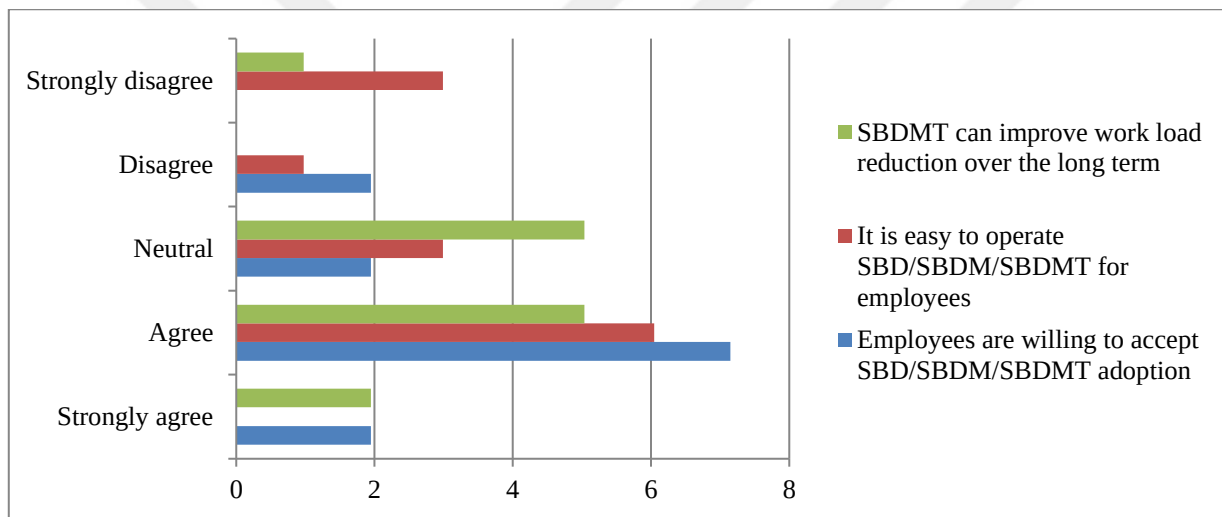


Figure 47. Employees: staff adoption of SBD/SBDM/SBDMT and workload reduction

More than half of the firms' owners thought that SBD/SBDM/SBDMT could improve innovation and development of an architectural design. And, most of the firm's owners agreed or strongly agreed that SBD/SBDM/SBDMT could improve organizational learning. Figure 48. Internal factors: improving workflow efficiency) status of participants building design firms in Iran.

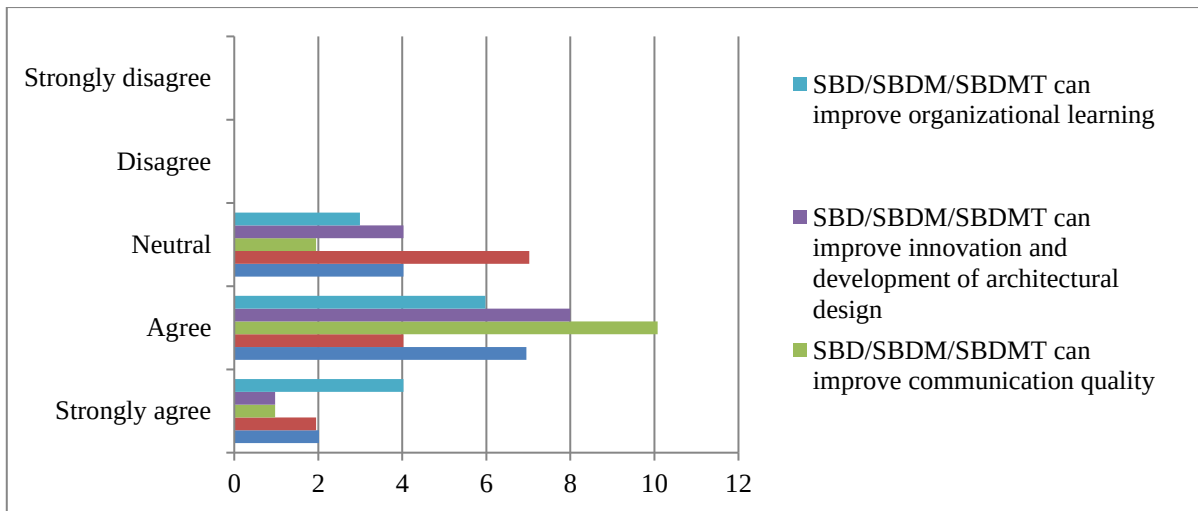


Figure 48. Internal factors: improving workflow efficiency

6.7 Characteristics of the Firms

Following is the description of thirteen firms based on self-reported characteristics in Table 2.

Seven respondents were at the Ph.D. level, four were at the master level, and two were at the undergraduate levels, five were in architecture major, three were in an architectural engineering major, two were architecture-energy major, and one was in urbane design engineering.

Three of the firms were very small, four of them were small, two of them were very large, and the rest four of them were medium. Very large and medium firms had more years of operations. Very small firms were sole operation based or corporation in nature firms. The numbers of partnership and corporation firms were more than others. Partnerships and corporations firms had conducted more projects than others. Years of operation didn't influence a number of SBD project conducted by the firms. Architecture majors had conducted more projects than others and after that was an architecture-energy major.

In contrast to graduate level managers, undergraduate level managers were less concerned about the lack of compactness in the site and land used resulting from disallowing by higher organizations. Moreover, this item had more concerns among partnership firms compared to other kinds of firms.

Medium firms cited the fact that lack of knowledge was the cause of shortages in compactness for compact cities. They reported that user interest (especially in women), caused SBD in harmony with nature.

...greenery attracts feminine house buyers...(B)

All the firms confirmed the fact that local food production needs occupants' actions. While the very small and small graduated level and firms were more concerned about the fact that lack of acceptance among people and government prevented this item from implementing. Graduates level firms were more concerned about the fact that the designers were not allowed to do actions regarding reducing transportation impact. While larger and medium firms were more concerned about the fact that partially used international codes could help the implementation of SBD in Iran. Architecture majors were more in favor of the idea that partially used of the international codes was useful for SBD implementation in Iran.

On the other extreme, owners of the firms with 11-15 employees found using process tools confusing. This confusion was one of the reasons that prevented a successful SBD implementation in Iran. Smaller firms were more concerned about the fact that there was insufficient local process tools checklist etc. Plus, graduate-level firms were more concerned about hardware limitations for using design evaluation tools. It was among the obstacle of implementing SBDM according to the respondents.

Younger firms (fewer years of operation) earned part of their income from training tools. They insisted that spending on learning the world trends d SBDM and SBDM and teaching them to others not only helped them learned and grew information and updates, but also generates revenue. They also had to do student projects for income generation.

Many younger firms were concerned about finding an SBD project. They tried to aware people and government regarding SBDM and advantages in the hope of taking a job and improve the future of this profession. Some of them did it solely for the sake of their interest and their main source of income came from elsewhere.

Among the younger and smaller firms, there was concern about online platforms to attract more customers. They stated that it can intensify learning, advertisement, and reputation, and improve connections. these startups were popular in well-educated and senior-level firms These firms managed their information online and had good communication management and information exchange compared to large and older firms.

Young firms were unhappy with the dominance of traditional architects who lack information and have an influential and decisive role in the academic and construction sectors with high job security.

Besides, in terms of tools, both young and old firms and small and large firms complained about hardware limitations and the high cost of some SBDMT for those that weren't open sources.

6.8 Summary of Chapter 6

Quantitative analysis showed that among the SBD principles, energy consideration attracted the most attention while water management, site and land use had received less attention.

The high payback time of energy and water efficiency strategies in buildings and local code deficiency were the reasons for lack of sufficient success in managing sustainable water and energy use in buildings in Iran. While educating occupants and their behavior after residency as well as partial use of international codes were the most important success factors according to the respondents. The information the respondents had about water consideration in SBD was high. Despite this, they did not implement it in their SBD practices. Searching the education system in Iran concerning water consideration in SBD, it has been cleared that there was not enough informative education system focused on this issue in none of the education levels. Recent water crises in the country attracted the managers to grasp knowledge on water consideration in general and in SBD in their own will and curiousness.

Lack of knowledge and misunderstanding was the most critical reasons for implementing sustainable site and land use. The review of the education system regarding sustainable site and land use showed that, there was insufficiency of information. The most mentioned items for lack of consideration of SBDP were lack of knowledge, improper informative education system, lack of informative notification, lack of peoples' priority, lack of proper tools or not knowing the tools and lack of acceptance among people and by the government.

Education in Iran Regarding SBD was reviewed using the databases of the education system in Iran from high school to the Ph.D level. syllabus and course regulations. The results show that except for the energy principle, which was provided in master period titled Architecture and Energy (Memari-energy) and some basics of construction and design, there was weakness. The respondents also reported a self-inattention and constraint in an attempt among the individuals (Managers, staff, graduates people, etc.) towards understanding the principles of sustainability and SBD. On the other hand, occupants' behavior and training occupants showed the most mentioned contributors to implementing SBD. In these two mentioned items, the managers held people accountable and

responsible for SBD and stated that it would not happen unless the occupants adopted principles of sustainability into daily behaviors.

For site and land use and community, many respondents suffered from misunderstanding and lack of knowledge. While many of them also accepted it as out of scope of their duties and/or state responsibility. They also reported poor informative information and education system regarding this item. It was reported that lack of knowledge and lack of financial priorities embedded in deficiencies regarding health and well-being considerations in building design. Limited budget and lack of knowledge were the items that prevented sustainable material use in building design projects.

Firms' personal platform (website, channels, etc.), as well as teaching abilities, were counted as the most crucial success factors for business management in Iranian SBD firms while emotional conflicts were the most cited obstacle.

The courses provided in architectural education in Iran, did not include financial management and strategic planning, which the graduates had to learn through master degree or by experience. Lack of experienced experts was reported as an obstacle for planning and controlling the overall design and service process. Regarding organizational structure, traditional designers who didn't update their knowledge in SBDM and had critical decision making roles as well as job security were introduced as a threat. The lack of local code appropriateness was pointed as a threat to performance evaluation in SBDM. A high-quality environment for exchanging, receiving, storing, and retrieving information was reported as the most important factor for successful information system management.

Confusion and insufficiency of local process tools were among the most cited items regarding the obstacles of using process tools. The non-existence of information for process tools, lack of validity, and reliability, as well as lack of peoples' ability to discern appropriate ones were reported as reasons for confusion for process tools. Using international codes, local codes, a manual combination of checklists, and optimization were stated as success factors. "Hardware limitation" was the most cited obstacle in implementing design evaluation tools in Iran.

The items that were most mentioned concerning SBDMT were lack of knowledge, lack of motivation and acceptance, lack of English language skills for tools and information, lack of government regulation and penalties, lack of cost-effectivity, the complexity of tools and time-consuming process of using tools.

Years of operation made differences in use of SBDMT. While older firms' owners took lesser attention and did not need updates and improvement regarding these items, the younger firms' owners substantially searched proving their ability and institutionalize the newly emerging techniques regarding the topic under consideration of this study. They compensated for their monitory deficiency by teaching the tools and principles and accepting the student projects for supervision. They complained about the traditional older decision-makers regarding SBD, SBDM, and SBDMT.

Evaluation of readiness for adopting SBDM and their associated tools in SBD firms in Iran showed that the majority was not ready for this change. While from the operating environment, employees' capability, there was a medium readiness. Also, fewer respondents thought that their firms' technical environment didn't have readiness for adopting these items. From the perspective of willingness, the majority of respondents were willing to join for the aforementioned items. However, they had a neutral explanation of the procedure. even though they doubted the efficiency of the business aspects, most of the respondents acknowledged that there would be an improvement in building projects in the presence of SBDM.

CHAPTER 7

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

7.1. Discussion

In this study, the review of the literature revealed that there is a lack of comprehensive research about the SBDM and its associated management tools for Iranian building design firms specifically. Therefore, similar studies related with SBDM were discussed with a special reference to the findings of this thesis.

The results of the thesis showed that among the SBD principles, energy consideration attracted the most attention while water management, site and land use received less attention. The reasons for lack of sufficient success in managing sustainable water and energy use in buildings in Iran were the high payback time of energy efficiency strategies in buildings and local code deficiency. Occupant behavior as well as partial use of international codes were the most important success factors according to the respondents. Ease of using cheap grid energy and high initial costs were stated for lack of energy minimization in buildings and renewable. These mentioned items have complied with the results of the study of Jahangiri et al. (2018), on feasibility analysis of using renewable energies in Iran. The authors reported that cost and payback time issues were the most important barrier to implement and make use of renewable energies. Low costs of fossil fuels were the demotivating factors for endeavor towards renewable energy extractions. The more scarcity among non-renewable sources of energy increases the more cost effective the renewable energies become.

The information the respondents had about water consideration in SBD was fully acceptable. Despite this, they did not implement it in their SBD practices. Concerning water consideration in SBD, it has

been cleared that there was not enough informative education system focused on this issue. Recent water crises in the country concerned the managers to grasp knowledge on water use.

Regarding sustainable water consideration in buildings, Sassi, (2006) stated that education of users towards sustainable water consumption was essential to accomplish water saving. Efficient equipment was another strategy for minimizing water consumption. The third influencing factor was maintenance which refers to water leakages.

Similar to the findings of this study, Sassi (2006) stated that contemporary collection and recycle of water alternatives were not cost-effective due to long payback time. For example, greywater systems' payback time ranged from 15 to 100 years. Rainwater systems were more promising providing 50 % saving a yearly manner.

In terms of greywater management, Al-Jayyousi (2003) drew similar conclusions to the results in this thesis. Greywater management in Iran needed government support and facilities. New technologies and facilities for greywater use and standardization of greywater chemicals for the secondary use were among the other needs.

Lack of knowledge and misunderstanding was the most critical reasons for implementing sustainable site and land use. According to Bovet, Reese, & Köck (2018), also, a lack of determining targets for sustainable land used among the countries caused a deficiency in achieving quality. Lack of regulations and monitoring was the weakening aspects.

Figures 32 to 37 show lack of which issues affect which items in terms of sustainable building design. Figure 38 and 39 show the affects of occupant behavior and the importance of the education of the occupant, stated by the respondents. There are studies (Sassi, 2006; Hoes et al., 2009; Hong et al., 2015; Sodiq et al., 2019) that drew similar conclusions to the results in this thesis in terms of occupant behavior. Sassi (2006) and Rekola et al. (2012) stated the need for teaching the occupants how to use the buildings and technologies.

The results showed that creativity was the strongest power for improving sustainable communities. The importance of designers' creativity was also highlighted by Knotten et al. (2015) and Rekola et al. (2012). They stated that designers need to manage the creativity and the logic behind it as well as doing the ordinary management job.

According to the literature review, regarding the importance of promoting sustainability, many sustainable designers utilized their productions as educational machines that can teach clients,

municipal authorities, and other builders with the building process. Knowledge was increased by learning the principles of sustainable buildings while understanding the more efficient operation of the building. The more care the inhabitants give to the usage of their building, the possible success would be for a sustainable design method (Sassi, 2006; Sodiq et al., 2019). Also, mobilizing the public for decision making and affecting their life provides an understanding of the clear honest situation, needs, and potentials (Spiliotopoulou, 2017). In line with the lack of knowledge and improper education system, Sassi, (2006) stated that change in values was a requirement for obtaining sustainability.

Limited budget and lack of knowledge were the items that prevent sustainable material use in building design projects. Difficulties in selecting sustainable materials were also reported and addressed by Mahmoudkelaye, Taghizade Azari, Pourvaziri, & Asadian, (2018). LCA tools were a solution which these authors recommended for this for evaluating the impacts of materials on the environment from manufacturing to the recycle period. The impetrations of "losing high budget while choosing green", the low level of information about sustainable materials, and lack of tools for this purpose were the barriers for choosing sustainable materials (Akadiri, 2015).

In terms of managemet, lack of decision-making tools was reported as an obstacle. Fazli et al. (2014) found the similar results in terms of inadequate use of building project management tools. In another study in Australia, Kiani Mavi & Standing (2018) the highest importance was pointed to the management and sponsor support, stockholder separations, and end-users restrictions. Srinivasan & Dhivya, (2019) found that decision making, stakeholder participation, customer factors, organization structure, and quality were among the critical factors in terms of building project management. Client, communication, decision making, health, safety, and environmental consideration for sustainable building, interface management, knowledge management, performance evaluation, planning, risk management, team management were the success factors of BDM, which was highlighted by Knotten et al., (2017).

Success factors in using management tools in Iran were using international codes, local codes, a manual combination of checklists, and optimization. The results of the thesis reveal that regulations and laws regarding sustainable building design should be put into practice by the governemnet. Olawumi & Chan, (2018) stated that each country and region must provide its policy standards to achieve sustainable development. According to this, the insufficiency of local process tools was a challenge for implementing SBD. Zarghami et al. (2018) indicated that to improve the building standardization in Iran, the Iranian construction practitioners can become familiar with the common

indicators of international SBDMT, which have the potential to be used as an evaluation process while developing the local assessment tool. They highlighted the deficiencies of Iranian regulation system for building energy efficiency. Riazi & Hosseyni (2011) who reviewed the current building energy policies, standards, and regulations in Iran, asserted that Iran strongly needs to improve its current policies for sustainable building sectors.

The reason of "lack of knowledge", "lack of motivation and acceptance", "complexity of tools", "lack of cost-effectivity", complexity of tools, and "time-consuming process of using tools" were all for more impede in the fact that managers and staffs did not entirely know the basics and logics of the principles and rules as well as the language used in these tools. The importance of knowledge and understanding of the basics and logic behind SBDMT was mentioned by Brophy & Lewis (2011). Well awareness and understanding the logic behind the assumptions, simplifications in the contexts of theoretical analysis methods were necessary for the potential designers who used these tools.

As a result of the evaluation of the results of the thesis and its comparison with the literature showed that while some of the findings have similar results with the literature some of the findings related to Iranian design firms, are peculiar to this study and these have, to the best of the author's knowledge, not been presented in literature before.

7.2. Conclusions and Recommendations

The fact that in each region sustainable development needs to follow regional conditions led this research to select Iran as a case study. The research demonstrated in this thesis investigates the use of SBDM and its SBDMT in Iranian building design firms. The thesis begins with the examination of SBDM, SBDM and SBDMT. Then the thesis continues with the survey and analysis of the conducted survey. The results showed that among the SBD principles, energy consideration was found the most important item while water management and site and land use were found less important.

The high payback time of energy and water efficiency strategies in buildings and local code deficiency were the reasons for lack of sufficient success in managing sustainable water and energy use in buildings in Iran. Occupant behavior as well as partial use of international codes were the most important success factors in implementing sustainability. The respondents had knowledge and concerns about water use however did not implement less water consumption in their SBD practices.

Lack of knowledge and misunderstanding were found the most critical reasons for implementing sustainable site and land use.

Lack of knowledge; improper informative education system, lack of informative notification; lack of peoples' priority; lack of proper tools & knowledge, lack of acceptance among people and by the government were found as the reasons for lack of consideration of SBDP.

Education in Iran regarding SBD was reviewed using the databases of the education system in Iran from high school to the Ph.D level through syllabus and course regulations. The results show that except for the energy principle, which was provided in a master period titled Architecture and Energy (Memari-energy) and some basics of construction and design, there was not adequate information on SBDP and SBDM.

Occupant behavior and training occupants were found very important in implementing SBD. Site and land use and community concern were found out of the scope of architects' duties. Regarding health and well-being consideration in building design, lack of knowledge and financial priorities embedded in deficiencies, limited budget were found to be as obstacles for sustainable material use and sustainability concern in design.

Firms' personal platform (website, channels, etc.), as well as teaching abilities, were counted as the most crucial success factors for business management. Lack of experienced experts and designers who preferred traditional methods instead of current ones were found as obstacles for planning and controlling the overall design, service process and organizational structure. Local code appropriateness was found to be threat to performance evaluation in SBDM. High-quality environment for exchanging, receiving, storing, and retrieving information was found to be the most important factor for successful information system management. Confusion and insufficiency of local process tools were found to be the most important obstacles in using process tools.

For SBDMT, lack of knowledge, lack of motivation and acceptance, lack of English language skills for tools and information, lack of government regulation and penalties, lack of cost-effectivity, the complexity of tools, and time-consuming process of using tools were found to be the most important obstacles.

SBDM in building design firms in Iran suffers from a lack of sufficient decision-making tools, governmental systematic guidelines, and monitoring. The majority of the Iranian design firms were found not ready to adopt SBDM and their associated tools. From the perspective of willingness, the

majority of respondents were willing to join for the aforementioned items and agreed there would be an improvement in building projects in the presence of SBDM.

Based on the findings, the following recommendations are made;

- The building design curriculum should be reviewed, especially at the undergraduate level, to be more consistent with the principles of sustainability. In most cases where the understanding of the principles of SBD was lower, their implementations were also lower, and vice versa. The role of the designer in realization of sustainable development should be understood by the designers and the stakeholders.
- Teaching occupants about use of energy and water should be taken into account by national and local authorities. The informative educational system is important for stepping towards sustainable development. This could provide more updated experts, designers, and society as well and put an end to uncertainties regarding retail educations of SBDM and SBDMT.
- Iran's regulation on SBD should be revised to be more consistent with SBD principles and provide more flexibility for designers.
- Regarding SBDMT, there was a language problem which does not cover the information for designer and experts. There should be local tools, provision or teaching the principles in English for upbringing experts capable of handling the tools for SBDM.
- Government support was needed for SBDM in building design firms and motivating society to grant the business aspect and job opportunity of SBD. This could also include a definition of agreements regarding the responsibilities and duties of designers, experts and stakeholders as well as ethical and financial details for more unification and preventing financial loss while adopting SBD.
- Developing or introducing tools for decision making regarding sustainable material choices in local scale availability and analyzing, insensible agents of disease, monitoring after design, SBD project management, stakeholder management, strategic planning, people management, business management, and marketing was more than other SBDMT isolating which needs consideration.
- There was no consideration for investment in SBD by younger firms, including government support and job securities. In addition, job security for traditional building designers should be revised. There should be updated regulations and penalties to be more

consistent with SBDP for those who have critical positions in decision-making regarding building design.

- Since management techniques have changed based on new information systems and internet worldwide service, there should be more infrastructures regarding facilitating SBDM especially for younger firms who have shown interest in SBD practices.
- More flexibility and ease in the management process should be added to designer responsibilities through SBDMT. This could include, easy and user-friendly tools, less confusion, more inclusive tools, a more informative system for educating the designer about managerial techniques and logic behind tools, etc.

These available challenges and immaturities identified in this thesis have opened a long term enthusiasm and a tendency for me to address the shortcoming of this developing branch of knowledge. Furthermore, it provides me with a potential and opens to an improvement path to prepare powerful proposals to improve the current status of SBD. As such future work, it was aimed to concentrate on a couple of sub-categories and principles of SBD, SBDM, and SBDMT individually to shed more light on headed aspects of their drivers both contributors and obstacles. Besides, there would be a feasibility study on local food production in Iranian construction. Also, there would be a review study on educating occupants for more sustainable buildings.

APPENDICES

APPENDIX A. Survey Questionnaire

Dear Respondent,

We would like to invite you to share your valuable opinions about sustainable building design and amangement and experiences of your practice in the sector completing a short survey. This survey is conducted as part of my Masters research thesis titled, *Evaluation of Sustainable Building Design and Its Associated Management Tools in Design Firms: Case of Iran* at Özyeğin University in Istanbul Turkey.

The study investigates on sustainable building design, building design management and sustainable building design management tools used in design firms.

This survey comprises two sections, where the first section gathers basic information about the firm and sustainable building design principles, management knowledge area and management tools the firm includes in design stage while the next section seeks your opinion on success factors and obstacles in implementing sustainable building design management and its associated tools. Completing the survey will take between 45 and 60 minutes.

Participation is voluntary and the information you provide will be treated with strict confidentiality and anonymity. The study findings will be shared with the respondents if requested.

Thank you very much for your assistance with this research.

Please contact me if you have any questions or would like to know more about this study

Rana A. Rizi

Master of Science in Architecture student
Özyeğin University

Table 19. Survey questionnaire

Survey Questionnaire			
Sustainable Building Design principles (SBDP)	1	Do you pay attention to Site and land used in your design?	YES → NO→Why? - Which part/parts do you consider? And how? ☐ Compactness for compact cities ☐ Reducing transportation impacts ☐ In harmony with nature ☐ Local food production - Do you use any specific tools for consideration regarding any of these?
	2	Do you pay attention to Community consideration in our design?	YES → NO→Why? Which part/parts do you consider? And how? ☐ Community participation ☐ Housing for all ☐ Training and employment ☐ Enhancing the quality of life ☐ Promoting sustainability - Do you use any specific tools for consideration regarding any of these?
	3	Do you pay attention to Health and well-being consideration in your design?	YES → NO→Why Which part/parts do you consider? And how? ☐ Comfort ☐ Insensible agents of disease ☐ Identity and independence ☐ Restorative environments - Do you use any specific tools for consideration regarding any of these?
	4	Do you pay attention to Materials consideration in your design?	YES → NO→Wh ? Which part/parts do you consider? And how? ☐ Design for longevity ☐ Waste as a resource ☐ Avoiding resources depletion ☐ Minimizing manufacturing impacts, Materials, and energy ☐ Waste minimization - Do you used any specific tools for the consideration regarding any of these?
	5	Do you pay attention to Energy consideration in your design?	YES → NO→Why? Which part/parts do you consider? And how? ☐ minimizing energy use ☐ energy efficiency ☐ renewable energy used in your design - Do you used any specific tools for the consideration regarding any of these?
	6	Do you pay attention to Water consideration in your design?	YES → NO→Why? Which part/parts do you consider? And how? ☐ Decreasing water consumption ☐ water source alternatives ☐ minimizing the entrance of water to the main drainage while design? - Do you used any specific tools for the consideration regarding any of these?
Building Design Management (BDM)	7	Project management	What other fields do you manage in your office other than architecture as project management? And how? - Do you use any specific tools for the consideration regarding any of them?
	8	Stakeholders management	How do you manage a procedure to provide your stock holders for the best values and design? - Do you use any specific tools for the consideration regarding any of these?

	9	Business management	How do you compete with your others peer offices in this field? - Do you use any specific tools for the consideration regarding this?
	10	Education management	How do you train yourself and your employee about the architectural management? - Do you use any specific tools for the consideration regarding any of these?
Sustainable Building Design Management (SBDM)	11	Strategic planning	Do you prepare timing and planning for conducting the duties in your firm in your sustainable projects? How? What do you do as strategic planning in your firm? And how? - Do you use any specific tools for the consideration regarding any of these?
	12	Organizational structure	- Does the employment process in your firm was based on the professions in field of sustainability? Or does any work conducted with its own experts and professionals in sustainable projects? - Do you use any specific tools for the consideration regarding any of these?
	13	Financial management	Do you consider the risks while controlling the profits and investments? How do you manage finance in firm? - Do you use any specific tools for this?
	14	People management	- Do you pay attention to continue education as well as training the others (employee and customers) especially in your sustainable projects? - Do you have special policy or rule in your firm for employing people especially in terms of sustainability knowledge? How do you manage people in your firm? - Do you use any specific tools for the consideration regarding any of these?
	15	Business management and marketing	Do you have prepared any special business agreement for your firm in your sustainable projects? Do you try for marketing dimension of your firm? Do you use any special tools and application for business and marketing in your firm?
	16	Information system	How do you store and receive the information you need? - Do you use any specific tools for the consideration regarding any of these?
	17	Planning and controlling the overall design and service process	How do you control the sustainable design process? Which tools do you used for this?
	18	Performance evaluation	Do you usually evaluate the performance of what you do in your firm in your sustainable projects? - Do you use any specific tools for the consideration regarding any of these?

Barriers, readiness, and willingness and acceptance	23	Barriers		What are the barriers to the implementation of SBD?	
	24			What are the barriers to the implementation of SBDM?	
	25			What are the barriers to the implementation of SBDMT?	
	26	Readiness	Leadership	How much do you as a manager think you need to change towards SBDM?	☐ unwilling ☐ low ☐ intermediate ☐ No idea ☐ high
	27			How much do you as a manager think you have the power to change towards SBDM?	☐ No power ☐ low ☐ intermediate ☐ No idea ☐ high
	28		Business performance	How much the business side let you to take SBDM measures in your firm?	☐ low ☐ intermediate ☐ No idea ☐ high
	29		Organizational culture	How much do you think the organizational culture (both inside and outside) is ready to take the SBDM?	☐ unwilling ☐ low ☐ intermediate ☐ No idea ☐ high
	30		Operating environment	How much do you think your company is ready for conducting SBDM in terms of operation (hardware, software, knowledge, database, etc.)?	☐ low ☐ intermediate ☐ No idea ☐ high
	31		Workforce	How much do you think your current employees and staffs or your future applicants have the ability for SBDM?	☐ low ☐ intermediate ☐ No idea ☐ high
	32		Technical environment	How much do you think the supply management chain is supported in terms of technology, continuous training feasibility, colleagues?	☐ low ☐ intermediate ☐ No idea ☐ high

33.	SBD/SBDM/SBDMT technology	I am now using SBDM/SBDMT for work flow operation	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

transmission	I am willing to join the SBD/SBDM/SBDMT experience program					
34. External Environment: conditions and factors influencing the organization's SBD/SBDM/SBDMT-related activities, adoption, opportunities and risks	I am satisfied with the current process of building projects regarding SBDM					
	SBDMT is helpful toward the current process of building projects					
	I desire to use SBD/SBDM/SBDMT in the future process of building projects					
	SBDMT can improve the efficiency of business communication					
	SBDMT can improve owner satisfaction					
	SBDMT is helpful to resolve construction disputes					
	SBDMT is helpful to clarify drawings					
	I like to adopt SBD/SBDM/SBDMT if other competitors have adopted it					
	SBDMT is helpful to develop new types of business					
35. Employees: staff adoption of SBD/SBDM/SBDMT and workload reduction	employees are willing to accept SBD/SBDM/SBDMT adoption					
	it is easy to operate SBD/SBDM/SBDMT for employees					
	SBDMT can improve workload reduction over the long term					
36. Internal factors: improving workflow efficiency	SBDMT can improve the efficiency of existing processes of SBD					
	SBDMT can improve the exchange of quality drawings					
	SBDMT can improve communication quality					
	SBDMT can improve innovation and development of architectural design					
	SBDMT can improve organizational learning					

APPENDIX B Code formation and themes

Table 20. Code formation and themes

Phrases representing the content of the speech	Content of speech
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<i>Phrases with the concept of deterrence</i>	
Lack of Knowledge	"SPDP does not have anything to do with the compactness of cities." (A, B) "I did not know that the more compact a city is, the more sustainable it is." (D) "It is the first time I hear that local food production is of interest to SBD."(H) "The problem with the tools is that we do not always know the logic behind the tools." (J) "Why people need a sense of identity in their home?." (K) "In case I want to do monitoring an SBD, how can I convince the people to let me do so?"(M)
Misunderstanding	"For a proper site and land, isn't it enough to follow the municipal limitations and rules?" (A) "I think high rise buildings cannot bring sustainability"(B) "Is the compactness for compact cities the same as traditional narrow alleys?"(C) "So we can increase the height of buildings to increase the sustainability" (D) "Compactness brings a sense of depression and is in contrast with quality of life"(E) "For transportation issues, there should be trees for dealing with pollution; it does not have anything to do with SBD" (I) "Compactness might bring daylight availability issues" (J) "People management is the same as only customer service management" (M)
Lack of Acceptance among People and Government	"People think that alternative water sources like gray water have a religious problem."(A) "People prefer grid energies rather than renewable onsite energy sources."(B, D) "Local food production needs maintenance, and people do not like being in trouble." (E, H) "People might think o local food production as something unfashionable and insane."(I, K) "Local food production is a time consuming for people and government."(J) "People might think alternative water sources are not hygienic." (M)
Known as Out of Scope of their duties	"A sustainable training and employment need governmental supports and implementation." (A, H, J) "Architects can't provide people with training and employment through their design; this is a responsibility of the education system and municipals."(C) "Architectural firms are not in charge of doing anything for sustainable training and employment."(D,E,M)
Hardware limitations	"SBDMT needs high ranked hardware, which is expensive."(C) "Sometimes, the laptops become hot and soundly while using these tools."(E) "Monitoring needs many internets of things hardware connections and installation." (G) "I had to keep my computer on for days because of the heavily running simulation." (J)
Traditional design dominance	"...they say whatever we say is sufficient ..." (A)

	"They don't have to prove themselves through their projects."(B) "most of them teach in schools many unfashioned techniques." (E) "They don't undergo learning new techniques and tools." (J) "They don't let new designers and ideas to grow"(K)
lack of local code appropriateness	"Our country energy code is really limited compared to international ones." (B,E,J) "I haven't seen any code regarding the quality of life in space." (F)
<i>Phrases with a positive connotation</i>	
User interests	"Greenery attracts feminine house buyers."(B)
The importance of Occupant's behavior	(A,C,H,M) "When people occupied the designer is not around to force the energy-efficient behavior, the occupant then themselves should manage the process."(H, J, K, M) "Occupants kind of lifestyle in occupants' building energy use (B) "Occupants should like the process of local food production and have time to do so."(All) Children as the next generation need to learn sustainable behaviors (A, H)
The importance of Occupant's training	"Children, as the next generation needs to learn sustainable behaviors." (A, H) "People will partly practice what they learn, while they will not be informed they might not know what is right or wrong, then they choose an easy lifestyle which is not always sustainable."(B) "There should be public training in a sustainable lifestyle."(All) If the Occupant knows how to decrease how to minimize the entrance of water to the main drainage."(D) "The architectural design itself could teach occupants a sustainable lifestyle."(J)
Teaching intensify learning and economic income	"Whenever we teach, we try first to learn something deeply."(A, J) "Lack of sustainable awareness among students and experts raises the idea of teaching for whom know the principles." (D, E)
Success in finding and receiving project	"Indeed, the first step for the SBD project is finding one"(E, H, J) "There is not always an SBD project available if a firm could find one; it is a success."(K)
Personal Website, channel, or forum	"The world has been changed to a world of virtual connection internationally, in this world, it is of importance to show yourself to be prosperous, this is for a large part possible in online platforms like personal websites."(C) "For most, we find our employers and customers through our online platforms."(E) "Followers intensify the validity and reliability of SBD firms."(J) "Personal platforms are strong marketing, business, and information management."(K)

APPENDIX C. Firms' Obstacles and Success

Table 21. Firms' obstacles in implementing SBD, BDM, SBDM, and SBDMT in Iran

<i>Theme</i>	<i>Categories</i>	<i>Sub-categories</i>	<i>Obstacles</i>	<i>Firms</i>
SBD	Site and land use	Compactness for compact cities	Disallowed by higher organs	D, E, G, H, J
			Financial loss	B, E,
			Improper informative education systems	D, H, J
			Lack of acceptance among people and government	B, H
			Lack of governmental regulation and penalties	D, F,
			Lack of informative notification	B, J,
			Lack of knowledge	A, B, C, D,
			Lack of motivation	I, L
			Lack of people's priority	B, F,
			Misunderstanding	A, B, C, D, E, I, J, M
		In harmony with nature	Improper informative education systems	B, F, I
		Local food production	Improper informative education systems	C, H, I
			Lack of acceptance among people and government	C, E, H, I, J, K, M
			Lack of governmental regulation and penalties	B, H,
			Lack of informative notification	D, E, I,
			Lack of knowledge	A, B, D, H, J, K, M
			Lack of people's priority	B, C, E, I,
			Traditional design dominance	F, J, K,
			Traditional designers who are not updated but have influencing key role in decision making and teaching	H,

	Reducing transportation impacts	Disallowed by higher organs	C, D, E, G, I, J,
		Improper informative education systems	H,
		Lack of knowledge	D,
		Lack of motivation	L
		Misunderstanding	B,
Community	Community participation	The improper informative education system	A, I, J,
		Lack of informative notification	A,
		Lack of knowledge	D, G, M
	Housing for all	Misunderstanding	A, B,
		Lack of knowledge	A, D, E,
	Training and employment	Lack of knowledge	A, G,
		Lack of governmental regulation and penalties	A,
		Known as out of the scope of their duties	A, C, D, E, H, J, M
		Disallowed by higher organs	A, C, D, E,
	Enhancing the quality of life		
	Promoting sustainability	Lack of knowledge	
		Known as out of the scope of their duties	E,
		Improper informative education systems	B,
Health and well-being	Comfort	Traditional design dominance traditional	K,
		Designers who are not updated but have influencing key role in decision making and teaching identity	K,
	Identity and	Lack of knowledge	A, D, H, I, J,

independence		
	Insensible agents of disease	Improper informative education systems
		Lack of financial priority
		Lack of knowledge
		Lack of proper tools or knowing them
	Restorative environments	Lack of knowledge
		Restriction due to the rules
Material	Avoiding resources depletion	Emotional selection
		Lack of knowledge
		Lack of proper tools or knowing them
		Limited budget
	Design for longevity	Emotional selection
		Lack of financial profit
		Lack of people's priority
		Lack of proper tools or knowing them
		Limited budget
	Minimizing manufacturing impacts, materials, and energy	Emotional selection
		Improper informative education systems
		Lack of knowledge
		Lack of proper tools or knowing them
	Waste as a	Lack of proper tools or knowing

	resource	them	
	Waste minimization	Lack of proper tools or knowing them	J
Energy	Energy efficiency	Lack of English language skills for using tools, skill, and information	K,
		Traditional designers who are not updated but have influencing key role in decision making and teaching	A, J,
	Minimizing energy use	Ease of using cheap grid energy	A, B, G, K,L,
	Renewable energy	Ease of using cheap grid energy	B, G, I, J,
		High initial costs	A, B, D, I, J, L, M
		Lack of acceptance among people and government	B, D,
		Lack of people's priority	A, B, D,
		Lack of prolific installation equipment and services	A,
		Long payback time	A, B, G,
		Stakeholder rejection	A,
Water	Decreasing water consumption	Improper informative education systems	H, K,
		Lack of governmental regulation and penalties	H,
		Lack of knowledge	A,
	Minimizing the entrance of water to the main drainage	Improper informative education systems	
		Known as out of the scope of their duties	A, I
		Lack of governmental regulation and penalties	K
		Lack of knowledge	A
	Water source	Financial loss	A, C, F, L, M

alternatives			
		High initial costs	A, C, E, J
		Improper informative education systems	J
		Lack of acceptance among people and government	A, C, M
		Lack of English language skills for using tools, skill, and information	F
		Lack of governmental regulation and penalties	K,
		Lack of informative notification	B,
		Lack of knowledge	
		Lack of people's priority	A, C,
		Lack of prolific installation equipment and services	A,
		Long payback time	B, C, E,
		Stockholder rejection	C, I,
SBDMT	Process tools	Confusion	C, F, G, I, L,
		Difficult decision making	F, G, I,
		Insufficiency of local process tools check list etc.	C, I, J, M
		Lack of cost-effectivity	F, G,
		Lack of English language skills for using tools, skill, and information	E,
		Lack of government support	H,
		Lack of governmental regulation and penalties	G,
		Lack of knowledge	B, H,
		Lack of motivation and acceptance	G, K,
		Lack of resources	C, E, I,
		Time-consuming process of using tools	E, G,
		Too complicated tools	C, I,

Design evaluation tools	Hardware limitations	C, E, G, J,
	High costs and a lack cost-effectivity	F, G,
	Lack of English language skills for using tools, skill, and information	B, G, M
	Lack of governmental regulation and penalties	G, J,
	Lack of knowledge	L
	Lack of motivation and acceptance	A, C,
	The time-consuming process of using tools	A, B, I,
	Too complicated tools	A, H, I,
	Traditional design dominance	A, B, E, J, K,
	Traditional designers who are not updated but have influencing key role in decision making and teaching	B, G,
assessment tools	Lack of cost-effectivity	F, L,
	Lack of English language skills for using tools, skill, and information	G, J,
	Lack of governmental regulation and penalties	H, J,
	Lack of knowledge	A, M
	Lack of motivation and acceptance	E, G,
	Partial using of international tools	E, G,
	The time-consuming process of using tools	A,
	Too complicated tools	I,
	Traditional designers who are not updated but have influencing key role in decision making and teaching	J
Monitoring tools	Hardware limitations	I,
	High costs	C, D, F, G, J, L

		Lack of cost-effectivity	C, D, F, G, M
		Lack of English language skills for using tools, skill, and information	F, L
		Lack of facilities	D, K,
		Lack of governmental regulation and penalties	D,
		Lack of knowledge	A,
		Lack of motivation and acceptance	E
		Lack of people contribution	C, E, G, J, M
		Lack of proper tools or knowing them	E,
		Privacy issues	A, H,
		The time-consuming process of using tools	A, G,
		Too complicated tools	C, G, J
BDM	Business management	Emotional conflicts	E
	Education management	Abusing informative information and tutorial in other businesses	J
		Filtering (like telegram)	A, J
		Traditional designers who are not updated but have influencing key role in decision making and teaching	G,
	Project management	Emotional conflicts	C, J
		Filtering (like telegram)	K,
		Insufficient consideration	C, G,
		Lack of decision-making tools or lack of knowing them	E, G, J
	Stakeholder management	Emotional conflicts	E, J, M
		Lack of proper tools or knowing them	J

SBDM	Strategic planning	Lack of decision-making tools or lack of knowing them	G,
		Lack of knowledge	B, H, I, J, M
		Lack of proper tools or knowing them	E, J,
		The similarity of rules in all the regions of the country	J
	Organizational structure	Emotional structure	B,
		Financial priority	B, F,
		Lack of decision-making tools or lack of knowing them	J
		Lack of experienced experts	A,
	People management	Low salaries	A, F,
		Traditional designers who are not updated but have influencing key role in decision making and teaching	E, F, H,
		Filtering (like telegram)	J
		Lack of knowledge	A, D, G,
	Business management and marketing	Lack of proper tools or knowing them	J
		Misunderstanding	A, M
		Filtering (like telegram)	J
		Lack of government support	C
	Information system	Lack of proper tools or knowledge	L
		Newborn discipline	A, C, J, M
		(filtering (like telegram)	A, D,
		Lack of knowledge	J,
		Weak hardware	A,

Planning and controlling the overall design and service process	Lack of experienced experts	A, J, K,
	Lack of local code appropriateness	E,
	Lack of proper tools or knowing them	I, J,
	The similarity of rules in all the regions of the country	F,
	Traditional designers who are not updated but have influencing key role in decision making and teaching	E,
Performance evaluation	Lack of decision-making tools or lack of knowing them	D, F, K,
	Lack of knowledge	F, G,
	Lack of local code appropriateness	B, E, F, J
	Lack of proper tools or knowing them	B, D,
	Misunderstanding	B, C, F
	The similarity of rules in all the regions of the country	C

Table 22. Success Factors in implementing SBD, BDM, SBDM, and SBDMT in Iran

<i>Theme</i>	<i>Categories</i>	<i>sub-categories</i>	<i>Success factors</i>	<i>Firms</i>
SBD	Site and Land Use	Compactness for Compact Cities		
		In harmony with Nature	Attractive for Costumers especially for Women	G, K, M
			User interests	B, G, H, K
		Local food production	The importance of Occupant's behavior after residency	All
		Reducing transportation impacts	—	
	Community	Community participation	The importance of Occupant's behavior after residency	D

	Housing for all	–	
	Training and employment	–	
	Enhancing the quality of life	Creativity	C, E, F, J
		Knowing the physical proportions	A
		Knowing the potential of the site	B, M
		Social science and understanding occupant behavior aspects and needs	A, J
		Spending time	F, H, K
		User Interests	E
	Promoting sustainability	–	
health and well-being	Comfort	Ubiquitous and easy to used software and indices	I
		Availability of Partial Local Standards	B
		Availability of well-known Persian tutorials of tools	I, J
	Identity and independence	–	
	Insensible agents of disease	–	
	Restorative environments	–	
Material	Avoiding resources depletion	Financial priority	K
	Design for longevity	User interests	A, M
	Minimizing manufacturing impacts, Materials, and energy	Financial priority	I
		Financial profits	B,

	Waste as a resource	Financial profit	A,
		Limited budget	A, B, G, L, M
	Waste minimization	Financial profit	I, M
Energy	Energy efficiency	Existence of Local Code	All
		The importance of Occupant's behavior after residency	H, K, J, M
		The importance of occupant's training	All
	Minimizing energy use	Existence of Local Code	
		The importance of Occupant's behavior after residency	A, C, H, M
		The importance of occupant's training	A, C, H, I, M,
	Renewable energy	–	
Water	Decreasing water consumption	The importance of Occupant's behavior after residency	A, C, H, I, M,
	Minimizing the entrance of water to the main drainage	The importance of occupant's training	C, M
		The importance of Occupant's behavior after residency	C, H, M
	Water source alternatives	–	
SBDMT	Process Tools	International Codes	D, F, G, J, M
		Local Codes	C, E, F
		Manual Combination of Checklists	B,
		Optimization	J
	Design Evaluation Tools	Previous customers satisfaction	D, E
		Qualitative ranking	

Assessment Tools		Partial using of International Tools	D, B, F, J
Monitoring Tools		Online survey for receiving feedbacks	J
		Similar to Monitoring for BDM Process	D
BDM	Business Management	Expending salary on the project first then taking salaries and profit	A
		Not to fail the customers' needs	C
		Personal Website, channel, or forum	A, S, E, J
		Prediction of possible occurrences and predefined solutions and alternatives	I, K, L
		Preparing a good graphical resume in which the strength ability and achievements are highlighted	D, J
		Teaching intensify learning and economic income	A, D, E, J
		Well defined agreements between customers, stakeholders, and employers	M
		Well defined time table	A, D
		Well justifying the stakeholders and client (Powerful justifying briefing)	J
Education Management		Consulting with professionals and Experts	A, C, D, I, L
		Expending money and time for learning something new and helpful, which is in a worldwide trend	H, J, K
		High-quality environment for exchanging information and saving and searching	C, J
		The high-quality informative connection between the employees and experts and collaboration	H, J
		Teaching intensify learning and economic income	H, J

Project Management	Assigning a correct person to each task	A, C, E, G, H, J, M
	Flexibility for partial changes	E, J
	Following up the deadlines of the individual tasks and paralleling tasks	B,
	Graphic design for conveying results for customers and staffs	J
	High-quality environment for exchanging information and saving and searching	C,J
	The high-quality informative connection between the employees and experts and collaboration	C, J
	High team workability	B, C
	Knowing the rules, rights, and ethics	L, M
	Not to fail the customers' needs	E, G
	Optimization	J
	Power of passing from negligible	I, J
	Prediction of possible occurrences and predefined solutions and alternatives	F, G
	Preventing redundant or valueless detailed conversation among experts	C, D, J, F
	Success in finding and receiving project	E, E, H, K, J
	Well defined agreements between customers, stakeholders, and employers	F
	Well defined time table	A, D
	Well defining the projects	A,
	Well justifying the stakeholders and client (Powerful justifying briefing)	J
	Well understood project definition among the project members	A, M

Stakeholder Management	Knowing the rules, rights, and ethics	B, F
	Not to fail the customers' needs	H
	patience	F
	Preventing redundant or valueless detailed conversation among experts	C, D, J
	Well defined agreements between customers, stakeholders, and employers	B,
	Well justifying the stakeholders and client (Powerful justifying briefing)	G, I
SBDM Strategic planning	Following up the deadlines of the individual tasks and paralleling tasks	G, L
	Understanding the Nature of Project	A, H
Organizational structure	Experience	I, L
	Graphic design for conveying results for customers and staffs	J
	High-quality environment for exchanging information and saving and searching)	J, L
	Internship	F, H
	Interview	C, M
	Lack of decision-making tools or lack of knowing them	J
	Personal Website, channel, or forum	C, J
Financial management	Accompanying teaching to conducting the project as for more salary	J
	Comparison of Income and Expenses	A,
	Newborn discipline	H, J
	Success in finding and receiving project	J
People management	Consulting with professionals and Experts	A, D

	Expending money and time for learning something new and helpful, which is in a worldwide trend	F, J
	High-quality environment for exchanging information and saving and searching	C, J
	The high-quality informative connection between the employees and experts and collaboration	C, J
	Personal Website, channel, or forum	C, E, J, K
	Teaching intensify learning and economic income	J
Business management and marketing	Finding and Conducting Students' project	A, C, D, E, J, K
	Increasing followers	C, E, J, K
	Personal Website, channel, or forum	C, J, K
	Powerful ResumePreparing good graphical resume in which the strength ability and achievements are highlighted	C, D, F, H, I, J
	Providing beneficial contents for free to attract people	C, E, J
	Receiving Feedback	E
Information system	High-quality environment for exchanging information and saving and searching	C, J
	The high-quality informative connection between the employees and experts and collaboration	C, H, J, K
	Mobile Phone or Internet Banking	E, G
Planning and controlling the overall design and service process	Careful review at each step	C, E, H
	Consulting related experts	A, D, F, H, K
	Continuous monitoring	C, H, I, K, L

	Entrusting work to exports	A, D, I, L, M
Performance evaluation	Optimization results	J
	Simulation Results	E, J



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VITAE

Rana Abdollahi Rizi graduated from International Azad University of Najafabad in 2013. She started her M.Sc. as a full scholarship student at Özyeğin University in 2018. Her field of interest focuses on sustainable built environment and building energy efficiency. Her work also investigates renewable energies, thermal comfort, visual comfort, adaptive skins, and occupants' behavior. She has been actively involved in computational design practices, parametric thinking, and optimization for occupants' comfort and building energy efficiency.

