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Identification of Key Challenges of Smart Buildings Projects in Egypt

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Abstract

The world is changing rapidly heading to the future with quick intelligent steps. Adaptation of smart and responsible architecture that can cope with future demands is no more a choice. Nowadays; Smart buildings projects (SBP) is a new trend and very important worldwide type of projects. Smart buildings projects evolved during early 1980s and were called "Intelligent Buildings". Since then; different definitions have been stated by many institutes and researchers, and the terminology "Intelligent Building" was then replaced with "Smart Building". SBP in Egypt are rare; they don't have clear description or specific definition. There is a lack of guidelines to establish a smart building in Egypt and lack of research work discussing SBP, their design, management system, life cycle costs, risks, etc. as well. This paper is concerned with determining the main challenges of SBP in Egypt through both: analysis of literature sources and analysis of some SBP internationaly and comparing them to SBP in Egypt. Finally; the results of the study were collected, analyzed and categorized and the key challenges of SBP in Egypt were determined and pointed out.

Keywords

Smart Buildings Projects (SBP); Smart Cities(SC); Egypt

1. Introduction

The world is changing, adaptation became a must; moving into the future with smart progress requires more responsible architecture and more smarter buildings in order to cope with future demands. "Smart" doesn't only refer to the automation and artificial intelligence; it also refers to the way of dealing with and approaching the challenges; this is in addition to the methods which are presented by planners, architects and city officials to face and metigate those challenges. Dominique Davison & Ashley Z. Hand, 2016 clarified that "Being smart about architecture means understanding economic growth, density and zoning and how the existing network of roads and grids can be better".

The concept of Intelligent Building was first adopted by the United Technology Building Systems (UTBS) Corporation in the USA in 1981. In 1983, the City Palace Building was constructed in the USA and was announced to be the world's 1st Intelligent Building (So Albert &Wong KG, 2002). The UTBS was resposible for operating and contolling the shared equipment of the City Palace Building; this included shared elevators, shared air-conditioning equipment and disaster prevention devices (Albert T.P. et al., 1999).

SBP were being studied over the last three decades. Many institutes alover the world had many attempts to define SBP, their concepts and targets; however, the definition of SBP is still vague (A.H. Buckman et al. 2014). The aim

and concept of SBP are not clear as well, they differ from one country to another according to time, needs and culture. Asia, Europe and Australia are considered pioneer continents in the field of SBP. Asia mainly concentrates on environmental aspects; the Asian Instiute of Intelligent Building determined 10 quality environmental modules to define and assess SBP (So Albert &Wong KG, 2002). In Europe; the main target is to improve the European economy by achieving low-carbon economy goals through adopting smart cities and smart buildings (eceee policy brief, 2010). Australia focuses on increasing the performance of environmental, economic, operation and safety aspects in addition to improveming the performance and reliability of various technologies in communications, control, automation, etc. (Amir Ghaffarianhoseini et al., 2015).

In Egypt; Smart Village (SV) is considered the first attempt to establish SBP in. SV adopted an ecosystem platform that connects all the buildings in addition to providing a smart facility management system (Smart Village Report, 2010). The New Administrative Capital (NAC) in Egypt is a new trend of projects. NAC in Egypt can be considered the second attemp to build SBP and the first attempt to establish a smart city. In Egypt; there is a lack of research work covering the field of SBP generally; characteristics, targets and challenges particularly. The lack of experience, guidelines and frameworks to establish and manage SBP is considered the main risk that may face this new trend in Egypt.

1.1. Research Problem and Objective

Smart Village (SV) is considered the first attempt to establish SBP in Egypt. The New Administrative Capital (NAC) is the second attemp and the first attempt to establish a smart city in Egypt. Lack of experience in the field of SBP in addition to absence reference projects and absence of clear guidelines or frameworks to establish and manage SBP are counted as major risks that may face this new trend of projects in Egypt.

The entire research is concerned with a main problem that is demonastarted in the lack of research work in Egypt that covers the field of SBP generally; characteristics, targets and challenges particularly. Identification of the risks and challenges is considered the first step in finding appropriate solutions to mitigate and resolve those challenges. The main objective of the current research is to determine the key challenges of SBP in Egypt.

2. Method

The objective of this paper will be fulfilled through both: analysis of literature sources and analysis of some SBP internationaly and comparing them to SBP in Egypt. Based on the output of the data analysis; the challenges of SBP in Egypt were divided into four main categories by project phase; data collection to concept design challenges; schematic design to design challenges; construction to testing and commissioning phase and operation and maintenance phase. Figure (1) shows the flow of research methods in terms of input, process and output.

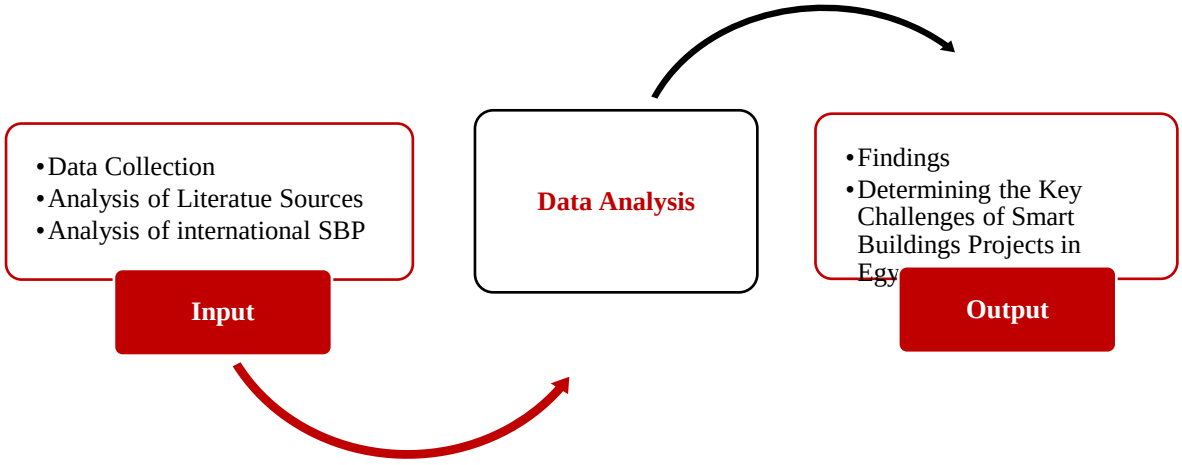

Figure 1. Flow of Research Methods; Source: Authors

3. Literature Review

There is a lack of a comprehensive or unified definition that sums up the common characteristics of SBP. Definitions and characteristics of SBP vary according to time and location where a smart building is established. The literature review will collect and summarize the different definitions and characteristics of SBP aiming at standing on the key risks and challenges that may face this type of projects through their life cycle.

3.1. Analysis of Literature sources

Although the concept of SBP evolved in early 80's, the definitions and characteristics of SBP are still vague. There have been many worldwide and local attepms to analyse the concept of SBP and issue a comprehensive definiton that reflects the objectives of this type of projects. Most of the researchs in Egypt and worldwide concentrated on definitions of SBP.

O.Omar, 2018 proposed a multi-criteria framework composed of sixty-eight sub factors on the core level as a comprehensive tool for categorizing SBP. The final findings categorized the usage of SBP into two approaches. The first is a multi-criteria framework that illustrates and defines the design process' involved factors. The second proposes a conceptual environmental framework helps in limiting the carbon dioxide emissions. Ghaffarianhoseini et al., 2016 objective was to extract the common features, key performance indicators and challenges of SBP in order to identify a comprehensive definition that can be used as a reference framework for designing, evaluating and developmening future SBP.

A.H. Buckman et al., 2014 aimed at assessing the existing meaning of Intelligent Buildings and extracting a new successful definition for Smart Buildings. This definition aims at reflecting more advanced criteria, targets and guidelines that exceeds limitations of previous terminology, in addition to meeting the criteria of assessing high-performing buildings. This was achieved through focusing on and analysing the key drivers behind SBP development from past to present. Albert T.P. So et al., 1999 developed a new method for defining and specifying intelligent buildings; they categorized the users' requirements into eight key modules and they divided the buildings' features and systems into ten elements. Each group of elements was then assigned to a particular key module; and each type of building is then allocated certain key areas for detailed design.

Khashaba Sherif, 2014 focused on providing a proposal for achieving sustainability by using the capabilities of intelligent buildings for the public buildings in Cairo city. The researcher extracted an architectural proposal for public buildings that helped in determining sustainability elements through applying the available recent techniques of intelligent buildings that are compatible with users in Cairo city in Egypt. So Albert & Wong KG, 2002 analyzed the available definitions of SBP and defined a comprehensive method of assessing intelligent buildings which they called the Intelligent Building Index (IBI). The IBI consists of different quality environment modules; each module has different score and rank; based on the rank, the intelligent building is assessed and the overall performance is determined. The key elements of each module are flexible depending on the practice of the country where the intelligent building is being built or assessed.

The conclusion of the above analysed literature sources can be pointed out as follows:

- Most of research work focus on analysing the available definitions of SBP and introducing new ones while there is a lack of research work discussing the challenges of SBP.
- Some of the analysed reseraches provide clear but not holistic understaning for the concept of SBP.
- Objectives of SBP are not constant, they differ from on place to another and from one SBP to another.
- In Egypt; there is a lack of research work discussing the concept of SBP in general.
- In Egypt; the difference between sustainable buildings and SBP is not clear, sustainable or green buildings are considered SBP.

- There are attempts to provide assessment frameworks and intelligent building index to assess SBP; the introduced frameworks and intelligent building index will be used as a guidline to design a checklist to assess the case studies in the entire research.

3.2. Definitions of SBP

The entire paper collected and analysed the available definitions of SBP that were issued by official international authorites and institutes. The international authorites and institutes of SBP are responsible for inreasing the public awareness and understanding of SBP as new futuristic worldwide trend. The main task of SBP authorites and institutes is to determine the key characteristics and definitions of SBP; this is in addition to setting and developing set of tools to help in assesseing the smartness level of SBP in a simple and practical way.

Table 1.Definitions of SBP; Source: Authors Based on Literature Sources

Definition	Reference
The Intelligent Building Institute (IBI) in USA concentrated on achieving cost effective environment. In order to achieve this goal; the IBI determined four basic elements that should be considered (structure, systems, services and management). The IBI also determined other SBP goals like safety, flexibility and energy management but didn't recommend or suggest any tools to achieve those goals (Kent Peter, 2004).	The Intelligent Building Institute (IBI) in USA, Washington DC, 1985
The International Symposium focused on cost aspects and achieving maximum return. The definition illustrated that the integration between innovations, technology and management can be considered a tool to achieve the target cost return. This definition ignored other smart aspects like energy, flexibility, safety, etc. (Kent Peter, 2004).	The International Symposium, Toronto, 1985
The European Intelligent Building Group identified three main objectives of smart buildings; maximizing efficiency of occupants, acheives effective management of resources and minimum life cycle. This definition is very generic and not clear; there is a lack of determining the tools to achieve the mentioned objectives. There is also a lack in clarifying the meaning of efficiency of occupants and effective management (Krawczyk Robert & Sherbini Khaled, 2004).	The European Intelligent Building Group (EIBG), Europe, Late 80s – Early 90s
The International Council for Research and Innovation in Building and Construction (CIB) introduced the most comprehensive defnition of SBP compared to available ones. This definition provides a guideline to the nature of architectural design of SBP; it describes the design of SBP as a dynamic and responsive design. This definition explained the main target of SBP and determined a comprehensive tool to achieve this target through integrating four basic elements of the building; places, processes, people and management (Kent Peter, 2004).	The International Council for Research and Innovation in Building and Construction (CIB), 1995

Table 1 continued

The definition of SBP in Asia evolved in 1999; the main objective was to meet user's requirements and achieve long-term building value through selecting the suitable quality environment modules (Albert T.P. So et al., 1999). From 2000 to 2015; the Asian Institute of Intelligent Buildings developed the concept of SBP and SBP became a description of buildings which contain systems that are integrated into an advanced information technology (IT) environment, smart structure and modern management theories. This concept was then formulated and replaced with the one that was previously issued in 1999 (Asian Institute of Intelligent Buildings web site, 2017). The old definition is more comprehensive and covers more aspects than the one which was adopted in Asia from 2000 to 2015 (So Albert & Wong KG, 2002)	Dr. Albert So who has developed a definition of Intelligent Building (IB) for Asia, 1999. The Asian Institute of Intelligent Buildings (AIIB), Asia, 2000 to 2015
The European Alliance of Companies for Energy Efficiency in Buildings (EuroACE) concentrated on energy efficiency of SBP through its life cycle and the way of connecting SBP within the same neighborhood through a smartgrid. The main target was to achieve comfortable, healthy indoor environment and low energy demands that allows the use of cost-effictive renewable energy sources. This definition concentrated on energy aspects while ignored design and management aspects. (The European Alliance of Companies for Energy Efficiency in Buildings (EuroACE), 2015).	The European Alliance of Companies for Energy Efficiency in Buildings (EuroACE), 2015
The International Council for Research and Innovation in Building and Construction (CIB) determined five characteristics of SBP; responsive, sustainable, lowly polluting, healthy and fuctional. Although the mentioned charcteristics seem comprehensive; CIB ignored cost, design and management aspects. CIB also didn't propose a framework or action plan to achieve the SBP targets and characteristics (CIB World Building Council Congress, 2016).	The International Council for Research and Innovation in Building and Construction (CIB), in the "W098 - Working Commission Report for Intelligent and Responsive Buildings", 2016, adopted Prof. Derek Clement-Croome's 2010 definition
The Buildings Performance Institute Europe (BPIE) focused on energy aspects. BPIE determined three main environmental objectives "(i) stabilizes and drives a faster de-carbonization of the energy system through energy storage and demand-side flexibility; (ii) empowers its users and occupants with control over the energy flows; (iii) recognizes and reacts to users' and occupants' needs in terms of comfort, health, indoor air quality, safety as well as operational requirements of SBP"; BPIE then identified "energy storage and demand-side flexibility" as a tool to achieve the three objectives. BPIE ignored management, cost and design aspects of SBP. (De Groote Maarten et al., 2017)	The Buildings Performance Institute Europe (BPIE), 2017

As illustrated in table (1); most of the authorities and institutes that are concerned with and responsible for SBP present in Europe, Asia and America while there is a lack of authorites which are responsible for SBP in Egypt. Although there is a lack of comprehensive definition that describes SBP worlwide; most of the available definitions are concerned with achieving users' requirements . In Europe; most of the authorities concentrate on energy aspects and life cycle of SBP, Asia focuses more on the value of SBP and technology aspects that can connect SBP together, while America focuses on cost aspect of SBP. Generaly; the guidelines that facilitate achieving the objective of SBP are missing in most of the definitions.

3.3. Characheristics and Targets of SBP

Europe, Asia and Australia are three pioneer continents that set different characteristics of SBP based on their circumstances, culture and needs.

In Europe; the main target of SBP is to improve the European economy by achieving low-carbon economy goals through adopting smart cities and smart buildings. According to the European Council for an Energy Efficient Economy and "The Energy Performance of Buildings Directive (2010/31/EU)"; smart new buildings should achieve nearly zero energy by 2020 (eceee policy brief, 2010)

SBP in Australia focuses on enhancing the performance of environmental, economic, operation and safety aspects; this is in addition to adopting communications, control and automation technologies.

In Asia; the AIIB determined nine "quality environment modules" (Ms) or "IB Index" that define SBP; "M1; Environmental friendliness; health and energy conservation; M2; Space utilization and flexibility; M3; Human comfort; M4; Working efficiency; M5; Culture; M6; Image of high technology; M7; Safety and security measures; fire, earthquake, disaster and structural damages; M8; Construction process and structure; M9; Life cycle costing; operation and maintenance with emphasis on cost effectiveness; M10; Health and Sanitation" (So Albert & Wong KG, 2002). In addition to the characteristics which were determined by the AIIB; some countries in Asia identified other characterestics for SBP that can cater more for their own needs.

- In Korea; according to the Intelligent Building Certification Program" (IBCP); SBP aim at providing a comfortable, safe, and environmentally sustainable built environment through achieving the integration between architecture, electricity and electronics, information and communication, mechanical equipment, energy, and environmental systems to (Amir Ghaffarianhoseini et al., 2015)
- In Japan; SBP focus on energy consernation, environmental and ecological sustainability, users' health and comfort, efficiency of operations and management and flexible responsive economics that can cope with and adapt changing environment (Amir Ghaffarianhoseini et al., 2015).
- In China; SBP are divided into two types; type 3A which contains three main functions; Communication Automation (CA), Office Automation (OA) and Building Management Automation (BA) and type 5A which contains all the functions of 3A in addition to Fire Automation System (FA) and Maintenance Automation System (MA) (Albert T.P. So et al., 1999).
- In Singapore; according to the Public Works Department of Singapore Government; SBP should adapt advanced automatic control systems in order to monitor various facilities and to provide a comfortable working environment for the user. SBP should also adapt proper infrastructure network and suitable telecommunication facilities in order to enable data flow between floors and stay connected to the surroundings (Albert T.P. So et al., 1999).

Characteristics of SBP are flexible and differ from place to another according to different cirumstances such as objectives, needs, culture, cost, etc. The most holistic characteristics of SBP are those described in Asia as the environmental modules cover most of SBP aspects, they are flexible and can be applied, increased or decreased according to the objectives of SBP.

Based on the analysis of literature sources, definitions and characterestic of SBP; a checklist to identify smartness aspects of SBP can be conscluded as illustrated in table (2).

Table 2.SBP Smartness Aspects Checklist; Source: Authors Based on Literature Sources

	Smartness Aspects	SBP1	SBP2	SBP3
1	Efficient life cycle costing			
2	Efficient facility management (operation & maintenance, safety, comfort, health, sanitaion, etc.)			

Table 2 continued

3	Flexible architectural design			
4	Efficient energy performance			
5	Internet of Things (IoT) technology, automation applications and BIM applications			
6	Environmental sustainability			
7	Connected to surrounding SBP through smart grid			

The checklist determined 7 key smartness aspects that partially or fully present in SBP. This checklist will be applied on the casestudies to compare between them and identify the differences between SBP in Egypt and worldwide.

3.4. Analysis of Case Studies

The checklist was applied on three SBP which are located in Europe, Asia and Australia. Europe, Asia and Australia are considered three pioneer continents in identifying the characteristics of SBP. The Edge Office Building in Amesterdam, Europe is internationally known as the smartest building in the world, IRENA Head Quarter in Masdar Smart City, Abu Dhabi, Asia and Pixel Smart Building which is considered the most successful building to achieve characteristics of SBP in Melbourne, Australia. The three worldwide SBP were analyzed and compared to an SBP (Dar office building) in Smart Village Egypt. The main aim is to determine the main differences between SBP in Egypt and worldwide.

Table 3.Analysis of Case Studies in Egypt and Worldwide; Source: Authors Based on Literature Sources

	Smartness Aspects	The Edge office building, Amsterdam, Netherlands, Europe	The International Renewable Energy Agency (IRENA)'s Global Head Quarter (HQ), Masdar Smart City, Abu Dhabi, Dubai, Asia	Pixel Building, Melbourne, Australia	Dar Office Building, Smart Village, Egypt	Smart Buildings in the New Administrative Capital, Egypt
						
1	Efficient life cycle costing	✓	✓	✓		
2	Efficient facility management (operation & maintenance, safety, comfort, health, sanitaion, etc.)	✓		✓	✓	
3	Flexible architectural design	✓		✓	✓	
4	Efficient energy performance	✓	✓	✓		✓

Table 3 continued

5	Internet of Things (IoT) technology, automation applications and BIM applications	✓	✓			✓
6	Environmental sustainability	✓	✓	✓	✓	
7	Connected to surrounding SBP through smart grid		✓			✓

Worldwide SBP achieve more than 50% of SBP smartness checklist while in Egypt SBP achieve less than 50% of SBP smartness checklist; this percentage reflects that SBP approach in Egypt is not comprehensive. Some SBP in Egypt concentrate on flexibility in architectural design and efficient facility management; other SBP in Egypt concentrate on IOT technology and energy efficiency aspetcs. Most of SBP worldwide focus on life cycle cost efficiency while this aspect is ignored in Egypt. Green sustainable buildings in Egypt are counted as SBP, while worldwide; sustainablity is considered on of the smartness aspect in SBP.

4. Findings

The trend of SBP is new and very rare in Egypt; there is a lack of studies, guidelines or benchmarks in Egypt that can be used as reference to establish new SBP. The attempts to design, construct or operate SBP in Egypt are not comprehensive and don't reflect the holistic meaning of SBP compared to worldwide experience. Table (4) summarizes the general challenges of SBP in Egypt categorized by project phase based on the analysis os literature review and initial analysis of some case studies in Egypt and worldwide.

Table 4.Challenges of SBP in Egypt ; Source: Authors based on Literature Sources and Analysis of Case Studies

Category by Phase	Challenges
Data Collection to Concept Design Challenges	Lack of clear definition to smart buildings in Egypt Most of the associations and researchers concentrate only on automation and technical aspects (ICT, communication, connection to smart infrastructure grids, etc.) of smart buildings and ignore other aspects
Schematic Design to Design Challenges	Lack of set of guidelines to design a smart building project Lack of experience to manage the design process of this type of projects in Egypt Operation and maintenance requirements are not clear as the responsible team is not involved during early project phases
Construction to Testing and Commissioning Challenges	Many variations result in increase in the budget and time schedule of the project Lack of well-trained labor who can work on this type of projects Lack of experience to test the smart aspects and systems of this type of projects
Operation and Maintenance Challenges	Huge operations and maintenance costs Due to the absence of the operations and maintenance team during early project phases; a lot of risks evolve during operation and maintenance phase.

The above concluded general challenges were re-categorized into six key challenges; lack of research work, absence of comprehensive definition, absence of characteristics, vague objectives, lack of framework an ignoring LCC aspects. The re-categorization is based on analysis of case studies along with analysis of available definitions and characteristics. The analysis of case studies and literature resources reflect the average number of repetition of each

of the six identified key challenges categories. The number of repeition of each category was translated into percentages which were pointed out in figure (2); the main aim is to fullfil the objective of the entire paper and to identify the average percentages of different challenges that face SBP in Egypt.

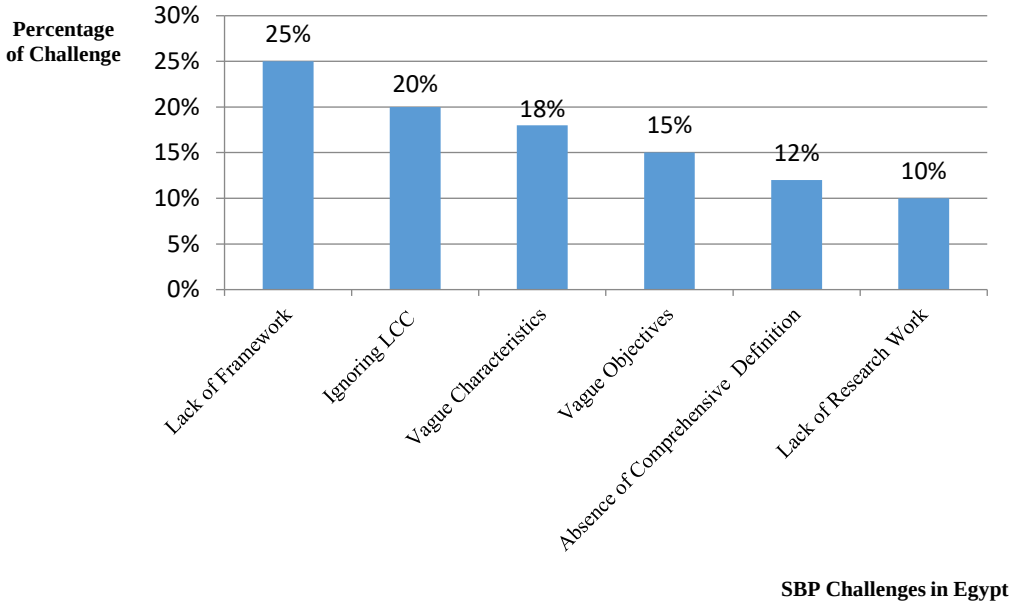

Figure 2. The Key Challenges of SBP in Egypt; Source: Authors Based on Literature Sources and Analysis of Case Studies

More than 50% of SBP challenges in Egypt are due to the absence of framework to establish SBP, ignoring LCC aspects and absence of clear characteristics. The rest of challenges are divided between lack of research work, absence of obvious definition and objectives. The resulted percentages reflect the importance of needed further studies to develop a comprehensive set of characteristics, holistic definition and framework that incorporates all smartness aspects and respects circumstances in Egypt while establishing SBP.

5. Conclusion

The objective of this paper has been partially fulfilled through the literature review and an initial analysis of some SBP projects in Egypt and worldwide; however, the extracted challenges facing SBP need to be validated through undergoing analysis of examples for such buildings and then through investigation and detailed analysis of local case studies.

Validating the extracted challenges is the first step to mitigate and resolve them. Providing appropriate solutions to face the challenges can be achieved through designing a comprehensive framework to be applied while establishing an SBP and through its life cycle. In order to design this important framework, further studies are required to identify the objectives, holistic definition and characteristics of SBP. The action plan to design and validate a framework to face the challenges of SBP in Eygpt is illustrated in figure (3).

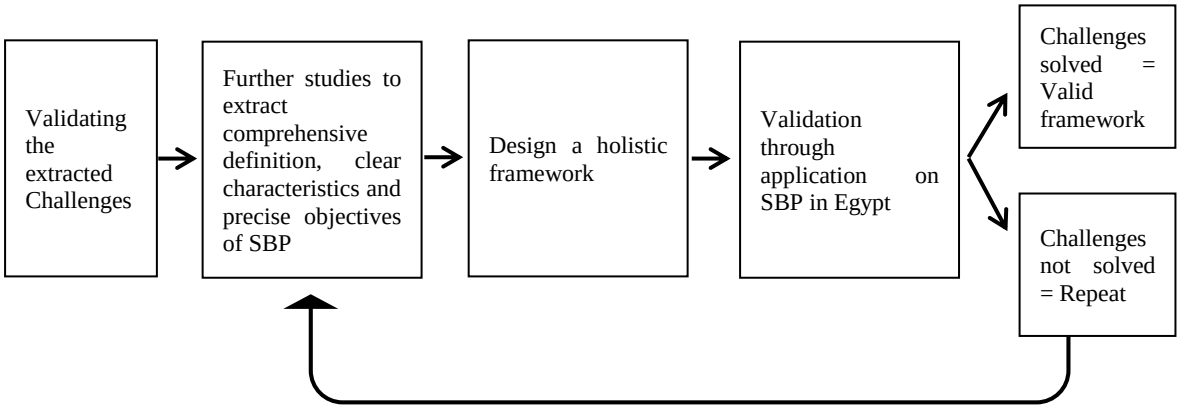

Figure 3. Action Plan of Designing and Validating a Framework to Face SBP Challenges;source: Authors

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