Study on The Challenges Faced in The Implementation of Intelligent Buildings

Anas Ibrhem Mohamed Amer[1] , *Jenny Ong*[2]

1 Civil Engineer, Libya, Email: anas.i.amer@gmail.com
2 Senior Lecturer, Faculty of Engineering, Bult Environment & Information Technology, SEGi University, Selangor, Malaysia,
Email: jennyong@segi.edu.my

Abstract

In recent years, during the rapid technological development, the concept of intelligent buildings (IBs) has become trendy due to emerging technologies and attractive sustainable design toward maximized comfort and well-being of users. However, various challenges faced in implementing intelligent buildings. The purpose of this study is to identify the main factors that cause challenges in the implementation of intelligent buildings. Also, to indicate society and construction developers' interest in the conventional building compared to intelligent buildings then to provide suitable recommendations to overcome all barriers that lead to difficulties in the implementation process by analysing information collected. The conducted survey will question that were distributed randomly to experts' in the construction industry and homeowners. Based on the results, can identify several challenges that have impacts on the implementation process. Poor promotion and low awareness level have a huge impact on intelligent building implementation. Hence it is necessary to create a suitable plan to overcome these challenges.

Keywords: Intelligent buildings, Smart Cities, Sustainable Development, Libya.

1. Introduction

Rapid changes in the information communication technology known as (ICT) has a huge influence on our business and impact on our daily lifestyles such as expectations, attitudes and our behaviours. Hence the increment demand for ICT buildings has also affected all life aspects in terms of daily use. Information communication technology plays a major role in influencing our life whether at home or work. Therefore, ICT becoming more familiar than before and affecting expectations on lifestyles in terms of sustainability and living in an intelligent environment [1].

To achieve sustainable development, it is important to work on traditional components of infrastructure such as structural building environment to be more intelligent and sustainable and utilizing intelligent buildings application methodology. Based on International Business Machines (IBM), the intelligent building is a part of the smart city concept and to achieve this transformation is required an intelligent system such as Information Communication Technology (ICT). At the same time, intelligent buildings can provide intelligent responses to various types of needs, including daily living, environmental protection, community and public safety infrastructure, industrial and commercial activities.

Intelligent buildings are not about technology, but about the transformation of sustainability that geared towards meeting current needs without jeopardizing the ability of the future to satisfy their needs. In terms of the increasing population without well designed, and proper managing resources people need better life standards within the limits of natural systems [2].

Intelligent building structures are the package deal for sustainability and lifestyle. However, there might be some challenges that prevent applying these projects, that has been mentioned in some articles[3], the main objectives in intelligent building design is to satisfy occupants' need with high energy efficiency [4]. Several studies show it is not only about energy but it is about economy and standards that represent sustainability requirements. Earlier 80s, in United State, intelligent building institutions explained intelligent buildings as the integrating of systems various to manage resources effectively to maximize investment cost and technical performance, flexibility [4].

The process of intelligent buildings construction is way different from traditional buildings, in terms of implementation and requirements that have been listed in the Leadership in Energy and Environmental Design (LEED) rating system. If the intelligent project was not up to the LEED standards or that has not been implemented, an intelligent building will be as any traditional construction without any difference. Achieving those requirements will incur an extra cost. Leadership in Energy and Environmental Design is one of the most well-known and successful rating systems, where it is adopted over 140 countries. LEED has rapidly grown in all global building markets such as the European and Asian countries [5] [6].

It is impossible to deny all those evaluation systems are the guidelines for sustainability requirements but in addition to more requirement might lead to more challenges in implementing. Especially in the less advanced countries are not yet in the market

because less developed countries are not having enough knowledge and experience to apply the method of intelligent buildings and smart cities concept.

This study aims to identify factors leading to difficulty in intelligent buildings implementation and to propose suitable suggestions to overcome barriers faced. This paper focuses on determining the challenges faced in the implementation of intelligent buildings in Libya. The result was based on a survey conducted development countries experiences.

2. Literature Review

2.1 Introduction to Intelligent Buildings

Intelligent buildings can be defined as an active integration of intelligent planning ideas, of construction and control modes, smart improvement tactics are included [4]. While the principle of building intelligent cities is adopted by controlling the digital networks of the city's grids, depending on the basic aspects of the concept of sustainability, which are financial, environmental and social. The formation and interconnection of these elements are very important to create an enabling environment for creating smart buildings [1].

Intelligent buildings involve several components, where the components are key items that cover all walks of life. Intelligent cities require to design and implement intelligent buildings based on design and buildings standards and requirements. Intelligent buildings must include dynamic responsive and achieve cost-effective for every occupant also aims to create an approved environment. Since buildings and structures are an integral part of smart cities, hence in this paper more emphasis has been placed on intelligent buildings and barriers oppose the build process.

Intelligent buildings consider as one of the significant signs of development and sustainability. However, opinions differ on how it should be defined, for instance. Back in 1988, an intelligent building described as one has information communication network by which two or more of its service systems are automatically managed, driven by building and usage awareness forecasts, stored in an interconnected database [7]. Systems can be described as the use of, network, telecommunication tools for processing information and, Buildings automation systems (BAS), depicted as the main features of intelligent buildings. In the 1980s definitions of intelligent buildings were in particular related to the automated generation features. At the same time as later definitions had been extended to encompass different functions.

Intelligent Building Institute (IBI) foundation in 1989, described an intelligent building associate degree as one that generates competitive and cost-effective a setting by improving its three basic components are structures, systems, services, and management as well as their interrelationships [8]. While the concepts of the intelligent building extended at some point in the 1990s to consist of several components associated with a coherent a connection between buildings occupants, intelligent systems and environment to produce main dimensions of life quality (CIB 1995) [9][4].

According to Working Group W98, the concept of the intelligent building is based on the effectiveness, performance, and their capacity for adapting to social and technological modification [4].

The intelligent buildings were described as a dynamic and responsive architecture that provides every occupant with productive, cost-effective and environmentally authorized condition via an endless interaction. Amongst the core elements are:

i. Places include fabric services and structure.
ii. The technique includes automation, system control.
iii. Society includes consumers, programs, and administrators.

The primary focus in smart design has moved to the idea of learning ability within an equal situation. As well as the interaction with the community and the users. The intelligence of intelligent buildings can be categorized in step with the subsequent characteristics:

i. Environmentally friendly: green energy and water management architecture efficient waste disposal; zero emissions.
ii. Flexibility and space utilization.
iii. Quality-giving value for the cost of an economic lifetime.
iv. The health of the population.
v. Working effectiveness and efficiency.
vi. Security measures and safety: fire, earthquake, and disaster.

On recapitulation of previous definitions, this assessment indicates how definitions of intelligent buildings have modified through the generations. By analyzing the evolutionary effects of intelligent building development. The character of multidisciplinary professional collaboration, designers, clients, and strategy-makers in practice. Pathways can be described that cause of exploration for true potentials of intelligent buildings Figure 2.1

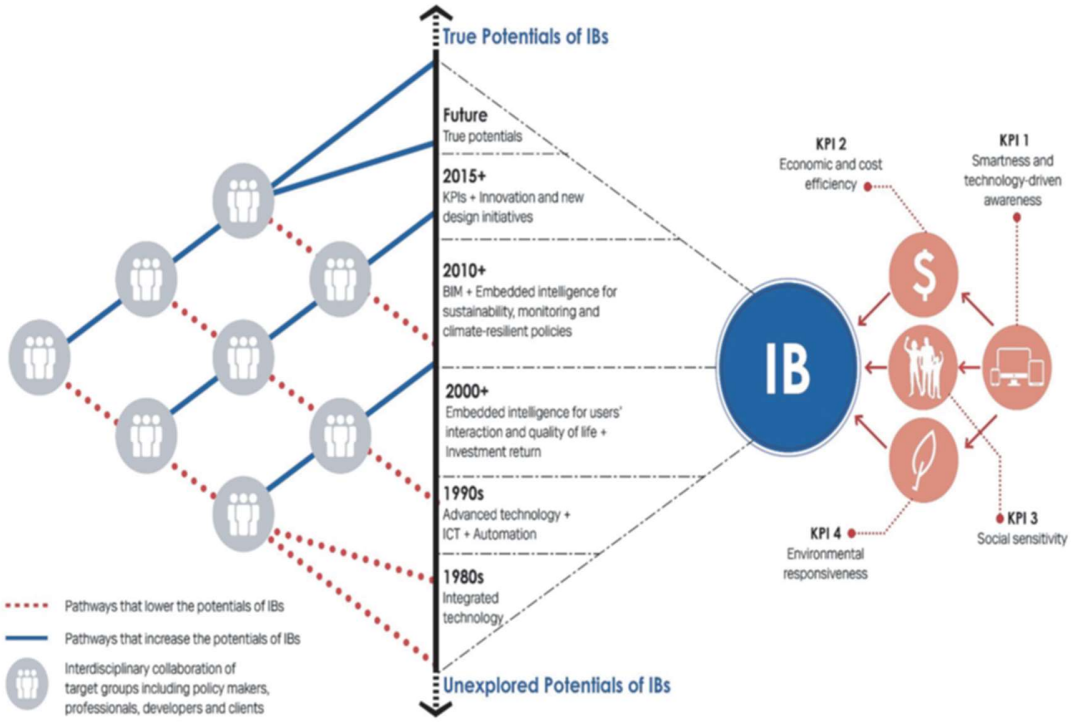

Figure 2.1: Pathway towards formation overview of intelligent buildings[4].

Figure: 2.1 represent the most recent depiction of intelligent buildings, with four main Key Performance Indicators (KPI) as follows:

- KPI-1 Smartness technology awareness.
- KPI-2 Economic efficiency and cost efficiency to give high quality.
- KPI-3 Social sensitivity.
- KPI-4 Environmental responsiveness.

Table 2.1 summarizes the features and components keys of intelligent buildings derived from the previously available definitions.

Table 2.1: Key features and components of IBs based on available definitions.

Period	Key of features	References
The 1980s	• Maximizing return on cost-effective and information communication network and productive automatically controlled system investment.	Leifer (1988)
The 1990s	• Performance of ecological and sophisticated operating system application to efficiency cost and lifecycle. • Automated system and information system technology emergence. • Responding to technological and social and changes and maximizing the building's occupants and management of resources efficient	Bedos et al. (1990) Clements-Croome (1997)
2000-2005	• Responding to quality and user expectation in life. • The role of social changes and user interaction. • Responding to owners, environment changes and users' needs	Wigginton and Harris (2002) Wong, Li, and Wang (2005)
2005-2010	• Health, efficiency, cost, environment and security aspects. • More productivity and operationally efficient for communicating owners between owners of building systems	Gray (2006) AlWaer and Clements-Croome (2010)
2010-2015	• Design of ecologically sustainable. • Building management system (BMS).	Ghaffarianhoseini (2012)

2.2 Intelligent Building System

Many researchers have proposed basic and non-basic systems that must be available in intelligent buildings. Systems that are used to make the building's environment better compared to traditional buildings in terms of sustainability aspects. Researchers identified some of these systems, as heating, ventilation, air conditioning lighting systems (HVAC), safety and security systems and building automation system [10][10].

Building Automation System (BAS), also known as the Building Management System (BMS), is considered one of the most important intelligent building systems responsible for moving all smart building systems, consists of an external base station, which is the mother console, and it is a digital unit connected via a network, as it is more like a computer system designed to collect information and data several functions. Control units consist of four types as follows:

i. Digital control unit
ii. Electrical control unit
iii. Electronic control unit
iv. Pneumatic control unit are still been used but it isn't popular [8].

Table: 2.2 Proposed intelligent building systems

Researchers and intelligent systems	**(Nikolaou et al., 2004)**	**J. K. W. Wong et al., 2005)**	**(J. Wong et al., 2008)**	**(Ionnidis, 2011)**
Lighting system	Have	Have	Have	Have
Combinations Of various systems	Have			Have
Integrated building management			Have	
BAS	Have	Have		
Life safety	Have			
Data communication		Have	Have	
HVAC	Have	Have	Have	Have
Energy Efficiency	Have	Have		

2.3 Discussion

This review documents the findings of an intelligent building and implementation general process carried out in development countries features and explaining more about the idea of intelligent building design and expansion methodology. The rate of intelligent buildings and sustainable development from professionals was examined intelligent buildings combination aspects of untested intelligent technologies, insufficient and inadequate incentive programs, and funding. For the use of intelligent buildings systems, lost the public awareness of the positive effects of intelligent buildings and their long-term benefits. Also, inadequate technological resources, affect the capacity of adopting smart technologies.

3. Methodology

3.1 Research Design

This paper applied the systematic method to develop a framework for the implementation process of intelligent buildings, to identify main barriers and point of view of experts in the development field These experts may have interest in many levels of complex dimensions that entail electing broad selection of information which is represented in management, decision making, stakeholders and engineers who are in the industry. A quantitative approach was applied to study and analyze the intelligent sustainable buildings concept.

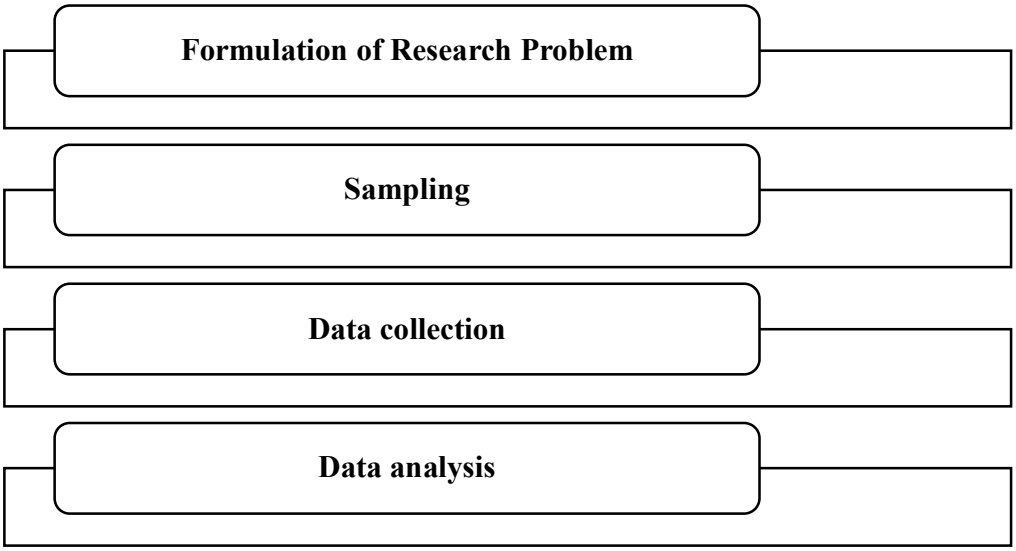

Figure 3.1: Research Methodology

3.2 Quantitative Research

For the quantitative aspect, this study used a questionnaire to collect data to analyze the concept of intelligent buildings in terms of the design and construction process. Also, to discuss the idea of building intelligence and explain the requirements and standards for intelligent buildings. Analogize to them with traditional construction in terms of implementation factors, to identify main factors, lead to difficulty in developing intelligent building implementation. Further development incentives and the benefit of the prices issued and received. Also, to find out the reason that developers interested in the method of traditional construction over intelligent buildings based on the studies in the literature review. Therefore, will have the lead to come up with the possible suggestions to overcome challenges in intelligent building implementations.

Quantitative approach will offer respondents an opportunity to share their views on the building sustainability implementation and discuss all challenges facing in the implementation of intelligent buying on a five-point Likert-scale format (Strongly disagree, Disagree, Neither Agree nor Disagree, Strongly agree, Agree). The Likert-scale is used to demonstrate that the scores for each factor or variable for system production vary when taking into account the particular group of participants and to fulfil the normal assumptions about the variance of each factor or variable in data collection.

3.3 Data Analysis

The data will be collected through the questionnaire was tabulated and analyzed using percentage. The data will be explained by utilizing diagrams and charts. The interviews were recorded using questionnaires sheets for descriptive analysis. The survey includes specific information and background of responses. That will help to analyze survey answers based on year of experience, specification trade and role of response, whether the response was an engineer, a contractor or a consultant. The questionnaires are consistent in total to 20 twenty questions distributed in two sections.

Section A will provide 10 ten questions of quantitative approach for developers to discuss their point of view of challenges faced.in the implementation of intelligent buildings and section B, This section includes 10 ten questions for a survey to explain the difference between conventional and intelligent buildings. To provide an intelligent construction process, bearing in mind the experience of the engineering industry, to share developers' opinions about construction and demolition management, regarding the recycling process. Also, to determine what are important incentives could be achieved toward intelligent buildings development.

4. Results and Discussion

In this topic, analysis of research results were obtained from survey questionnaires. Also, it involved a summary and discussion of all data collection of questionnaires that been generated from sequential questions and each would be explained by using the chart. Through applying the quantitative approach, questions were prepared in a sequence of research objectives. responders were given the five-point Likert scale to determine whether the respondent strongly disagrees or strongly agree with each statement included in each question.

4.1 Results and Research Analysis

In this research, the survey was distributed randomly to selected groups of engineers and stakeholders from specialized companies in building and construction. The survey distribution took over two months period, from 1st / February / 2020 to 30th / March / 2020, for determining research objectives, as well as greater coverage area, different stages of knowledge between developed and less developed countries.

Figure 4.1 indicates to work positions for each responder in the engineering industry. From the pie chart below Figure 4.1 shows that majority of respondents were engineers at 31.5%, followed by 9.3% contractors, and consultants were presented with 7.4% there was a minority with 5.7 % for expert’s technician and only 3.8% for senior process engineers. The rest of the responder's percentage range between 1.9% to 3% for designers and senior lectures.

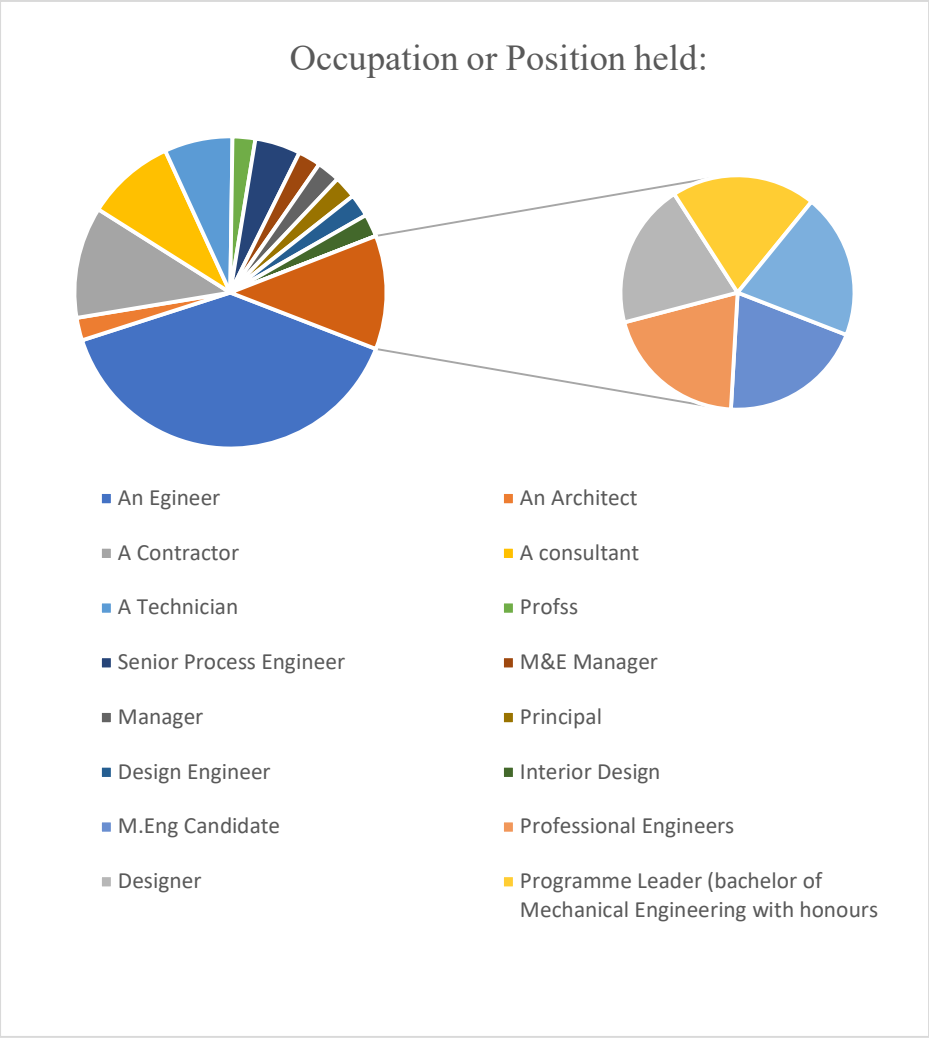

Figure 4.1: Occupation or Position held

The following section aimed to determine challenges faced in the implementation of intelligent buildings by analysing and discussing the response of the survey questionnaires as shown in the following figures.

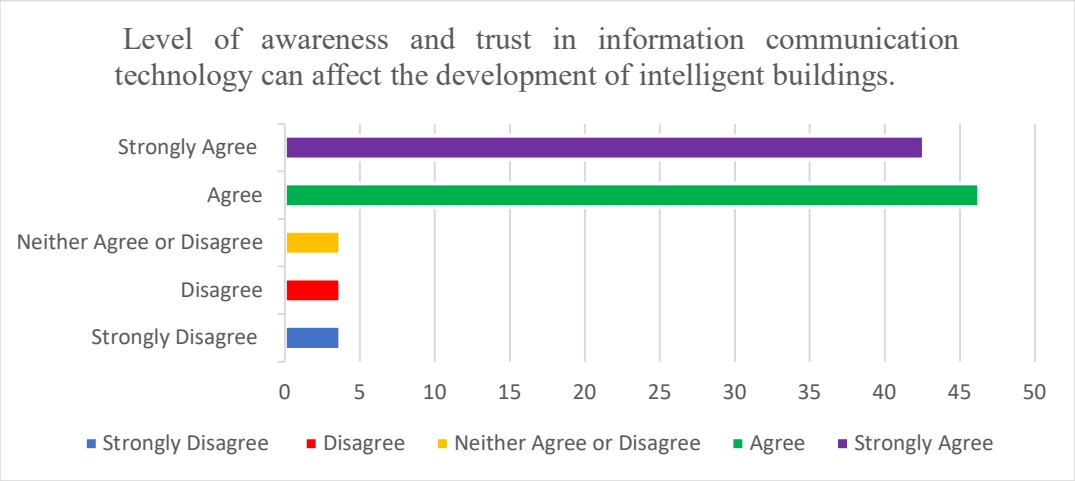

Figure 4.2: Level of awareness and trust in ICT.

Figure 4.2 shows that the majority of respondents agreed and strongly agree with total percentage 88.9% the level of trust and awareness in information communication technology (ICT) will affect the development of intelligent buildings where only 7.4% did not agree with which means the level of awareness of (ICT) in intelligent buildings is an ideal factor to achieve the aim of the smart building to provide smart life for every occupant.

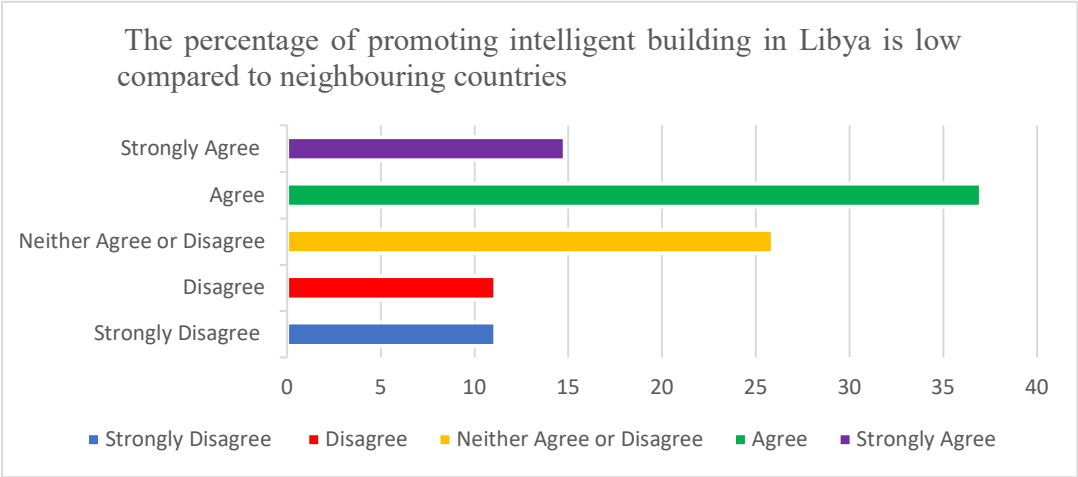

Figure 4.3: The percentage of promoting IB.

Based on the results Figure 4.3, 37% of the respondents were completely in agreement that the rate of promoting intelligent buildings is relatively weak compared to them in conventional buildings where is 14.8% strongly agree. As evidence, only 11.1% were disagreeable which is approximately similar to the percentage of strongly disagree, in addition to one-fourth of neutral respondents. Such findings prove to the situation for developing intelligent buildings is unsatisfactory to developers.

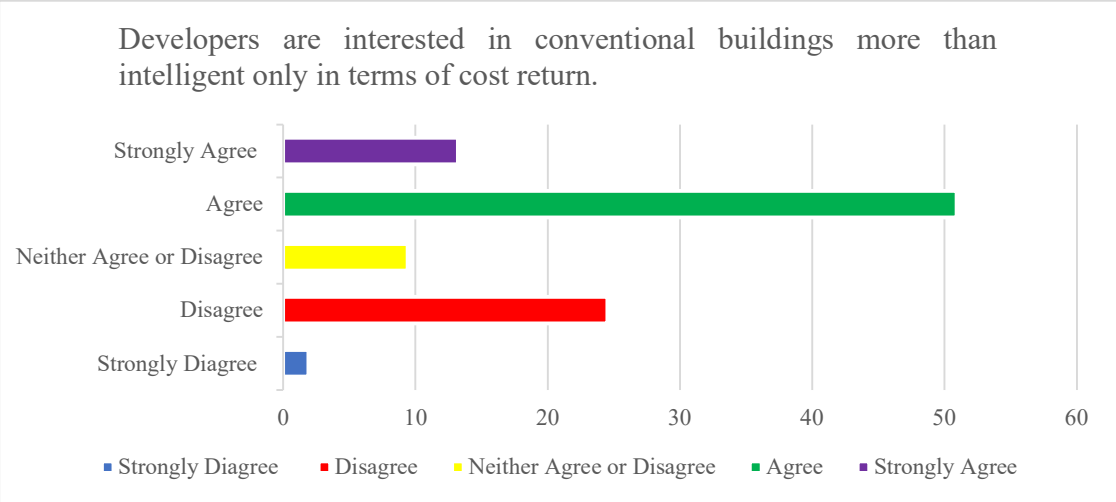

Figure 4.4: Cost return in conventional buildings vs IB.

In resulting of a rapidly increasing in the construction cost, which leads to high-risk investment especially in the intelligent building's implementation process. This risk causes low interest in developing IB by construction developers to compare with conventional buildings. Figure 4.4, shows that half of the responders agreed that developers are only interested in conventional buildings investment due to cost return.

Conventional buildings provide immediate cost return via real estate trading. As for IB, it provides long time cost return and low lifecycle cost though saving energy a successful energy management system offers lowest-cost energy and allows users to achieve efficiency and comfort [10].

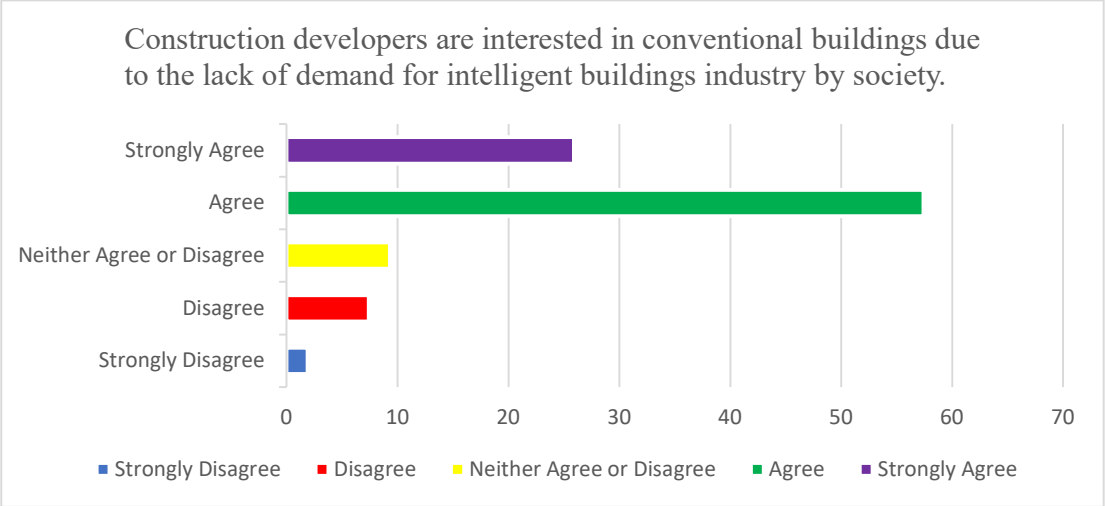

Figure 4.5: Intelligent buildings and lake of demand.

Figure 4.5 shows the highest frequency of developers agreed with 57.4% lack demand affect developing the intelligent building. The majority of developers having difficulty in (hard-sell) way of selling their property, means developers must keen to see the profit flowing in quickly, with less investment cost. IB implementation requires high initial cost in the result of the multiplicity of requirements, such as intelligent servers and unique design. On the other side, the homeowner would choose to buy a cheaper house if the design is identical to IB. Homeowners are more worried about the price and building location when purchasing or investing in real estate.

4.2 Discussion

Based on research analysis and survey results, a conclusion can be drawn that intelligent buildings still far from the maturity stage, as a result of the fact that the majority of real estate developers and the community have not reached the stage of sufficient awareness that enables them to gain advantages from intelligent buildings.

Figure 4.6, indicates a summary of barriers that affect the implementation of intelligent buildings, and level of impact caused by each barrier. The result shows that the lack of incentives for developers is one of the most common barriers based on figures it has achieved the highest frequency, based on the summary of responder's number shows the lack of incentives prevents the implementation of intelligent buildings.

The developers of the construction sector need to be promoted by the institutions in charge of the constructions and build environment to provide the necessary services such as reducing taxes and providing building materials. Likewise, the level of social awareness about intelligent buildings an important element that has an impact on the level of demand for intelligent buildings.

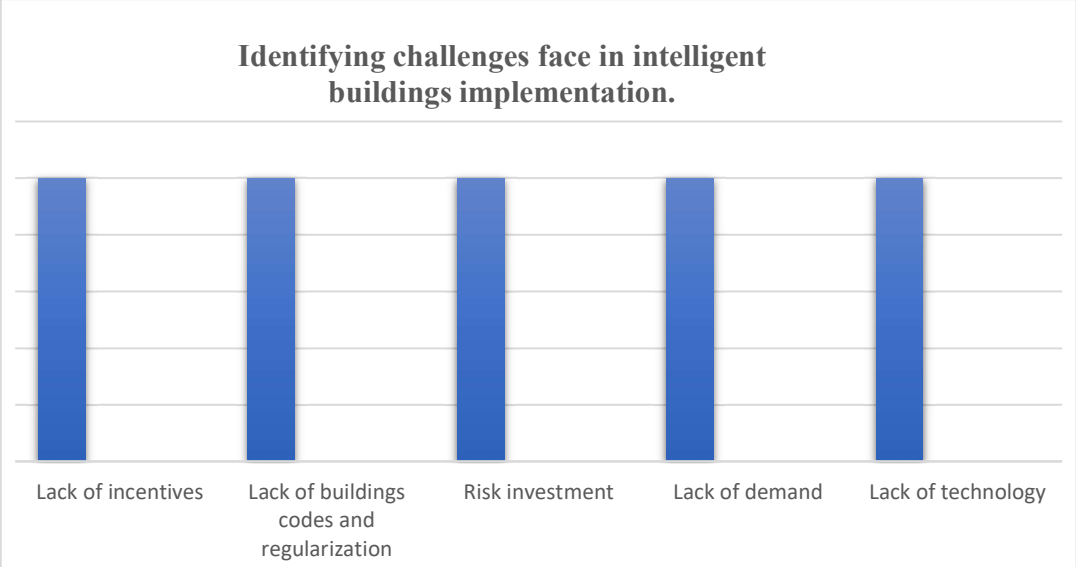

Figure 4.6: Identifying intelligent buildings implementation barriers.

The demand for intelligent buildings has several implications, including the impact on developers. Improving social awareness about intelligent buildings lead to reduce risk investment is a result of the increasing demand. Educated customers who will demand sustainable goods from companies and promote more intelligent buildings. Additional to achieve intelligent buildings implementation and make a balance between construction developers benefits and public society needs.

According to the research, survey developers are more interested in conventional buildings construction due to the challenges facing the implementation of intelligent buildings. As intelligent buildings required other specifications, such as the types of materials used in the construction process that contribute to energy saving and achieve sustainability, in addition to intelligent systems and technology that make buildings intelligence. Intelligent buildings require a high initial cost compared to traditional buildings.

5. Conclusion and Recommendations

In order to increase the promotion of the implementation of intelligent buildings must seek to identify challenges facing the process of implementing intelligent buildings. Understand and analyse the reasons leading to implementation barriers. Establish a useful strategy to overcome challenges and implementation barriers.

As it has been proven in the previous chapter based on results shown in Figure: 4.6, that the implementation of intelligent buildings faces many challenges were summarized and set in order as follow:

1. Lack of promoting and level of public awareness regarding intelligent technologies.
2. Lack of sufficient experience and knowledge to build and design intelligent buildings.
3. Difficulty to provide green materials to provide sustainability and also intelligent technologies.

All the majority of challenges were identified have a major impact on the resources and materials used in the implementation process. This leads to the difficulty of implementation due to the impact of the capital cost of the project. Especially with a lack of demand and public awareness of society and the government responsible. That causes investment risks to increase. In developing the implementation process for intelligent buildings, there must be a financial justification for investing in intelligent and sustainable technologies and assessing the potential return on this investment. It is necessary to consider the aspects and requirements and the implementation process and adjust them to bring benefit to all stakeholders represented in the developers and homeowner, customer and occupants for the country.

5.1 Research Recommendation

The following recommendations were proposed, to overcoming the challenges faced in the implementation of intelligent buildings.

1. Government taking lead in adoption of intelligent buildings.
2. Promoting intelligent construction in privet sectors.
3. Strategic for raising awareness about intelligent buildings.
4. Justification for Investment.
5. Building intelligent buildings capability.

5.1.1 Government taking lead in adoption of intelligent buildings

Government is a major player in the development process. Plays a major role through taking actions to better implementation and expand the use of intelligent buildings. Provides a set of selected legislative requirements and setting standers that control intelligent buildings implementation. The government takes lead to adopting intelligent in the public sector. Motived construction developers to increase investment. Furthermore, the ability to develop the construction industry by buildings intelligent buildings capabilities. recognizing intelligent industry needs, in terms to provide sustainable materials used to achieve sustainability through developing factories and pump financial liquidity.

Promoting intelligent building in the private sector by involving intelligent sustainable construction in commercial sectors and real state. Promoting intelligent buildings requires a lot of stamina and reasoning to developers, stakeholders', engineers by fostering intelligent construction in the as main part of the construction process. Also, developers should control the design process and materials used to meet time and cost conditions.

Thus, it is important for the implementation of intelligent construction using sustainable materials in design. Furth more, including decision-makers for adopting new regulation to increase the incentive for developers to reduce risk investment. Encourage construction companies to enter the development race of intelligent buildings. Provide incentives able to recover the high cost of intelligent buildings and make them accessible to construction companies.

It must include education and training in the concepts of development and the intelligent and make it known by society. Training workers and responsible for the construction and implementation process through workshops and seminars. lead to making this industry available and familiar to society and stakeholders to reduces costs and increasing investment opportunities. Homeowners and buildings users should be aware of these environmental problems. This issue should be known in these projects. Hence, there are a few ways in which users and stakeholders can be interested in this matter that officials should enforce.

5.1.2 Justification for Investment.

The cost of implementing an intelligent building usually is not that different from the costs associated with traditional buildings construction. Some aspects related to technology and intelligent applications, such as cables, are less expensive than traditional infrastructure. The labour costs are often lower as intelligent designs are used. However, additional technologies, equipment, and other investments will be required to integrate all components of the system will lead to high costs. Heating, ventilation, and air conditioning (HVAC) systems would cost more in advance than building different systems on their own. During the development of a feasibility study, homeowner/developers must be convinced that, through the application of intelligent technologies, the recovery period will be much less than the expected operating life of this asset. In addition to a direct reduction in operating costs, the modern technologies applied in intelligent buildings lead to environmental improvement and effective for occupants of the building. Also, these benefits provide an improved return on investment and return on assets while increasing rental capabilities and higher values

5.1.3 Building IB capability

Intelligent buildings aim to provide environmental, economic and social sustainability alike. To provide environmental sustainability, the design must be taken into consideration, and this is only done in cooperation with engineers responsible for the design process. The materials used have a great and effective role in providing sustainability. Hence, it should work intelligently to take advantages of construction waste to provide sustainable materials and reduce cost.

International cooperation is important for linking global and local initiatives and facilitating cooperation and exchange experiences between the actors in the intelligent industry and international organizations. Provide contacts to unreachable supplies in the environment and/or area where the intelligent building is developed to increase the availability of materials used. Exploiting foreign expertise and providing international companies to increase competition between private sector companies to impose their entry into the intelligent building market. Increase the creation and innovation opportunities in other fields related to construction industries such as materials manufactures and technology organizations.

5.2 Overall Discussion

This research analyses the concept of intelligent buildings taking place on the construction front and identify the challenges faced and their implication for intelligent buildings implementation. Regarding the implementation process, several challenges were identified on first stage lack of awareness and are incentives for construction developers, which cause a lack of promotion and low interest in developing intelligent buildings. Also, the high initial cost for stating project in terms of construction phases because of certain requirements due to the implementation process, to achieve intelligent buildings aims. Intelligent buildings are dynamic ecosystems which respond to changing needs and lifestyles of their occupants. Furthermore, this research achieved the aim to indicated construction developers interest due methods took over the place of intelligent buildings development. In another word, construction developers are interested in the traditional construction method because it is more familiar and less complex compare to intelligent methods.

The intelligent method requires significant knowledge and required materials to provide sustainability to achieve an approved environment for every occupant. Hence will have to provide huge capital costs.it is necessary to educate and influence construction developers, engineers and end-users about benefits provided by intelligent buildings. Due to rapid technological development, intelligent buildings are still suffering from a lack of significant knowledge to be implemented in the proper method.

This research aimed to come up with the proper recommendation works as a foundation to create a suitable strategy by involving recycling construction waste and increase awareness of intelligent technologies, to overcome challenges and barriers faced in the implementation of intelligent buildings. In conclusion, the most important challenges have been identified, improving public awareness and motived privet sectors and technology assistance are major drivers to terminate challenges and overcome barriers to intelligent building growth.

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