A Framework to Embed Sustainability Concepts into the Design Processof Construction Projects in Iraq

Dr. Zeyad S. M. Khaled
Engineering, College, University of Al-Nahrian /Baghdad.
Dr. AfrahM. H.Kashkool
Building and Construction Engineering Department, University of Technology /Baghdad.
Azhar M. Mohammed
Building and Construction Engineering Department, University of Technology /Baghdad.
Email:amm.civil14@gmail.com

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ABSTRACT
Unfortunately, sustainability is overlooked in the Iraqi design practice of construction projects. This is clear for it has led to the prevailing unsustainable built environment in Iraq. There is a great lack of attention paid to the environmental, economic and socialimpactsassessment,life-cycle assessment (LCA) and life-cycle cost assessment (LCCA) for the complete projects, components or materials used. The aim of this research is to build a framework to embed sustainability concepts into current design work phasesin Iraq based on (LEED) criteria for green building. The framework suggested in this research was subjected to evaluation by Iraqi consultants at three major engineering consultancy firms. Results of the importance (impact on performance)and applicabilityof the suggested frameworkshowed that it is highly reliablewith high Cronbach's Alpha values.This sustainable design frameworkis expected to be useful for the Iraqi Construction Sectorin enabling the utilization of greenbuildingcriteria in the design process.
Keywords: Sustainable design, Sustainable development, Green building.

INTRODUCTION
The current Iraqi practice of after-builtperformance assessment can only maintain short sight perspective to limited aspects like cost and time overrun. Without prior assessment ofpotential impacts of functional performance,bad environmental, economic and social impacts are incurred. Therefore, it is important for the Iraqi Construction Sectorto assess the potential impacts during the design process in order to control the buildingimpacts on life-cycle scale.The project stakeholders must understand when, why and how to fit in sustainability concepts during the construction project life-cycle. Hence, a design framework focusing on sustainability aspects got to be developed based on the Iraqi prevailing design phases namely;preliminary studies, preliminary design and detailed design in a way that enables stakeholders to correspond in all design phasesthrough thecomponents and elements that can lead to green building. As an outcome, the framework will be a useful reference for the Iraqi Construction Sector to understand the procedure of employing sustainability aspects during the design process.

Research Objectives
The aim of this research is to investigate the Iraqi engineering consultancy practice concerning the application of sustainability conceptsin construction projects and to develop a sustainable design framework that is suitable to be implemented in Iraq while focusing on civil engineering aspects.

Research Justification

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

Many countries all over the world are moving from traditional design approaches towards sustainable design ones for it has been clearly recognized that natural resources are going to be depleted if the current policies of materials and energy consumption are continued. Furthermore, the impacts of the built environment on the natural environment and pollution caused by the construction industry drove many countries to adopt green building criteria where many professional organizations had set design standards for sustainable building performance. Yet, Iraqi Construction Sector is still adopting conventional approaches, a matter that needs changing the mentality of all parties.The first step to alter to sustainability as a new value in engineering is to adopt a sustainable design approach taking into account environmental, economic and social factors that are considered over the life-cycle of any building including; planning, design, construction, operation, maintenance, renovation, demolition, and disposal where natural resources consumption and waste generation are eliminated.

Research Methodology

At first, literature review was conducted to explore sustainability criteria, green certification agencies, design process of construction projects and sustainable performance indicators.Thereafter, a sustainable design framework was developed and evaluated through a questionnaire survey directed to Iraqi consultants at the biggest two firms (the National Center for Engineering Consultation and the State Company for Industrial Design and Construction) and a selected academic firm (Engineering Consultancy Bureau in Al-Nahrain University) in order to investigate their opinions on the importance (impact on performance) of each component in the suggested sustainable design framework and how applicable they are while exploring the actual practice of design works in Iraq.

Literature Review

Stuart Maxwell in (2014) [1], studied a new working method for decision making during design phase based on the Global Reporting Index and the Project Management Body of Knowledge. The aim of the work was to determine which indicators of sustainability are most relevant to the design phase and then to integrate those indicators into the (PMBOK) project management process. It is stressed that decisions made during design have a significant influence on the final outcome of the project where effective tools must be provided to facilitate decision making.

Rahim F. A., et al, in (2014) [2], studied the life-cycle costing (LCC) of sustainable construction and explored how to achieve best value over the whole life of the buildings projects. The study opens a way to explore how LCC can statistically assist sustainable construction.

Cidik M. S., et al, in (2014) [3], developed an information categorization framework to enable designers to quickly evaluate multiple conceptual design alternatives in the building information modeling (BIM) environment. The framework allows the identification and connection of the building aspects necessary for optimization in the early design.

LuísBragança, et al, in (2014) [4], emphasized the importance and ability of earlier design stages to influence sustainability, performance, and life-cycle cost and developed some sustainability key indicators suitable to be used at the conceptual design phase to predict the sustainable performance of buildings.

Leitch K. R., et al, in (2013) [5], emphasized that learning about LEED criteria help to prepare civil engineers to understand how civil engineering systems interact and operate more complementary with the natural world as well as to reduce water, energy, and material usage.

Akadiri P. O., et al, in (2012) [6], developed a conceptual framework to implement sustainability principles in building design based on resource conservation, cost efficiency and human adaptation. The framework allows design teams to have an appropriate balance in environmental, economic and social issues.

Andrade J. B., et al, in (2012) [7], emphasized the influence of earlier design stages in embedding sustainability, performance and life-cycle cost considerations for steel buildings. A tool was developed to enable designers in evaluating different design solutions based on which sustainable indicators can be early evaluated.

Akadiri P. O. in (2011) [8], conducted a questionnaire survey to investigate level of awareness and implementation of sustainable practice among UK building designers and how does it impact decision making. A set of sustainable assessment criteria for modeling and evaluating sustainability performance of building materials was developed to facilitate materials selection and derived criteria were evaluated and aggregated into a sustainability index.

LuísBragança, et al, in (2010) [9], developed some approaches to the building sustainability assessment based on performance feasibility study and extended life-cycle assessment (LCA) using different tools. It is found that LCA and building rating tools have a positive contribution in achieving sustainable developing targets.

Danatzko J. M. in (2010) [10], investigated some sustainable structural design methods of life-cycle analysis, inventory and evaluation used to minimize material and energy consumption and maximize material reuse. A computer program focusing on the structural system type selected at design was developed.

Bank L. C., et al, in (2010) [11], developed a decision-making framework for sustainable design integrated with the (BIM) tool and LEED sustainability metrics. It is found that this integration allows for earlier decision making and specific sustainability trade-off analyses using actual building characteristics and conditions.

Sustainability Concepts

The sustainability concepts have been introduced to combine concerns for the well-being of the planet, the human development and continual economic growth requirements. The definition offered by the World Commission on Environment and Development states that the major concept from human point of view is "Meeting the needs of the present without compromising the ability of future generations to meet their own needs" [12].

Natural resources consumption inflicts harmful damages on the environment and results in air, water and solid pollution and even more. The effects of irrational energy consumption are not limited to the construction operations, for it is also used for creating an artificial indoor ambient by cooling, heating, lighting and ventilation systems. This had driven to green thinking to minimize health threats as well as natural resources depletion [13].

This means that the people, governmental organizations, and businesses of today need to examine their actions in regard to consumption and production of goods and services, energy and water, and infrastructure systems aiming at decreasing degradation of the environment and increasing natural resources service life, while levering economic growth and the quality of life. This can be achieved by adopting the concepts of reducing, reusing, and recycling of resources which summarize the goals of the sustainability initiatives [5].

Therefore the preservation of the existing environment, so called sustainability need to be at the core of all engineering activities in addition to maintaining high living standards and life quality for people. Engineers must be aware of how to choose between alternative available resources, systems and methods in addition to the interaction between them [12].

Sustainable Construction Indicators

The term "sustainable construction" means the creating of healthy built environment using resource-efficient ecologically-based principles. The application of sustainability concepts necessitates establishing measurable indicators to be used to assess the building, neighborhood and town sustainability. Such indicators are still unconsolidated for the complex process of their identification, validation, measuring and selection. Many protocols are currently used for sustainability appraisal such as;The EU European Commission’s sustainable development strategy that involves an extensive list of items to measure sustainability, The World Economic Forum sustainability performance index that deals with two major groups of indicators (one for protecting the ecosystem vitality and the other for reducing environmental stresses on human health), The ecological footprint sustainability reports developed by the Global Reporting Initiative which consist of indicators for energy, water and material consumption in addition to emissions and waste generation and many other social and environmental issues, The American Society for Testing and Materials (ASTM) framework for sustainable design of buildings and many others[3].

Supportive Tools

The higher initial cost of implementing sustainable construction is considered as a major barrier. The common perception is that sustainable construction seems to cost more. This is because stakeholders solely consider initial cost. But lower operating expenses throughout the whole life cycle of the facility, caused by sustainable construction, are rarely considered by decision makers. To overcome this barrier it is necessary to move from short-term cost assessment to long-term one [2].

The Life Cycle Assessment (LCA) is an assessment tool to evaluate life cycle impact of a product considering the upstream and downstream impact of the whole process. The LCA process comprises three major steps; inventory, analysis of potential effects and interpretation (evaluation) of results. Using LCA in sustainable construction aims at identifying which stages of a product life-cycle have the highest environmental impacts and which alternative products with similar technical performance can be used instead. Therefore a common understanding of each product performance ought to be clear. An overview of a whole life-cycle of a product is shown Fig. (1). The most common LCA software tools used for building assessment are ATHENA, BEES, Semipro, and Gabi Build-it[14].

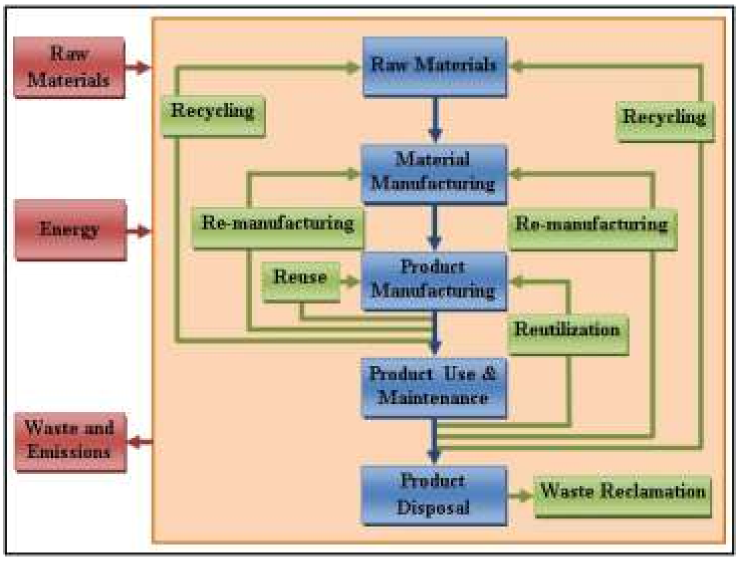

Figure (1): An overview of a product life-cycle [14]

The Life Cycle Cost Assessment (LCCA) is another tool that is applied to assess cost effectiveness (economical aspects) of products life cycle.The LCCA technique aims at providing a whole life perspective to gain the best value out of the project. The whole life perspective should cover all life phases including; construction and erection, occupation and operation, maintenance and repair, modernization and rehabilitation and at last dismantle and demolition.The LCCA should be included when making decision to enhance quality, functional performance and economic efficiency.It also helps in monitoring and controlling the cost behavior over the economic life span of the facility [2].

Building Information Modeling (BIM) is a different tool which creates and maintains multidimensional data-rich views throughout a project life-cycle to support communication, collaboration, simulations and optimization of data". The National Building Information Model Standard (NBIMS) define BIM as "The virtual representation of the physical and functional characteristics of the facility from the inception onwards" [15].

Green Building

Green building means design and construction of buildings using resources-efficient materials and methods which in turn do not harm the environment or the human health and well-being of the buildings' users, general public, construction workers, and future generations. This might include concerns about land use, indoor environment, site impacts, life-cycle effects of materials used, water and energy consumption, and pollutants and solid waste generation [12][13]. Table (1) illustrates an outline of green building objectives and outcomes[6].

Table (1): Green building objectives and outcomes [6]

Environmental objectives	Environmental outcomes
1- Effective environment protection. 2- Avoiding pollution. 3- Enhancing and protecting biodiversity. 4- Transport planning. 5- Prudent use of natural resources. 6- More efficient energy. 7- Efficient use of resources.	Reduced polluting emissions, noise and dust prevention, waste minimization/elimination, less pollution and environmental breaches incidents, habitat creation and environmental improvement, ecosystems protection, green transport during project execution and users business activities, efficient energy at depots and sites, reduced energy consumption, lower whole-life costs, employing local materials supplies with low embedded energy, lean construction, use of recycled products.
Economic objectives	**Economic outcomes**
1- Maintaining high and stable levels of local economic growth and employment. 2- Improve project delivery 3- Increase productivity and profitability.	Enhanced productivity, consistent profit growth, employee satisfaction, supplier satisfaction, client satisfaction, lower defects, shorter and more predictable completion time, lower and more predictable cost, more successful client business and better value to clients, local employment and procurement.
Social objectives	**Social outcomes**
1- Social progress meeting everyone needs. 2- Employee respect. 3- Supporting local communities. 4- Partnership.	Healthy & safe conducive work environment, effective training and appraisals, employee satisfaction and morale, people's participation and equal opportunities, social equity, culture preservation, minimum peoples and traffic disruptions, effective communication system.

Green building rating systems such as LEED, BREEAM, SBTool, SPeAR, BOMA BESt and CEEQUAL have proven to be of great aid in the design and delivery of green buildings through understanding and adopting their sustainability metrics by both design and construction teams. These systems have been developed to support the sustainable design process since they transform the sustainable objectives into specific performance objectives. In spite of their different perspectives in certification approaches they all have common points and deal with the same categories of building design and life-cycle performance [9].

The new version LEED-V4 developed in June 2013 consists of five distinct design areas. Each one requires various prerequisites including (49) separate categories in which up to (100) points can be achieved. This document provides design professionals with the intent, requirements, options and potential technologies and strategies for each prerequisite and category [16].A project going through LEED rating system might fulfill a final credit that determines whether the project can be certified at a certain level or not [17]. The project that achieves (40+) points are LEED certified, (50+) points earns silver, (60+) points earns gold, and (80+) points earns the highest level of platinum certification. The LEED Reference Guide presents detailed information on how to achieve the credits within the major categories listed in Table (2)[16].

Table (2): How to achieve LEED credits [16]

Categories	Details
Sustainable Sites	**Construction related pollution prevention, site development impacts, storm water management, transportation alternatives, heat island effect and light pollution.**
Water Efficiency	**Landscaping water use reduction, indoor water use reduction and wastewater strategies.**
Energy and Atmosphere	**Commissioning, whole building energy performance optimization, refrigerant management, renewable energy use and measurement and verification.**
Materials and Resources	**Recycling collection locations, building reuse, construction waste management, purchase of regionally manufactured materials, materials with recycled content, rapidly renewable materials, salvaged materials and sustainably forested wood products.**
Indoor Environmental Quality	**Environmental tobacco smoke control, outdoor air delivery monitoring, increased ventilation, construction indoor air quality, use low emitting materials, source control and controllability of thermal and lighting systems.**
Innovation and Design Process	**(LEED) accredited professionals and innovative strategies for sustainability in design.**

Design Stages

The concept of design staging is related to consecutive grouping of all design activities to guide the whole design process where these activities are grouped in what so called design stages according to their precedence. Each stage has a distinct domain of activities to produce specified outputs. It is important for the design team to understand the specific objectives and outcomes of each stage and their influence on the building performance and construction time and cost [4]. The client requirements and constraints are initially assessed by an expert consultant engaged to find out whether the project is feasible or not. If the project is feasible an initial strategic brief is developed covering key items including the nature of the project, location, functions required, broad qualityspecifications, preliminary cost estimate, time schedule outline, consultant roles and procurement route. According to this brief the client starts to assign the proper design team. Then the outline design is carried out according to the concepts stated in the initial brief where it shows design options and their analysis. The outline design must illustrate spaces diagram, relationships, requirements representation on a site layout, masses, functional issues, circulation, building system, utilities systems, construction methods, environmental impact and estimated project cost and duration. The next stage is preliminary design wherethe approved outline design is taken to a detailed level. Outputs of this stage include specifying spatial arrangements, site layout, building systems, materials, elevations treatment and engineering systems. Environmental concerns might also be highlighted by considering the building envelope, ventilation rates, glazing properties … etc. [18]. The final stage is detailed design,in which the approved design scheme is worked out into detailed drawings and specifications including all building components, services systems, interior design (finishes, fittings and installations) anddetailed outdoor, site works and landscape [19].

Performance Based Design

The traditional design process of any building is usually governed by a set of considerations that ought to be fulfilled including time and budget constraints, functional requirements, safety precautions, codes of energy and building regulations. The first step made by the design team is to coordinate effectively with the client and other stakeholders to create what is called the building program which describes functional, economic and time requirements and forms the basis of the design process. When this program is oriented to set performance objectives a performance-based design approach is established. This performance vision that is developed at this early stage of design is to be used throughout the building life to guide main decisions related to design, materials selection, and system operation and maintenance.The performance vision needs to be broken down into specific topics in order to be implemented by the design team and be used later by the building users to evaluate performance. It is basically divided into economic burden, environmental impact, service quality and occupants' health and safety. Each of these topics is in turn subdivided into more specific subtopics.The LEED system provides weighting factors to combine subtopics into a single performance indicator [9].

Building Materials

Building materials play a crucial role in achieving sustainability.Consumption of building materials has a substantial impact on the environment, mainly because they are obtained from non-renewable resources with potential of depriving the future generation's needs. Furthermore, all building materials impact the environment during their entire life-cycles. Various forms of pollution are created starting from extraction of raw materials until disposal of demolition waste having adverse effects on the atmosphere, water, and land. Raw materials are usually processed before being suitable for building work. This process often involves the consumption of huge amounts of energy. The construction practitioners have begun to pay attention to the environmental damage caused by their activities trying to take corrective actions by paying more attention in selecting suitable materials. In the past, the choice of building materials was predominantly based on cost, appearance and availability. Recently, the environmental suitability of materials is becoming an important factor [8].The design teams ought to consider the mission of a building process as a mission of resources management. To assist viewinga building creation job as a resource management one,some design methods are shownin Fig. (2).

Green materials selection is the first step in developing sustainable buildings for materials efficiency is a major criterion in green building design and construction. The LEED rating system has devoted an earmarked criterion for materials and resources (MR) which focuses on construction wastes, use of local materials, recycled and reused materials, rapidly renewable materials, and emissions during fabrication, hauling and installation. The MR category account for almost (13%) of the total possible points of LEED rating system. Three steps are followed in material selection;technical information (such as geometric properties, tests results and LEED characteristics), assessing different alternatives of the same function using LCA and selection of best alternative based on specific criteria including LEED rating system. Materials selection should strive to three main objectives for the sake of sustainability implementation; minimize materials and energy consumption, minimize environmental, economic and social impacts, and maintain a reasonable degree of people's satisfaction [17].

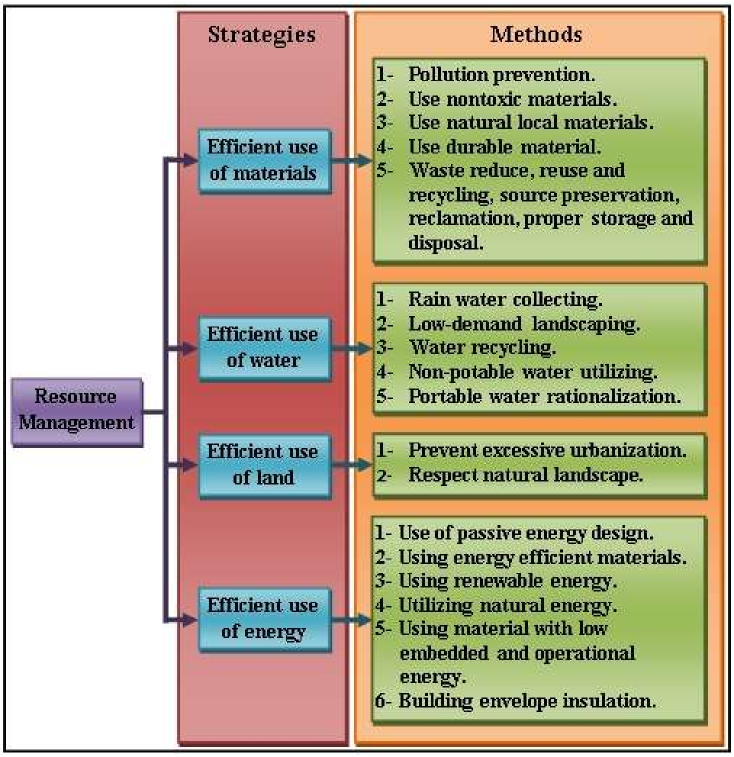

Figure (2): Resource management strategies and methods [8]

Sustainable Design Framework

A sustainable design framework is developed to comprise the aspects discussed in the previous paragraphs. The proposed design phases and their components and elements constitute assessment, analysis, comparison and decision making to choose sustainable solutions for building systems and products that fit stakeholders' needs, the project objectives, time and cost limitations, governmental regulations and risks entailed.The framework comprises three major phases as shown in Fig. (3).

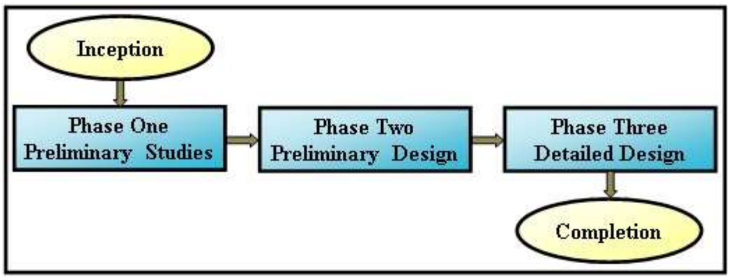

Figure (3): The major phases of sustainable design

Sustainability concepts are inserted early in the first phase ofpreliminary studies, starting with the identification of theproject functions and the client's, stakeholders', and users' requirements thenverifying what sustainable approaches can be employed to meet all these requirements aiming at reaching some balanced design strategies using sustainable building systems. These considerations need the appointment of a professional design team to carry out planning process, feasibility study, and prepare the initial project brief. The components of this design phase are shown in Fig. (4).

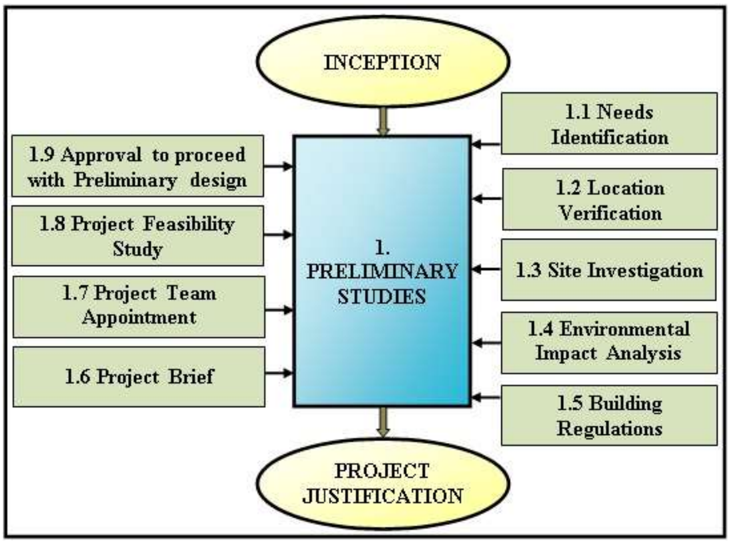

Figure (4): Components of design phase 1; Preliminary Studies

Sustainability concepts are also inserted with more details in the second phase of preliminary design where consultants are appointed covering all expertized fields needed. All technical reports on site topography, soil investigation, neighborhood constraints, town plan regulations and alike must be thoroughly studied. All risks must be assessed with consideration be paid to health and safety requirements. Preliminary time and cost planning must be carried out then a project brief that confirm with the sustainable project goals must be developed. The components of this phase are shown in Fig. (5).

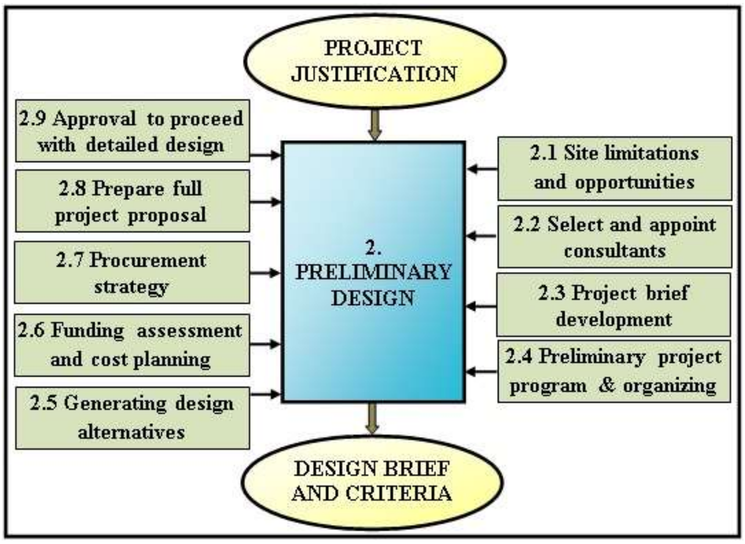

Figure (5): Components of design phase 2; Preliminary Design

Sustainability concepts are then deeply inserted in the third phase of detailed design where it deals with more detailing of the project planning and control activities, technical reports, drawings, analysis memos, information production and documentation. This design phase requires the use of environmental, social and economic assessment tools to achieve anoptimum balance of the sustainability performance indicators. Furthermore, the design team must specify the conditions need to be followed by the executors of the project before progressing to the tendering stage. The components of this phase are shown in Fig. (6).

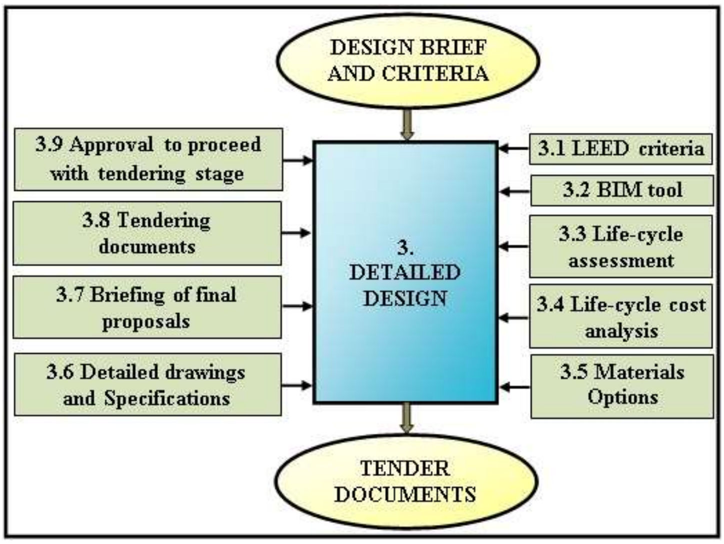

Figure (6): Components of design phase 3; Detailed Design

Considering the components of thefirst design phase(1. Preliminary Studies), the first component (1.1 Needs Identification) comprises three groups of elements (tasks)for assessment, evaluation and verification of client's, stakeholders' and users' needs. At this point the appointment of a sustainability consultant to cope with the project manager in every detail and to share decision-making with the client is essential. The role of the sustainability consultant is to ensure the implementation of the requirements for LEED certification. The elements of this component are; identify client's, stakeholders' and users' actual and potential needs, appoint the project manager, register in LEED (and continue if case is accepted), calculate initial project cost, seek sources of funding, appoint the project promoter, appoint LEED consultant, prepare environmental impact report, translate each requirement to building functional performance, study the consequencesof the environmental impact report, identify risks entailed, estimate cost, determine functional building performance, set sustainable strategies methods, sustainability indicators application, set alternatives for sustainable strategies and select the best alternatives.

The second component (1.2Location Verification) comprises three groups of elementstogather candidate sites information, select best location and check site sustainability. The elements of this component are; appoint health and safety expert, review the final region plan, adjacent buildings issues, refine candidate sites, collect technical information of sites and surroundings, decide size and shape of building, adopt building sustainable strategies, insert LEED-LT criteria, apply BIM tool, re-estimate cost, rank candidate sites, decide components of the building, set sustainability systems and methods, insert LEED-SS criteria, select sustainable materials, check cost versus budget and check regional planning.

The third component (1.3Site Investigation) comprises three groups of elements for collection, analysis and evaluation of site information. The elements of this component are;assess constraints andopportunitiesof the sustainable site, appoint site sustainability team, study site sustainability features, preparesite graphical representations, document information, classify information, verifying interaction points, determine enhancement opportunities, analyze risksentailed,resources management, checkbiodiversity issues, check existing historical and cultural buildings or works andcheck neighboring and adjacent buildings.

The fourth component (1.4Environmental Impact) comprises three groups of elements for assessment, evaluation and approval of environmental impacts. The elements of this component are; apply environment protection andenhancement regulations, verify pollution and renewable energy concerns, layout project description, analyzepollution and energy information, setenvironmental treatments, modify project description,and gain the Environment Protection Agencyapproval.

The fifth component (1.5Building Regulations) comprises three groups of elements for determination, comparison and adoption of building regulations. The elements of this component are;justification ofproject scope, scaleandbudget, verifying current situation and proposed improvements, identifying specific needs, orientation to sustainability, final product characteristics, carrying out cost andbenefits analysis thencreate alternatives and select the best.

The sixth component (1.6Project Brief) comprises three groups of elements for establishing sustainable objectives, obstacles and opportunities and outline analyses. The elements of this component are; sustainable building functions statement, sustainable performance description, sustainability indicators setting, advantages and disadvantagesanalysis andbalance, site and location dataanalysis, methods statement, cost re-estimating, risk analysis andtime scheduling,

The seventh component (1.7Design Team Appointment) comprises two groups of elements forappointment requirementsand team selection. The elements of this component are;sustainability criteria, health andsafety criteria, project special requirements, project cost vs. budget comparison, required performance, team organization, andprofessions required.

The eighth component (1.8Project Feasibility) comprises two groups of elements for preliminary and sustainability assessment. The elements of this component are; requiredlife-cycle resources,life-cycle resources availability, life-cycle risks analysis, life-cycle costs andbenefits, sustainability criteria, health and safety criteria, project special requirements and project cost vs. budgetcomparison.

The ninth component (1.9Approval of Preliminary Studies) comprises three groups of elements for functional,sustainability and feasibility success potentials. The elements of this component arereviewing of;all assumptions, all stockholders' needs, scope and work processes, success factors, LEED criteria, BIM intersections, time estimates, cost estimates, risks entailed and special requirements.Fig. (7) shows the elements of this component as an exampleof the first phase components.

Considering the components of the second design phase (Preliminary Design), the first component (2.1 Site Limitations and Opportunities) comprises three groups of elements tocollect and analyzesite information and to identifysite opportunities and limitations. The elements (tasks)of this component are to consider; urban planningandbuilding regulations, neighborhood restrictions, available utilities andresources, topographic survey andclimate report, soil investigationreport, health and safety issues, sustainability criteria, time limitations, project cost vs.budget comparison, risks entailed, stakeholders strategies, sustainable performance needs, design team vision and experts and specialists tips.

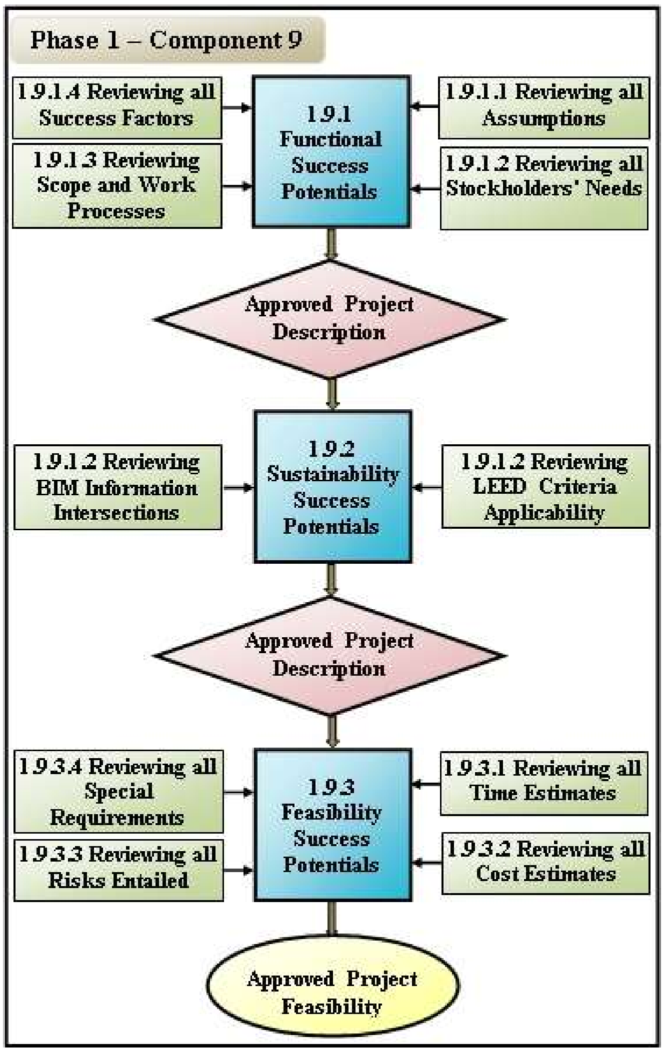

Figure (7): Elements of component 9 in design phase 1

The second component (2.2Consultants Selection and Appointment) comprises two groups of elements forprofessions,number required and selection. The elements of this component are; project breakdown, systems requirements, project constraints, client and stakeholders tips, LEED criteria,team organizationandqualifications.

The third component (2.3Project Brief Development) comprises three groups of elements forinformation analysis and alternativesdevelopment and evaluation. The elements of this component are; location andsite information, sustainability criteria, available resources, risks entailed, project cost and time limits, preliminary site components, sustainable building andservices systems, building components, time schedule, cost plan, and analysis and balance of objectives,constraints and risks.

The fourth component (2.4Preliminary Project Program and Organizing) comprises three groups to determine project activities, and to develop,checkand modifyworkprogram. The elements of this component are; work break-down, activities logic diagram, client requests, project cost vs. funding capacity, time forecasting vs.project dead line, resources management, necessary assumptions, suppliers precautions, sustainable objectives and LEED system activation.

The fifth component (2.5Generating Design Alternatives) comprises three groups for alternativesgeneration, development and selection. The elements of this component are; site information, sustainabilityindicators, advantages,ranking of alternatives, health and safety indicators, main program, risks assessment, life-cycle cost, aesthetics, security, added values, andprocurement method.

The sixth component (2.6Funding Assessment and Cost Planning) comprises three groups for cost estimating, cost-benefit analysis and cash-flow forecasting. The elements of this component are;estimated initial cost, estimated life-cycle cost, estimated green costs, allowances and risk margins, investment cost, economic assumptions, market conditions, funding conditions, LCCA tool, cost control system, LEED system, ensuring value of money, work programandprocurement method.Fig. (8) shows the elements of this component as an exampleof the secondphase.

The seventh component (2.7Procurement Strategy) comprises two groups forprocurement strategy selection and modification. The elements of this component are; governmental regulations andcontract conditions,project special requirements, external constraints, project duration andcost, standard procurement forms, risks sharing, and stakeholders precautions.

The eighth component (2.8Full Project Proposal) comprises three groups forproducts compilation and proposal evaluation byStakeholdersthenby the client. The elements of this component are; products of previous designactivities, checking compatibility, highlighting important issues, preparing proposal presentation, performance indicators, esthetics considerations, constructability review, value engineering, time and budget limitations, risks and assumptions, building regulations, consultantstips, health and safety measuresand project appraisal and revision.

The ninth component (2.9 Approval of Preliminary Design) comprises two groups tocheck life-cycle potential success andrisks. The elements of this component consist verification of; assumptions, likely performance, constructability, life-cycle cost-benefits, time program, sustainability indicators, health and safety measures, procurement strategy, flexibility to changes, cost plan vs.budget, market conditions, partners commitments, financial precautions andother external factors.

Considering the components of the thirddesign phase (Detailed Design), the first component(3.1 LEED Criteria) comprises two groups of elements for suitability needs and certification. The elements of this component are;projectrequirements, financial capacity, logistic capacity, project sustainable objectivesand performance, sustainable systems strategies, suitable LEED guide, applying to LEED, project categorization, investment priorities, project outcomes andcost-benefit analysis.

The second component(3.2Building Information Modeling) comprises two groups to adopt BIM and data management. The elements of this component are; purpose of implementation, project uses and performance, project sustainable range, BIM subdivisionsand data input, processing, recording, maintain andretrieval.

The third component(3.3Life-Cycle Assessment) comprises three groups for scope then information acquisition and analysis. The elements of this component are;assessment objectives, targeted life span, items included, systems included, required performance, data collectionand organization, inputs and outputs, impacts assessment, classification andanalysisand systems assessment.

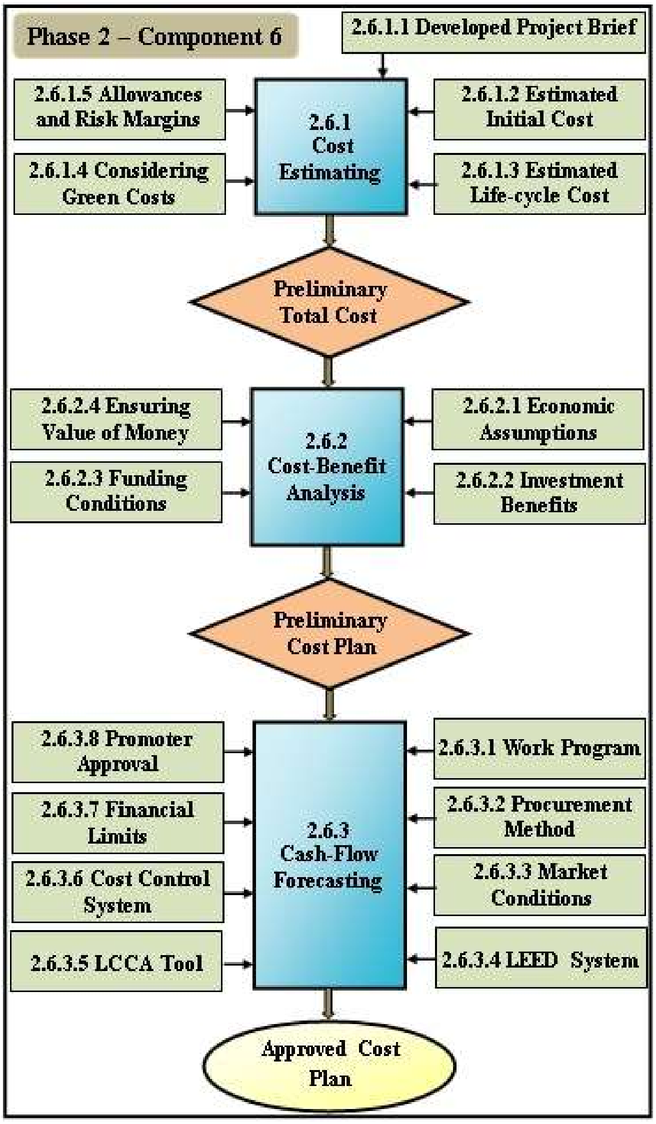

Figure (8): Elements of component 6 in design phase 2

The fourth component(3.4Life-Cycle Cost Assessment) comprises two groups for items scope identification and cost analysis. The elements of this component are;itemsrequired performance, alternative options andcosts, items initial costs, life-span, O&M costs, disposal costs, cost-benefit analysis andexpectedcosts changes.

The fifth component(3.5Materials Options) comprises three groups for alternative materials assessment, evaluation and selection. The elements of this component are; approved project brief, project functional performance, sustainability indicators, materials source origins, information gathering, alternativesustainable materialscharacteristics, building systems and methods, materials functional performance, LEED criteria, BIM program, LCA and LCCA analysis, cost-benefit analysis, materials interactions, reuseandrecycling opportunities, andexperts advise.Fig. (9) shows the elements of this component as an exampleof the third phase.

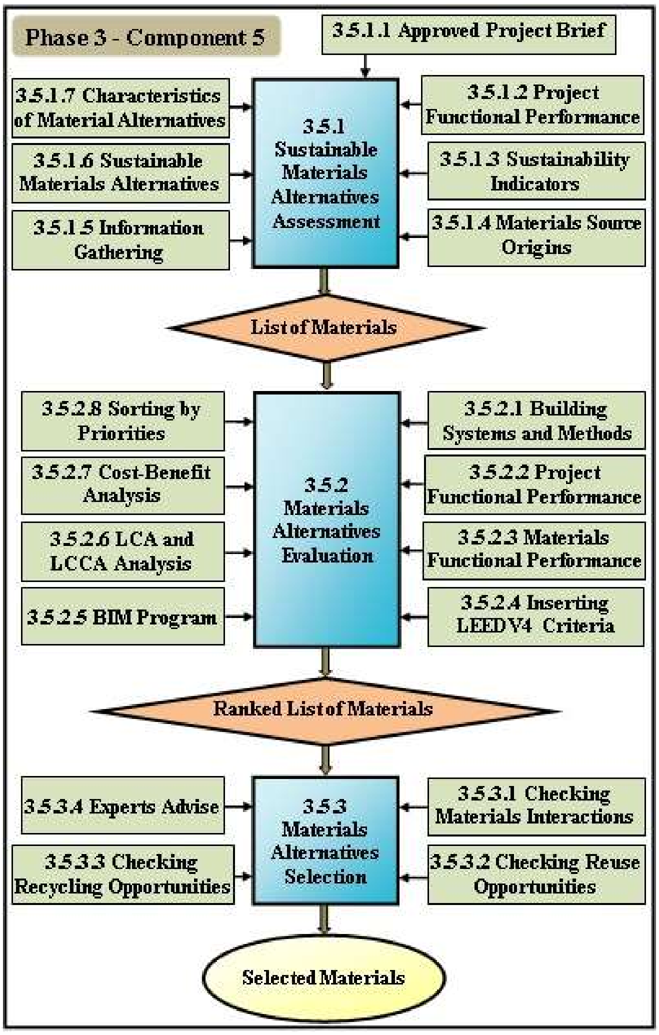

Figure (9): Elements of component 5 in design phase 3

The sixth component(3.6Detailed Drawings and Specifications) comprises three groups for preliminary design revision, detailed design outputs and tender documents. The elements of this component are;approved preliminary design, clients' andstakeholder' precautions, safety andhealth consultants tips, sustainability consultants tips, risks analysis, sustainablesystems andmaterials selected, LEED standards, value engineering, constructability review, safety andhealth measures, project budget and duration, project functional performance, design compatibility, specifications preambles, priced bills of quantities, time schedule and cost plan, procurement method and contract conditions.

The seventh component(3.7Final Proposal Brief)is a summary of the final proposal and the construction recommendations that is going to be presented to all stakeholders. The team recommendations are documented and a copy is approved by the project manager then by the client. The most important step is to obtain LEED certificate before approving the final design.

The eighth component(3.8Tendering Documents)is a complementary technical and contractual amendment that depends on the procurement method and contract conditions. Consultants' recommendations and tips to contractors that explain any embedded special needs, sustainability standards and health and safety measures are essential. Tender documents ought to be clear as far as possible to clarify any ambiguous items in the completed work.

The ninth component(3.9Approval of Detailed Design)means the approval of the client and ratifications of other stakeholders (e.g. municipality, sponsors, local environmental protection authority, sponsors) in addition to LEED certification which must be obtained beforeending design stage and starting tendering stage.

Design Framework Validation

In order to test the validity of the developed sustainable design framework in the Iraqi construction consultation practice, a questionnaire form was distributed to (45) consultants in three well-recognized consulting firms; the National Center for Engineering Consultation, the State Company for Industrial Design and Construction and the Engineering Consultancy Bureau in Al-Nahrain University.

The questionnaire form consists of four main parts; part oneincludes general information about the respondent and the firm, part two includes a comprehensive table that is designed to rate the importance(impact on performance) and applicability of all components of thedesign framework phases using Likert's scale, part threewas devoted to let the respondent interpret the answers of part two in order to ensure relevance and part four was dedicated for the respondent to participate in the subject of sustainable design and green building by giving notes and views according to his own experience.

It is evident that most of the respondents have been practicing engineering for a long time and practicing consultancy for quite enough time. The ever most of the respondents holds either a consultant or a licensee rank at the Iraqi Engineers Syndicate. About half of the respondents had accomplished more than thirty design works, while only one had contributed to a sustainable design work abroad.It was noticed that academics are more interested in sustainable design while higher posts holders at other firms are less interested.

The statistical program SPSS (version 19) was used to perform statistical analysis of the importance (impact on performance) ranking. It was found that the main three phases of the design framework have high Cronbach's Alpha values of (0.775, 0.849 and 0.851)respectively, so that replies are considered highly reliable.The statistical characteristics of the degree of importance of alldesign components showed that the overall mean importance of the suggested sustainable design framework was (3.82) out of (5) with standard deviation of (0.668).The overall mean importance of phase one (preliminary studies) was(3.89) with standard deviation of (0.679), while the mean importance of the components of this phase ranged from (3.61) to (4.29).Furthermore, the overall mean importance of phase two (preliminary design) was (3.75) with standard deviation of (0.81), whilethe mean importance of the components of this phase ranged from (3.32) to (4.34). Finally, the overall mean importance of phase three (detailed design) was (3.82) with standard deviation of (0.84), whilethe mean importance of the components of this phase ranged from (3.58) to (4.39). This means that the framework importance is highly appreciated.

In order to test the significance of results, one way F-test for variance analysis with confidence level of (0.95) was carried out where results are found to be significant with significance values of (0.183, 0.733, 0.908 and 0.663) and F values of (1.785, 0.313, 0.097 and 0.416) corresponding to phasesone, two, and three and the whole design framework respectively.

On the other hand, the same aforementioned methods and programhave been used to facilitate statistical analysis of the applicability ranking.It was found that the main three phases of the design framework have high Cronbach's Alpha values of (0.825, 0.885and 0.868) respectively, so that replies are considered highly reliable.The statistical characteristics of the degree of applicability of all design components showed that the overall mean applicability of the suggested sustainable design framework was (2.65) out of (5) with standard deviation of (0.741). The overall mean applicability of phase one (preliminary studies) was (2.88) with standard deviation of (0.812), while the mean applicability of the components of this phase ranged from (2.18) to (3.42). Furthermore, the overall mean applicability of phase two (preliminary design) was (2.57) with standard deviation of (0.914),while the mean applicability of the components of this phase ranged from (2.05) to (3.18). Finally, the overall mean applicability of phase three (detailed design) was (2.49) with standard deviation of (0.919),while the mean applicability of the components of this phase ranged from (2.03) to (3.39). This means that the respondents are hesitated to apply a sustainable design procedure especially when it needs using non-familiar tools like (LEED), (BIM), (LCA), and (LCCA). This can be noticed from the declining rate of the overall mean applicability of each phase as much as modern tools are more needed.

In order to test the significance of results, one way F-test for variance analysis with confidence level of (0.95) was carried out where results are found to be significant with significance values of (0.120, 0.869, 0.255and 0.196) and F values of (5.083, 0.141, 1.419and 1.707) corresponding to phasesone, two, andthree and the whole design framework respectively.

CONCLUSIONS

Sustainability had become a vital concern of the global community. It aims at achieving crucial objectives such as land protection, natural resources conservation, pollution prevention, human health preservation, economic prosperity, and people's amenities. The construction industry is highly involved in sustainable development for it has high impacts on the environment,a matter that is not limited to high consumption of raw materials and energy with high generation of pollutants and waste, but also being highly influential in economic development and social progress. By adopting sustainability concepts, the construction industry can avoid a lot of problems and threats to the environment, economy and society. In order to achieve sustainable performance in the construction industry, the application of sustainable construction criteria and tools must be started as early as planning and design phases of any construction project then be continued through efficient resources management during construction, operation, demolition and disposal phases. Many developed countries had developed rating and certification systems that provide criteria and standards to be used as a guide in design and to verify the achievement of sustainable objectives. The most adoptable building rating and certification system is LEED. Therefore a sustainable design framework is developed to insert LEED criteria in the local consultancy practice of construction projects design in addition to using LCA, LCCA, and BIM tools to facilitate decision making. The framework was subjected to evaluation by Iraqi consultants and proved to be acceptable where all of its components proved to be applicable and important (have impact on performance). The most withdrawing obstacle in implementing sustainability concepts is the higher initial cost of green projects and lack of interest in life-cycle cost analysis forthere is a lack in Iraqi engineers' awareness and knowledge in sustainable development and green building.The current analysis of environmental, economic and social impacts of construction projects and built environment is quite poor in Iraq. Furthermore, there are no construction materials recycling opportunities in Iraq for the absence of such specialized business. On the other hand, there is no chance to select the most suitable site in most of Iraqi projects for the site location is usually chosen before conducting feasibility studies.

Recommendations

1. It is suggested to implement the sustainable design framework developed in this research.
2. There is a need to issue confirmative legislations for sustainable development and green building.
3. Universities, Ministries and Engineers Syndicate are invited to conduct a continual educating program to raise Iraqi engineers' awareness and knowledge in sustainable development and green building.
4. It is advisable to involve some LEED experts in some major construction projects to facilitate knowledge transfer.
5. Municipalities are invited to update and develop new city plans taking into consideration sustainable development and promoting enough chances to select suitable sites for construction projects.
6. The construction industry in Iraq is invited to provide opportunities for new business in the areas of materials recycling, water recycling systems, renewal energy applications and other related industries.

Future Studies

1. To develop a local building information modeling system (BIM).
2. To develop a local life-cycle cost assessment system (LCCA).

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