A Proposed Management System for Construction Practices during Sustainable Buildings Life Cycle

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ABSTRACT

For many years, the construction industry damages have been overlooked such as unreasonable consumption of resources in addition to producing a lot of construction waste but with global awareness growth towards the sustainable development issues, the sustainable construction practices have been adopted, taking into account the environment and human safety. The research aims to propose a management system for construction practices which could be adopted during constructing different types of sustainable buildings besides formulating flowcharts which clarify the required whole phases of sustainable buildings life cycle. The research includes two parts: theoretical part which generally ,handles the sustainability concepts at construction industry and specially buildings .But the practical part comprises investigating the professional opinions in construction industry about applications possibility of sustainable requirements and global criteria to construction of sustainable buildings in Iraq where the weakness and strength points in the essential requirements for achieving the sustainable construction practices have been diagnosed and the development need has been specified. The utilized statistical analysis of questionnaire results show readiness of buildings sectors to implement the sustainable practices. The different strategies and techniques in the proposed management have been employed for getting the sustainable procedures of sequences practices within project life cycle.

Key words: system, practices, sustainable buildings, phases.

نظام إداري مقترح للتطبيقات الانشائية خلال دورة حياة المباني المستدامة

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الخلاصة

خلال سنوات عديدة , تم اغفال اضرار الصناعة الانشائية كالاستهلاك اللامعقول للموارد فضلا عن انتاج الكثير من المخلفات الانشائية , لكن مع تنامي الوعي العالمي نحو قضايا التنمية المستدامة تم تبني فعاليات انشائية مستدامة (تطبيقات) تاخذ في الحسبان سلامة البيئة والأنسان.يهدف البحث الى اقتراح نظام اداري للفعاليات الانشائية يمكن إعتماده خلال إنشاء انواع مختلفة من الابنية المستدامة الى جانب صياغة مخططات انسيابية توضح الأجراءات المطلوبة لكافة مراحل دورة حياة المباني المستدامة . تضمن البحث جزئين أساسيين : الجزء النظري , حيث تناول مفاهيم الأستدامة في الصناعة الأنشائية بشكل عام والمباني بشكل خاص وأما الجزء العملي فشمل أستطلاع أراء المختصين في الصناعة الأنشائية حول إمكانية تطبيق متطلبات ومعايير الأستدامة العالمية في إنشاء المباني المستدامة في العراق حيث تم تشخيص نقاط القوة والضعف في تطبيق المتطلبات

اللازمة لتحقيق الفعاليات الأنشائية المستدامة وتحديد مدى الحاجة للتطوير .اظهر التحليل الاحصائي المستخدم لنتائج الأستبيان استعداد قطاع الابنية لتنفيذ متطلبات الفعاليات المستدامة . وتم توظيف استراتيجيات وتقنيات مختلفة في النظام الاداري المقترح إعتمادا على معايير تقييم المباني المستدامة للحصول على أساليب إجرائية مستدامة للفعاليات المتتالية ضمن دورة حياة المشروع .

1 - INTRODUCTION

The present global environmental conditions are consequence of the increasing consumption of natural resources whose depletion exceeds what is physically possible to sustain in the long term. The effects resulting in damage of eco-systems are very evident. Therefore the need arises to find clean friendly sources for energy with environment and other strategies for protecting both of the environment and the opportunities of next generation for sharing with these resources within sustainability frame.

The construction sector is complex and has, therefore, a tendency to resist changes towards sustainability. Designers and project managers are facing barriers to the application of sustainability, e.g. lack of pro-active sustainable measures, conflicts in real and perceived costs and inadequate implementation expertise.

The sustainable construction practices are modern subject and the sustainable construction captures interesting position of the researchers but until now there is no management system for sustainable construction practices. In this research the researcher will propose management system for managing them during sustainable buildings life cycle therefore this research is considered the first thesis interested in this subject. The research scope of the sustainable buildings includes commercial buildings, public services (non-housing) buildings, multi-residential buildings and managerial buildings.

2- SUSTAINABLE CONSTRUCTION

The goals of sustainable construction are to maximize resource efficiency and minimize waste in the building assembly, operation, and disposal processes. Sustainable construction seeks to dovetail the construction industry into the global sustainable development movement by moving it onto a path where it adheres to principles that are able to provide a good quality of life for future generations **, Panagiotakopoulos,2005**.

2-1 Management of Sustainable Construction

The management team of a sustainable construction work project should consider the entire process from an early design stage towards the final product, and the benefits and negative impacts regarding the triple bottom-lines of sustainability that are to be expected during the lifetime of the final product, i.e. the facility **, Persson , 2009**.

2-2 The Sustainable Construction Practices

Sustainable construction practice refers to various methods in the process of implementing construction projects that involve less harm to the environment - i.e. prevention of waste production, increased reuse of waste in the production of construction material - i.e. waste management, beneficial to the society, and profitable to the company **,Akadiri , 2011.** To create a competitive advantage using environment-friendly construction practices and the whole life-cycle of buildings should be adopted also, **Akadiri et al., 2012.**

3- LIFE CYCLE OF SUSTAINABLE BUILDING

The term “Sustainable buildings” is often used interchangeably with “green buildings” or “eco-buildings” **,ADUPC,2010**. Construction activities affect the environment throughout the life cycle of a construction project. This life-cycle concept refers to all activities from extraction of resources through product manufacture and use and final disposal or recycle, i.e. from "cradle to grave" **, Akadiri, 2011**.

The Whole Building Life-Cycle that guides current practices comprises processes of feasibility ,design, construction, operation, renovation, and demolition of buildings **,Panagiotakopoulos,2005**, **Randolph et al., 2008,** and **Mer'eb, 2008. Bauer et al.,2010,** attempted to extend this thinking even further by considering the regenerative and productive reuse of products and materials in what they call a "cradle-to- cradle" approach**.**

As a result of advance, the researcher supposes the sustainable buildings life cycle should include the phases: planning, design, procurement, implementation, operation and maintenance, post operation and maintenance (which could include deconstruction / reusing / disposal/ demolition).

3-1 Cost of Sustainable Buildings

The opinions about the cost of sustainable buildings are divided into three attitudes:

1) **Halliday, 2008,** refers the overriding assumption that sustainable building inevitably costs more or is less profitable based on the market-driven economies and doesn't adopt them besides the innovation required has a cost implication of time, planning, risk and enhanced information requirements, and the innovators will be penalized and their profit margins reduced when put in direct competition with unsustainable practices.

2) **Persson , 2009,** opposes **,Halliday, 2008,** by saying "*there is a common misunderstanding that sustainability in construction works is more expensive in terms of investment costs compared to 'normal' mainstream buildings.",* based on survey conducted by the World Business Council for Sustainable Development in 2008 which investigated the difference in investment cost between a 'normal' building and a certified sustainable building which is about 17% for the last and **,Persson , 2009,**added that the initial costs do not necessarily increase if energy consumption (one of the most significant factors in building sustainability) is reduced by about 50%.

3) **Myers, 2008,** takes the neutral side when he clarified that cost-benefit analysis is a way of appraising an investment proposal. It involves taking into account the external costs and benefits of a proposed development as well as the conventional private costs and benefits. This is done by estimating monetary values for aspects such as health, time, and pollution.

3-2 Tools of Sustainable Buildings Projects Management

The researcher notes some tools are used numerously in management of sustainable buildings projects which are:

1) **Life-cycle cost analysis**

Life-cycle cost - sometimes also called - Whole-Life Cost (WLC) is the assessment of all relevant costs and revenues associated with a building over an agreed period, including procurement, operation and sometimes disposal. Whole-life cost looks at the life cycle from the start of design and construction, and might include**:** procurement costs, operating costs, recurring, end-of-life and revenue **,Halliday, 2008**.

2) **Value engineering**

In sustainable perspective, in value engineering all alternatives can be compared using life-cycle costing because the alternatives for each project component (systems, materials, plant, and processes) are defined to satisfy the same basic function or set of functions. When the alternatives all satisfy the required function, then the best value alternative can be identified by comparing the first costs and life-cycle costs of each alternative for achieving lowest life-cycle cost consistent with the required performance. Value engineering has been used at sustainability issues as siting factor, energy issues, water, facility costs **,Federal Facilities Council, 2001**.

3) <u>Computer simulation</u>

During the planning and construction process, computer-based simulation programs are used ,**Bauer et al., 2010. Site** and **Project Planning Group, 2002,** showed that computer simulation is used at pre-design, schematic design, design development, construction, commissioning, post-occupancy. Computer simulations serve to define the following practices **,Bauer et al., 2010**:

a. Maximum and minimum air temperature settings or indoor heating and/or cooling load, for thermal indoor comfort.
b. The operating behavior of a given building under real-life and variable conditions for defining energy efficiency.
c. For evaluation and optimization of a building and its envelope.
d. Using most efficiency water strategies.

4) <u>Rating systems</u>

Rating systems have been developed to measure the sustainability level of green buildings and provide best-practice experience in their highest certification level. With benchmarks, the design, construction and operation of sustainable buildings will be certified using several criteria **,Bauer et al., 2010**.

It is important to realize that any scheme is very good mechanism for encouraging design teams, particularly those unfamiliar with the issues of sustainable design, to focus on a client aspiration **,Halliday, 2008**.These systems often provide a defined format for projects to compare to a baseline to determine how they measure up against other projects **, Sarté, 2010**.

The researcher could draw out some of the most criteria repeatedly, which could search within the following axes: sustainable site, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovation in design.

4- MANAGEMENT OF CONSTRUCTION PRACTICES DURING SUSTAINABLE BUILDINGS LIFE CYCLE

The ways of management the sustainable construction practices could be explored and categorized them during sustainable buildings life cycle phases as follows:

4-1 Planning phase

Every project starts with a vision and a set of objectives. Once the structure is agreed on, a project has been defined and agreed upon, the next step is to establish appropriate design strategies to meet those goals **,Sarté, 2010**. Planning initiate with feasibility study which is carried out by assessing the client's objectives and providing advice and expertise in order to help the client define more precisely what is needed and how it can be achieved **,The Chartered Institute of Building, 2002**.

Federal Facilities Council, 2001, states that ecologically and culturally sensitive areas should be considered at sustainable site planning. The cost plays essential role in water planning .For example, in the tertiary treatment levels, they have improved water quality but they have come at a high energy cost **,Sarté, 2010**.

USGBC, 2009, states that the requirements like on-site renewable energy self-supply, minimum and optimize energy performance, measurement and verification should be considered at this phase.

In selecting sustainable materials, designers should aim to maximize durability, energy efficiency, recyclability, maintainability, and use of local materials to minimize the use of hazardous materials, and synthetic chemicals by using a strategy in the choice **,Akadiri ,2011**.

Life-cycle assessment (LCA)could be used as a method to measure and evaluate the environmental burdens associated with a product system or activity, by describing and assessing the energy and materials used and released to the environment over the life cycle **,Halliday, 2008**.

The planning phase, must take into account outdoor air quality levels, all the possibilities and limits of air supply in respect to natural ventilation via the windows, filtering and cleaning of outdoor air **,Bauer et al., 2010**. Besides using passive cooling strategies, it includes **,Halliday, 2008**.

4-2 Design Phase

Green buildings incorporate three critical factors: energy, environment /ecology, and human health. These factors are keys to the design process **,Panawek, 2007**. In sustainable site design the land, its hydrology, and the complex diversity of living systems are interdependent and cannot be isolated from the design process**, Sarté, 2010**.

Site design begins with the analysis of the site and environmental conditions and integrates them into the program and design solution. Integrating the natural attributes of the site can reduce energy consumption considerably **,Williams, 2007.**

Federal Facilities Council, 2001, considers the following issues:

1) Specifying measures of water use can be taken to ensure is as efficient as possible.
2) Specifying measures to reduce, control, and treat surface runoff.
3) Incorporating rainwater collection cisterns and separate gray water systems for below-ground irrigation to eliminate the use of potable water.

Designers can therefore help reduce operational energy consumption of buildings by adopting designs that reduce heat losses through the building envelop, reduce cooling and heating loads and by introduction of energy saving measures **,Ndungu , 2008**.

The efficient utilization of resources as possible needs to specify the use of renewable and recycled sources in order to close the life-cycle loop of materials and select materials with the least environmental impact throughout their entire lifetime **Akadiri ,2011.**

Design of indoor environment considers the following **,Bauer et al., 2010**:

1) Assuring optimal air quality.
2) The amount of daylight reaching the room.
3) The solar protective device's automation.

4-3 Procurement Phase

Federal Facilities Council, 2001, states that the following should be considered at procurement phase:

1) Stipulation on specification design criteria.
2) The contract method that will best support the achievement of sustainability objectives.
3) Implications of the choice of project delivery method.
4) Implications of the contract selection procedure.
5) The types of incentives and clauses.
6) Types of evaluations used.
7) The side responsible for sustainable construction practices.

8) The required level of commissioning, the liability for failures to meet the requirements and the remediation method in the failures case.

4-4 Implementation Phase

Implementation stage is the actual execution of what has been planned to be a development project. Implementation is made according to projects agreement and memorandum. During the implementation process complexity and risks come to closer, bureaucratic problems, and conflicts could emerge **,Oyoko et al., 2008**.

Halliday, 2008, mentions that particular attention should be paid to the commissioning operations – not just of innovative technology. Checking that products are of the required quality and that they work as specified is essential. It will become clear at this point how important it is to specify all the testing regimes at the tender period.

The following the procedures could be taken in the construction phase **,Federal Facilities Council, 2001**:

1) Evaluation, analysis, and consideration of change orders that may affect facility sustainability.
2) Study on value engineering of change proposals.
3) Implementation of monitoring procedures.
4) Reduction or elimination of the production of harmful waste.
5) Protection of construction workers from the hazard waste.

4-5 The Occupancy (Operation and Maintenance) Phase

The constructed works are expected to be in service for a long time. Maintenance is defined, according to Standard of International Organization for Standardization (ISO 15686-1), as: *"Combination of all technical and associated administrative actions during service life to retain a building or its parts in a state in which it can perform its required functions"* **,Hallberg , 2005**.

The most important job in maintenance is to make regular checks which might betray a more serious durability threat. Simple visual checking is often all that is required, but it should be thorough and regular. In this way almost all serious problems can be spotted early and dealt with cheaply and simpl, **Halliday ,2008**.

4-6 Post Operation and Maintenance Phase

At the end of life phase, sustainability issues that need to be considered are the reduction of waste when the buildings are demolished. All avenues to recover materials by recycling and reuse should be explored **,Ndungu, 2008**. Accordingly the researcher handled the following aspect:

1) **<u>Deconstruction</u>**

The processes of dismantling a building or site have shifted from demolition to deconstruction **,Calkins, 2009**. Deconstructing a building is the careful dismantling of that building so as to make possible the recovery of construction materials and components, promoting their reuse and recycling **,Couto et al., 2010**. A good deconstruction contractor will be able to reclaim/recycle 75%–95% of the site and building if salvage or recycling markets are available nearby **,Calkins, 2009**.

2) **<u>Source-separated recycling</u>**

Source-separated recycling (also called source separation) is the alternative to commingling. The highest benefits of recycling come from separating waste materials at the jobsite , transporting and recycling them individually into a different container which is then transported by a recycler, transfer site, or directly to individual markets **,Chiras, 2006**.

3) **Reclaiming and reusing of materials and products**

Reusing materials can add a layer of meaning to a project, revealing the cultural history of a place, which is often difficult to achieve with mass production due to the following **,Calkins ,2009**:

a. Finding appropriate types and quantities of materials.
b. There is often additional design time.
c. A reclaimed material will not be found in a catalog with all specifications listed.

4) **Demolition**

The demolition reduces the building or site to debris without preserving the integrity of its components for reuse **,Calkins, 2009**. During the demolition, rubble and debris are hauled away and disposed into the sea and sometimes at abandoned quarries **,Ndungu, 2008**.

5- FIELD SURVEY

There is a common misunderstanding supposes that the sustainable construction of the buildings is more expensive in terms of investment costs compared to traditional buildings and adoption of sustainable construction in construction works will lead to delay or confusion in methodology. Therefore, proposing a management system for the construction practices during sustainable buildings life cycle aims to correct this misunderstanding and encourage adoption of the sustainable construction practices and solve the avoidance of sustainable buildings.

As a result, the researcher embarked in testing the research hypothesis through field survey .The field investigation passed two stages, as follows:

1-Open questionnaire stage: through personal interview.
2-Closed questionnaire stage: by using questionnaire form.

The closed questionnaire form includes investigation the requirements of sustainable construction practices through six axes of sustainability: site, water efficiency, energy efficiency, and indoor environmental quality, innovation in design and awareness and education. Four determinants facing application the requirements of sustainable construction practices have been used in survey which is application's possibility, difficulty types, influence on cost and influence on time. The results of the first two determinates have been discussed depending on frequency distribution but the last two determinates have been discussed depending on the evaluation of statistical analysis results.

5-1 Statistical Analysis

The statistical analysis is used for analyzing the closed questionnaire results related with participants responses to the two determinants of using axes requirements which concern requirement influence on cost and on time by considering each response type of (always, often, some times and no) a class could give it evaluation range and extraction the class evaluation of degree (class center) as clarified in **Table 1**.The researcher used the following statistical features:

First: – The arithmetic mean

The weighted mean is used to evaluation every requirement of questionnaire axes .It has been calculated from the following equation **,Moore et al., 2009**:

$$M = \sum_{i=1}^{i=n} Xi * Fi/N \qquad (1)$$

where:

M = Responses weighted mean about requirement influence on cost or time.
Xi =Evaluation degree of responses class (i) about requirement influence on cost or time.
Fi = Responses frequency for class (i) about requirement influence on cost or time.
N= Sample size in each requirement.

The above equation is applied to influence of every requirement on each the cost and time.

Second: – The conformance ratio

It is used in influence evaluation for every axis of questionnaire axes on the cost and time .It represents congruence extent of axis influence with the ideal status depending on responses frequency for sample individuals by applying the following equation **,Al- Ani, 2006**:

$$Cr = M / X_{max} \quad (2)$$

Where:
Cr = Axis conformance ratio.
M = Arithmetic mean of responses weighted mean.
X_{max}= The maximum evaluation degree which represents the maximum class center for the responses evaluation (8.75).

The analysis and evaluation of the questionnaire results for every axis of questionnaire axes depend on conformance ratio computed for every axis whose value varies from (1.25/8.75 - 1) where the median of these ratios is the average of (0.42) and (0.72) and equals (0.57) and it is considered the lower limit to axis analysis, then the upper quartile will be computed for the values (0.14-1) as follows:

a- If **(Cr < 0.57)**, then evaluation of axis influence is **(poor)** therefore the required development would be **(must)**.
b- If **(0.57≤ Cr ≤ 0.86)**, then evaluation of axis influence is **(accepted-middle)** therefore the required development would be **(wanted)**.
c- If (**Cr > 0.86)**, then axis evaluation is **(good-very good)** therefore the required development would be **(desired)**.

Based on results of total weighted mean listed in **Table 2**, all axes have Cr < 0.86 thus all axes affect cost and time therefore the supposed actions which make the axes affect cost and time need development. Also from **Fig. 1**, it could be noted there is relation between the axis influence on cost and time since whenever the axis affect cost, it affect time too.

As a conclusion from analysis the closed questionnaire results, the building construction sector has the readiness for inclusion of the sustainability aspects but it suffers from absence of management system because of some of difficulties which are summarized by technical difficulties in the first place, followed by managerial difficulties are due to lack of awareness of sustainability targets in addition fear of effect on cost and time of project if the sustainable construction practices have been applied. But the proposed actions of management system could overcome both lack of awareness and some of these effects.

Then the comprehensive view of extent of acceptance of building construction sector has been reached .In addition, the light is shed on fields that need to be developed .Based on the results, the researcher could diagnose the weaknesses and strengths in managing the sustainable construction practices.

6- THE PROPOSED MANAGEMENT SYSTEM OF SUSTAINABLE BUILDINGS

The management system is an approach used to organize the activities and the resources to perform the actions according to a specified cost and time program relating to certain objectives. Since sustainable building life cycle consists of six phases, previously mentioned, the researcher has tracked the construction practices through the sustainability aspects during life cycle phases to find out the procedures and at the end to formulate the proposed management system.

The proposed management actions are based on management strategies and techniques that constitute most difficulties facing the construction practices, as well as the cost and time management through the placed plans and requirements that precede the intended actions, where every criterion of sustainable site, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation in design comprise many construction practices.

6-1 The Proposed Planning Actions for Sustainable Buildings

The planning phase is considered the first phase in the project. The project –owner requirements should be defined to clarify the project scope by the planning consultant and the project team (project manager, engineers, geotechnical specialists, other specialists, land surveyors, cost estimator and quantity surveyors etc.). At this point the sustainability features begin to originate from environmental and sustainability objectives such as energy targets, the systems performance requirements, operation and maintenance, occupants' requirements, owner and user requirements that are stipulated in project –owner requirements document as shown in **Fig. 2**.

Fig. 2 shows the main planning actions for sustainable buildings including the following:

1- Establishing the sustainability vision, objectives, and measurements and implementing systems approach.
2- Feasibility study and cost estimations
3- Site selection
4- Value engineering
5- Schematic design
6- Developing the basis of design (BOD)
7- Cost efficiency management system

6-2 The Proposed Design Actions for Sustainable Buildings

For advancing sustainability in design, the following could be achieved:

1- Integrate sustainability vision and values into design.
2- Implement sustainability objectives, measurement system, systems thinking models and sustainability framework.
3- Implement sustainability approaches.
4- Applying Life cycle assessment for sustainability features.

As shown in **Fig. 3**, for conversion to sustainable design the sustainability axes such as sustainable site, water efficiency, energy and atmosphere, material and resources and indoor environmental quality, and innovation in design have been considered. Each of these axes includes more than design set. **Fig. 3** shows actions that should be followed in each axis and how the researcher employed the construction practices related to them in the design phase.

6-3 The Proposed Procurement Actions for Sustainable Buildings

The procurement in construction life cycle of sustainable buildings is related to purchasing of materials, plant, and the correct choice of suppliers and subcontractors. The actions related to procurement could include the following:

1- Integrate sustainability vision and values into procurement.
2- Implement sustainability objectives, measurement system, systems models and sustainability framework.
3- Commit to green purchasing policy.
4- Implement sustainability.
5- Engaging procurement in design for a sustainable supply chain

As a result, the researcher summarized the procurement actions in a proposed flowchart in **Fig. 4**.

6-4 The Proposed Implementation Actions for Sustainable Buildings

The following activities must be followed:

1- Integrate sustainability vision and values into construction.
2- Implement sustainability objectives, measurement system, and sustainability framework.
3- Implement sustainability approaches.
4- Manage and minimize CO_2 emissions in construction.

Fig. 5 describes actions which must be undertaken for managing the implementation of sustainable buildings which are characterized by performing all the previously arranged plans starting from performing time management and ending in performing operation and handover plan.

The most time-consuming activity in the project is the creation of the physical constructing of practices. **Fig. 6** explains the work mechanism that is followed in implementation according to sustainability axes. It is obvious from **Fig. 6** focusing on testing efficiency of all of the installed systems and sustainable practices insures of achieving the cost saving at its performing and environmental targets that are planned before. Many of the management process have been permeated and schemed at the planning phase.

6-5 The Proposed Operation and Maintenance /Occupancy Actions for Sustainable Buildings

The suggested operation and maintenance actions are as follows:

1- Integrate sustainability vision and values into operation and maintenance stage.
2- Implement sustainability objectives and measurement system.
3- Start early in planning and design to provide operation and maintenance input to project development.
4- Implement sustainability approaches.
5- Individual behaviors and individual ownership

This phase is very important in achieving the planned and designed savings therefore it should be of interest. As a result the researcher suggests the flowchart in **Fig. 7** for the operation and maintenance actions.

After operational building life has been finished, the structural element should be sustained through reusing of them at the same site and rehabilitation the capable elements by friendly–environmental materials

6-6 The Proposed Post-Operation and Maintenance Actions for Sustainable Buildings

The sustainability's tendency doesn't end with building occupancy and benefits harvested that had been looked forward but this stage could be exploited to service the building's sustainability in materials arena ,through construction waste management including reusing, recycling ,reprocessing and safety disposal.

Fig. 8 represents the proposed actions for post-operation and maintenance that the researcher proposes where advanced planning for deconstruction or salvage before demolition is crucial for its success.

Building deconstruction supports the waste management in its sequence of preferred options for the management of generated waste materials. If a building is still structurally sound, durable and flexible enough to be adapted for a different use, then waste can be reduced by reusing the whole building. If components and materials of a building can be recovered in high quality condition, then they can be reused. If the building materials are not immediately reusable, they can be used as secondary feedstock in the manufacture of other products, i.e., recycled. The aim is to ensure that the amount of waste that is destined for landfill is reduced to an absolute minimum. This approach closes the loop in material flow thereby contributing to resource efficiency.

At last, the proposed management system flowchart during sustainable buildings life cycle is summarized as shown in **Fig. 9**.

7- CONCLUSIONS

1. As a result of undertaking closed questionnaire, it was determined there was awareness lack about realizing the benefits of a sustainable approach in construction in Iraq which has led to absence of sustainable construction practices.

2. There is a huge lack in understanding the techniques of sustainable construction.

3. There is a relationship between some sustainable construction practices therefore application some of them will be reflected positively or negatively on other practices whether in direct or indirect way.

4. When the aim is to reduce site pollution, achieve indoor environment quality, reduce using the materials and resources this really leads to additional costs but on other hand the increase in cost could be balanced by the efficient use of materials and resources in construction phase, operation and maintenance phase and in the next-phase, moreover efficient use of water, energy at operation phase could save cost too.

5. Although application of the management system of sustainable construction practices may increase initial costs of buildings through design and construction phase, it will lead to cost savings greater than initial investment besides the environmental and social benefits. These savings are due to reduced water costs, lowered energy use, lowered, and decreased waste disposal, reduced operation and maintenance costs, and savings resulting from increasing productivity.

6. Some of sustainable construction practices affect time but as noted in the proposed management system more than sustainable practice can be applied at the same time with each other in addition to traditional practice as a result time as possible as could be saved.

7. Adopting the sustainability principles, especially at the post-operation and maintenance phase (deconstruction /disposal), could help in providing work opportunities and reduce the unemployment.

8- RECOMMENDATIONS

The following recommendations have been drawn to enhance the proposed management system for sustainable construction practices:

1. Applying the proposed management system in all details and actions to the future sustainable buildings projects in Iraq.

2. It should be of interest to develop the current techniques in construction practices in Iraq to be sustainable.

3. It is necessary to make the competition basis between the constructed company according to its commitments about implementing the sustainability's' principles by introducing the related plans within the bid.

4. Holding training courses and workshops to spread the sustainability aspects for both private and public sectors in collaboration with professionals who have experience in construction sustainability from abroad that are very advanced at this arena.

5. Establishing Iraqi sustainable buildings council which will be in charge of rating the sustainable buildings projects and giving recognized certification for this purpose as well as issuing guides for specifying the sustainable buildings similar to what is done in other countries like Abu Dhabi, USA, and Australia etc..

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Table 1. Distribution evaluation degree on responses classes.

Response Class	Evaluation Range	Evaluation Degree
No	**(10 - 7.51)**	**8.75**
Sometimes	**(7.5 - 5.1)**	**6.3**
Often	**(5 - 2.51)**	**3.75**
Always	**(2.5 - 0)**	**1.25**

Table 2. The evaluation of influence of axes on cost and time compared with ideal condition. (Researcher)

Axis	Axis Influence on Cost				Axis Influence on Time			
	Total Weighted Mean	Axis Conformance Ratio (Cost)	Evaluation of Axis Influence	Development of Supposed Axis Actions	Total Weighted Mean	Axis Conformance Ratio (Time)	Evaluation of Axis Influence	Development of Supposed Axis Actions
Site	67.39	0.59	accepted-middle	wanted	73.18	0.64	accepted-middle	wanted
Water Efficiency	21.33	0.49	poor	must	24.32	0.56	poor	must
Power and Atmosphere	19.77	0.45	poor	must	23.82	0.54	poor	must

Table 2. continued.

Axis	Axis Influence on Cost				Axis Influence on Time			
	Total Weighted Mean	Axis Conformance Ratio (Cost)	Evaluation of Axis Influence	Development of Supposed Axis Actions	Total Weighted Mean	Axis Conformance Ratio (Time)	Evaluation of Axis Influence	Development of Supposed Axis Actions
Materials and Resources	55.00	0.63	accepted-middle	wanted	59.30	0.68	accepted-middle	wanted
Indoor Environmental Quality	73.46	0.60	accepted-middle	wanted	84.54	0.69	accepted-middle	wanted
Innovation in Design	23.36	0.67	accepted-middle	wanted	25.11	0.72	accepted-middle	wanted
Awareness and Education	17.77	0.68	accepted-middle	wanted	19.92	0.76	accepted-middle	wanted

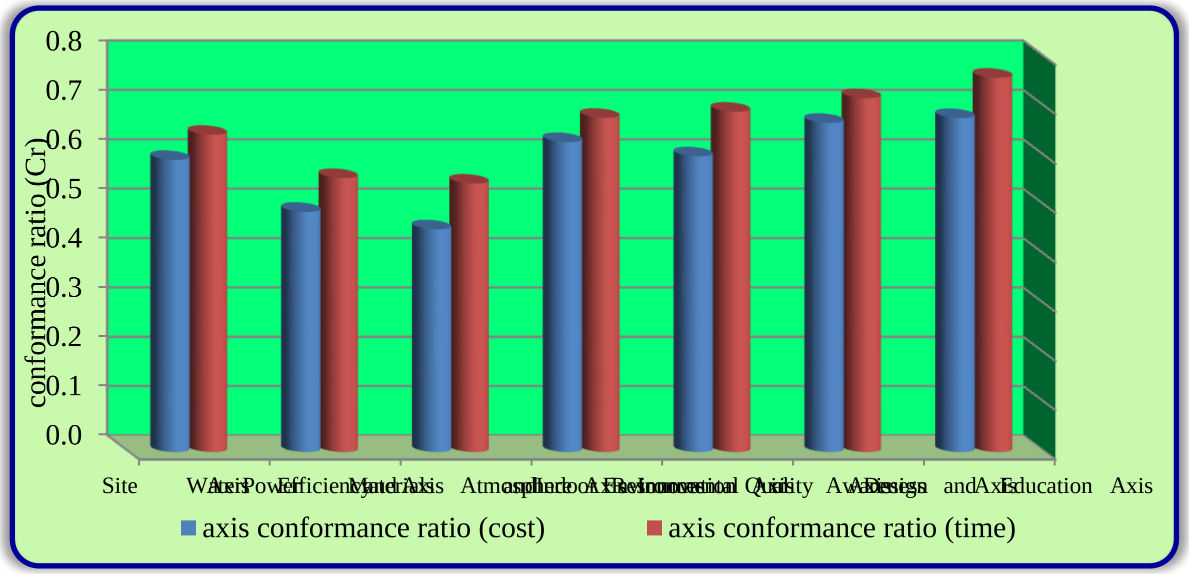

Figure 1. Conformance ratio of axis influence on cost and time compared with ideal condition.

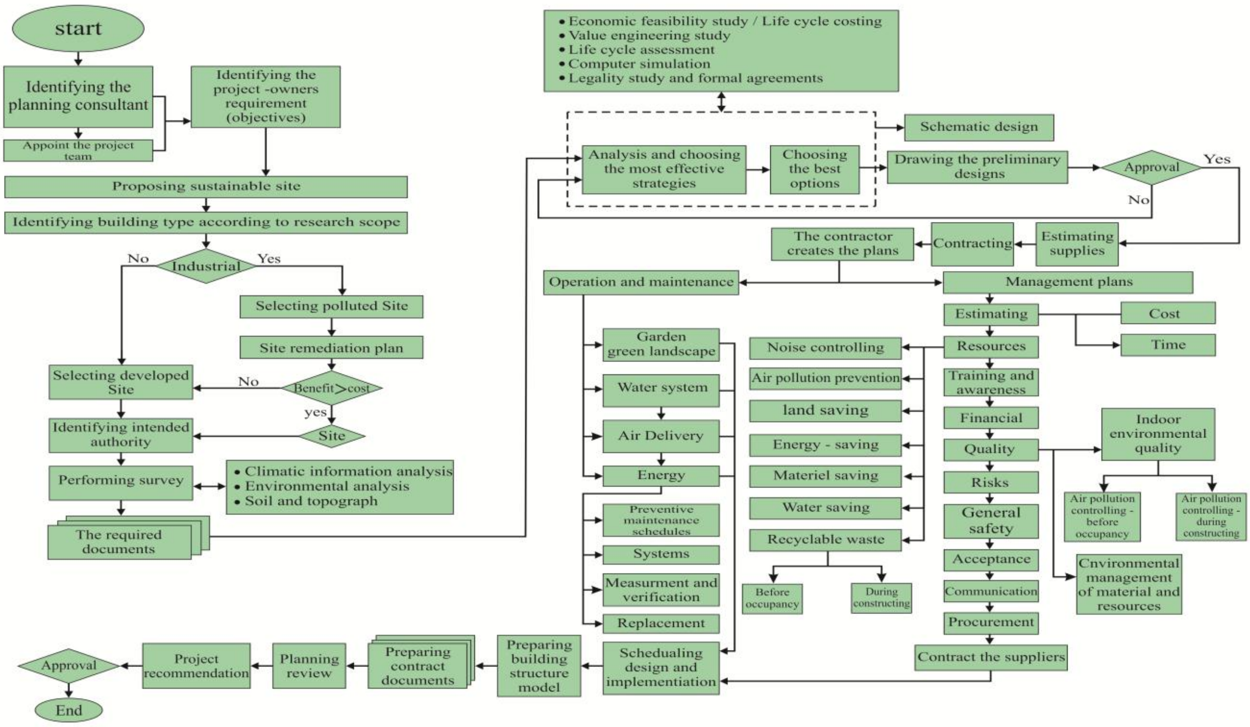

Figure 2. The proposed planning actions flowchart (researcher).

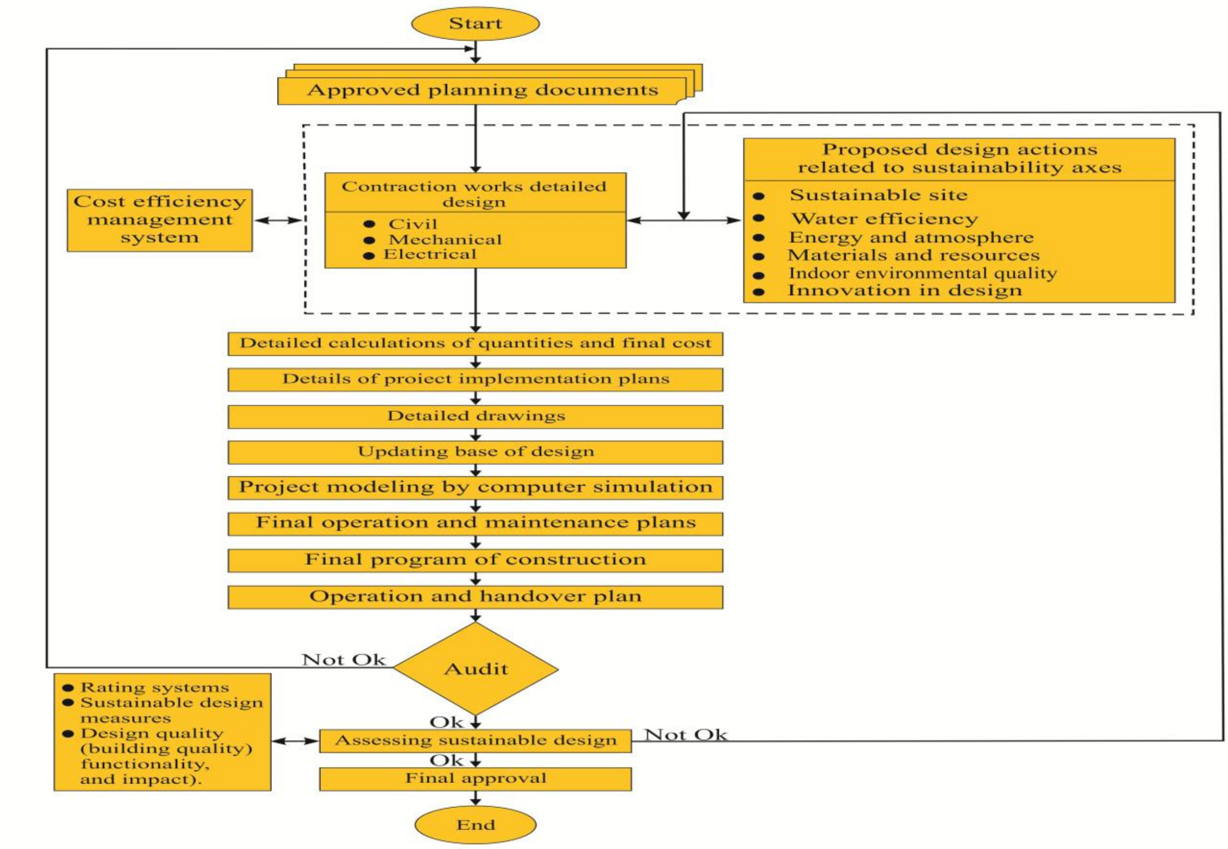

Figure 3. The proposed design actions flowchart (researcher).

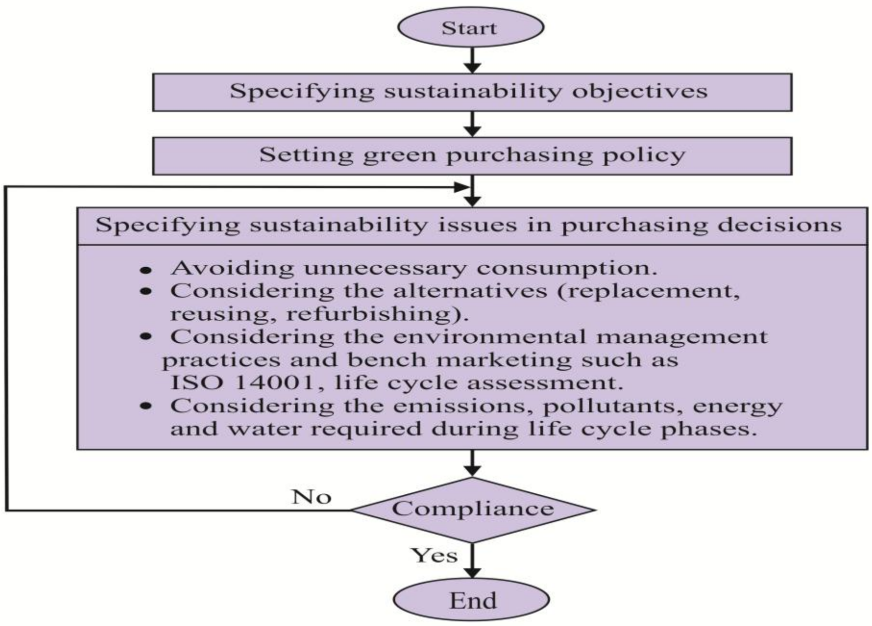

Figure 4. The proposed procurement actions flowchart (researcher).

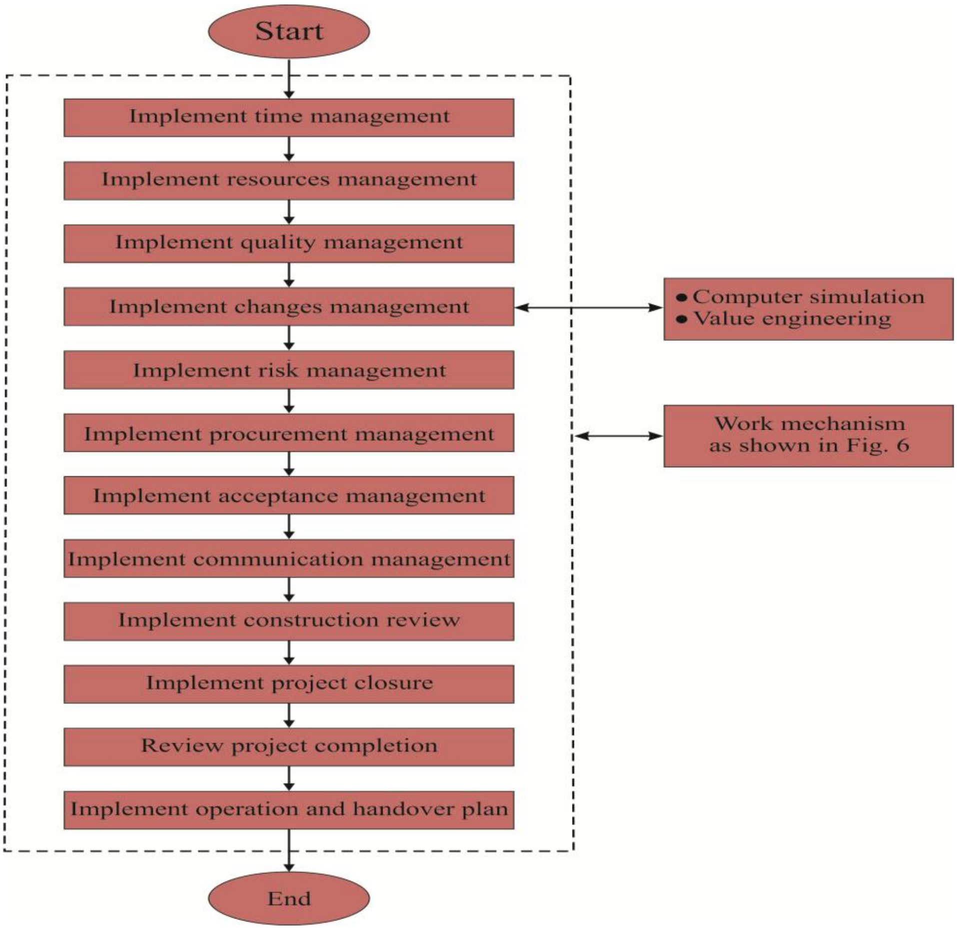

Figure 5. The proposed implementation actions flowchart (researcher).

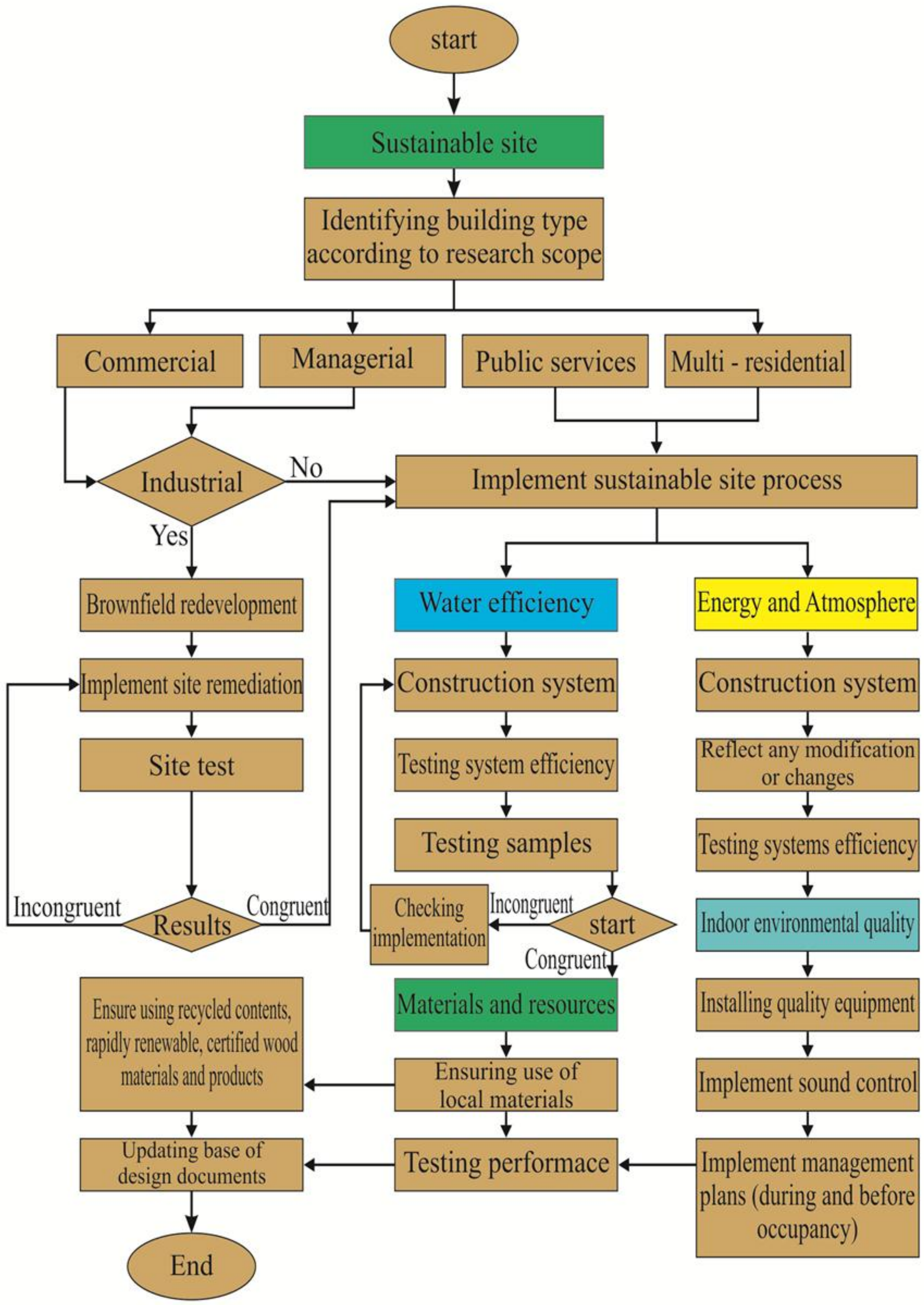

Figure 6. The proposed work mechanism in implementation phase of sustainable buildings (researcher).

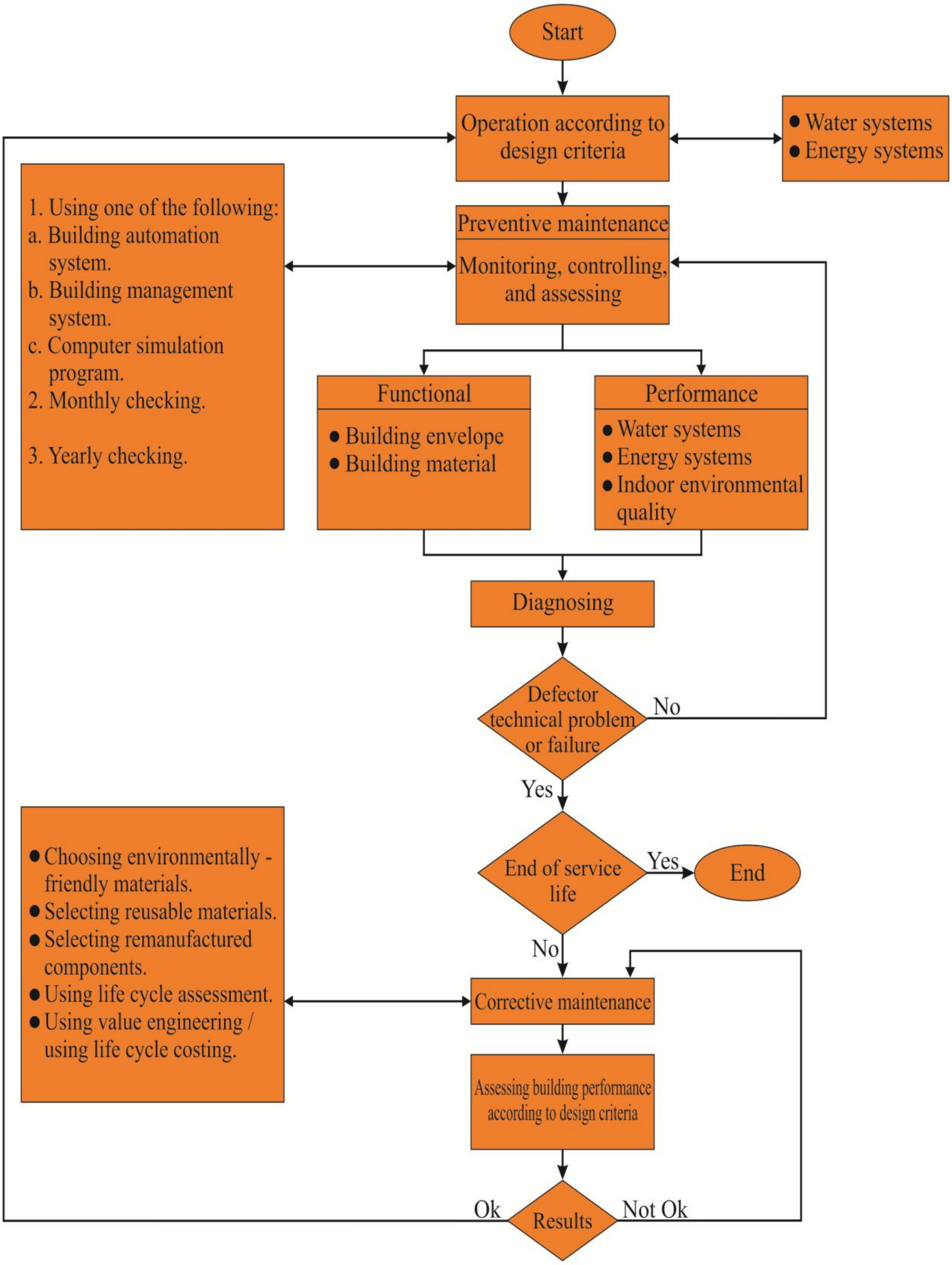

Figure 7. The proposed actions of operation and maintenance for sustainable buildings (researcher).

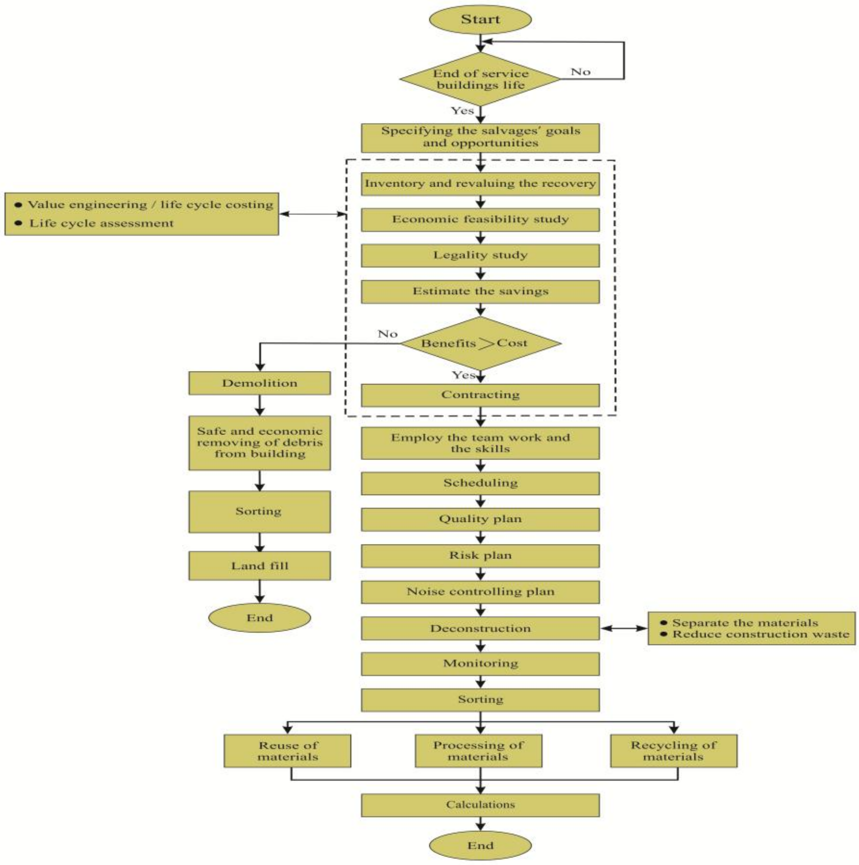

Figure 8. The proposed actions of post-operation and maintenance for sustainable buildings (researcher).

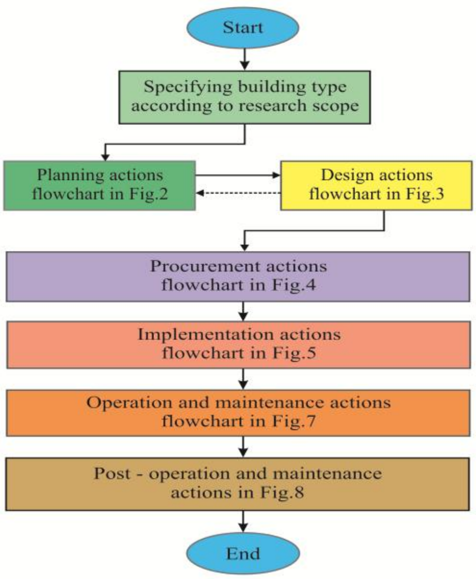

Figure 9. Summary of the proposed management system flowchart during sustainable buildings life cycle (researcher).