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Promoting Green Buildings Practices in Palestine

تعزيز انشاء المباني الخضراء في فلسطين

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Dedication

I would like to dedicate this work to the soul

Of My first teacher in engineering field in this life

To the Best Carpenter

My Grandfather

Naim Hashem Rustom

Naim Hani Rustom

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Firstly, I would like to express my deepest gratitude to my supervisor, Dr. Alaeddinne Eljamassi for his generous advice, kind assistance and patiently guidance. Thanks you for all your time and valuable experiences that have shared with me regarding this study. Without his support, this dissertation could hardly be completed. Special thanks for my friend Fathi Abu Sabha who supported me very much in the data collection.

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Naim H. Rustom

Abstract

Green construction is a way for the building industry to move towards achieving sustainable development, taking into account environmental, socioeconomic and cultural issues. Differing approaches and differing economic markets lead to different priorities.

This research aimed to promoting green building practices in Palestine through identified the challenges, barriers, applications and benefits which affect the implementation of greening construction in Palestine this achieved by studying green building practices in developed and developing countries and through conducting practical case studies, Also suggested specific modifications to conventional building practices to optimize the delivery of cost-efficient green building projects through conducting two simulation model using linear programming method to allocate best method to converse energy and water.

As a first step towards contributing to the dissemination of green architecture in Palestine, Mobile application prototype was developed under name (Design manager app.) and its slogan (To manage your green design home). The main function for application is to solve the major constraints facing the spread of green buildings which presented in a lack of awareness and the high cost of green building projects, so this application contains a number of tools to help people in Palestine to build green local Palestinian architecture.

The results of this research were summarized to promote green concepts as methodology in building design with all barriers which may be facing this concept especially high cost constraints. In other hand encourage engineers and designers to benefit from using simulation tools to identify the benefits and barriers for implementation green buildings projects, through simulation modes cost and time will be saved and many scenarios will be studied.

Finally, this study recommended to benefit from high spread of IT application especially mobile applications, which are the most prevalent tools among people and used it promoting green building practices.

ملخص الدراسة

تعد المباني الخضراء وسيلة للبناء والتشييد للمضي قدما نحو تحقيق التنمية المستدامة، مع الأخذ بعين الاعتبار القضايا البيئية والاجتماعية والاقتصادية والثقافية. تهدف هذه الدراسة إلى تعزيز انشاء المباني الخضراء في فلسطين من خلال التعرف على التحديات، والمعيقات، والتطبيقات والمزايا التي تؤثر على تنفيذ المباني الخضراء في فلسطين ، كما وتم دراسة ممارسات البناء المستدام في البلدان المتقدمة والنامية، و إجراء دراسة لحالة دراسية لمدرسة خضراء نفذت في قطاع غزة للتعرف على الفوائد الحقيقية لتنفيذ هذا المفهوم وكذلك أهم المعيقات التي واجهتها ومقارنتها والتحقق من النتائج من الخلال الدراسات العالمية، كما وتم اقتراح تعديلات محددة لممارسات البناء التقليدي لتحسين تنفيذ مشاريع المباني الخضراء الفعالة من حيث التكلفة من خلال إجراء اثنين من نماذج المحاكاة باستخدام طريقة البرمجة الخطية وبرنامج الأرينا وذلك لكيفية الاستفادة والمحافظة على مصادر الطاقة والمياه داخل المباني السكنية مع مراعاة الميعقات المحلية.

وكخطوة أولى نحو المساهمة في نشر العمارة الخضراء في فلسطين تم تطوير تطبيق محمول باسم (Design manager app.) والهدف الرئيسي منه هو حل المعيقات الرئيسية التي تواجه انتشار المباني الخضراء وهي قلة الوعي وارتفاع تكلفة هذا النوع من المشاريع لذا جاء هذا التطبيق بعدة أدوات وتطبيقات تساعد في بناء عمارة فلسطينية محلية مستدامة.

وتلخصت نتائج هذا البحث في التشجيع على استخدام مفاهيم العمارة الخضراء في التصميم مع كل ما يحمله هذا المفهوم من تحديات وخصوصا المعيقات المادية وكذلك تشجيع المهندسين على استخدام السميوليشن كأداة فعالة في عمل نماذج المحاكاة للتعرف من خلالها على فوائد ومعيقات تنفيذ مشاريع المباني الخضراء بأقل تكلفة وبعدد كبير من السيناريوهات والدراسات.كذلك الاستفادة من الانتشار الواسع للتطبيقات تكنولوجيا المعلومات في مجال الانشاءات وخصوصا تطبيقات الهاتف المحمول وهي الأكثر انتشار بين الناس وذلك للمساهة في نشر الوعي للمحافظة على البيئة وخلق عمارة محلية خضراء.

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List of Abbreviations

WCED: The World Commission on Environment and Development.

AIA: American Institute of Architects.

CAA: The World Commission on Environment and Development

UNRWA: The United Nations Relief and Works Agency for Palestinian Refugees.

PCBS: Palestinian Central Bureau of Statistics.

USEPA: United States Environmental Protection Agency

LEED: Leadership in Energy and Environmental Design

USGBC: U.S. Green Building Council

UNCTAD : United Nations Conference of Trade and Development

UNEP: United Nations Environment Program

CEA: Capital E analysis

EPA: Environmental Protection Agency

GDP: Gross Domestic Production

UPC: Urban Planning Council

EPC: Energy Performance Certificate

BIPV: Building Integrated Wind Turbines

QBS: Qatar Building Standers

LGBC: Lebanese Green Building Council

CEB: Compressed Earth Block

SWH: Solar Water Heaters

WDM: Water Demand Management

GW: Grey Water

Chapter 1: Introduction

1.1 Preface

Buildings and the construction industry play an important role in the needs of society by not only adding value health and economic benefits but also contributing to improving the way of living. Consequently, this sector is also a major cause of the depletion of natural resources high energy consumption, global greenhouse gas emissions, waste generation, and air pollution (Ding, 2008). The concept of green is being recognized worldwide as an essential need for the future. Recently in Palestine, there is a growing concern form the researchers and specialists in field of construction industry impact on the environment. As the construction of building in Palestine is on the increase and with the environmental impacts of buildings and its construction practices known, more attention must be paid to the creation of additional strategies for the enhancement of environmental performance in building design.

One definition of green building is '*a current design attitude which requires the consideration of resources reduction and waste emissions for the period of its whole life cycle*' (Wang, etal 2005). The concept of green building and sustainable construction facilitates the construction industry to have a positive and practical attitude towards environmental resources (Abidin, 2010). Green building practices include and emphasize on the principles of sustainable site, water efficiency, energy conservation and efficiency, resource-efficient materials, waste minimization, ventilation whereas other practices help to minimize environmental impact and resource consumption (Kibert, 2007). Sustainability issues become a focus point for communities and countries, as the earth's recourses are under severe pressure due to raising populations and economic expansion.

Construction works and the maintenance/ refurbishment of buildings impact on the environment and caused an irreversible changes in the climate of the all over world, atmosphere, and ecosystem. Buildings are a significant source of greenhouse gas emissions and in particular CO_2 , and unless action is taken, these emissions will increase with sustainability adaptation of all approaches of life and works towards facing demands with minimizing impacts of consumptions, and with saving the future generation (Reeves, 2002) .The concept of green and sustainable construction requires additional strategies in order to be able to implement sustainable construction practices in the future projects. Envelopments in the concept of green and sustainable construction are perceived to change both *"the nature of the* *built environment and the delivery systems used to design and construct the facility according to a client's needs"* (Kibert, 2007).

Through a complementary process, several parties contribute to the construction sector. Such stakeholders are the public and private sectors, universities and institutes, donor countries, international financing institutions and banking sector. Stakeholders make necessary services available; provide necessary materials, fund construction projects, and organize the construction contracting profession according to the laws and regulations enacted by governmental institutions (PCU, 2008). However this sector is deeply fluctuating and hence its contribution to growth is deeply affected by vast numbers of barriers. The need for clarifying the factors that effect on greening construction management process; leading to the importance of this research.

In light of the above and the need for restructuring Palestine; developing green construction is a strategically important goal in Palestine as well as in other countries. The construction sector is one of the key economic sectors and the main force motivating the Palestinian national economy. In 1994, the construction sector has witnessed noticeable expansion. This has resulted in the recovery of the construction contracting profession and Subsidiary industries; the construction sector has occupied the foremost position among the rest of sectors, mainly attracting investments and creating new jobs (PCU, 2008); The construction sector was identified as one of the most promising sectors (ILO, 2010), representing 21 percent of national GDP and involving 30 percent of private workers prior to the crisis. Today, the construction industry employs only 11.4 % of the total labor force in Gaza (Palestinian Central Bureau of Statistics, 2010).

The increasing demand for green construction, coupled with heightened perceptions of the risks associated with going green, mean that project managers will be responsible for managing tighter budgets with tighter profit margins on green projects. Based on those trends, this research argues that delivering a cost effective green building project requires adjustments to the conventional project management approach.

In order to achieve green housing a comprehensive approach is needed that includes not only environmental but also social, economic, cultural, and institutional sustainability dimensions. In order to make housing sustainable it needs to be connected to sustainable settlement planning strategies including specific urban forms such as compact city and mixed land use, infrastructure networks, services, employment possibilities, connectivity, environmental matters, disaster risk reduction strategies and tenure security. Building according to the prevailing climatic conditions is crucial in terms of saving energy and improved environmental conditions. Traditional and recycled construction materials are in general more environmentally friendly than contemporary materials such as concrete and burnt bricks but sometimes combining both can increase the lifespan of the building. Energy efficiency of new buildings and environmental retrofitting of old buildings are both of great importance and should be connected to strategies of using renewable energy and saving water in housing.

1.2 Statement of the problem

There are numerous barriers preventing green building in Palestine; most of the experts from engineers, contractors, developers and researchers attribute these barriers to the political situation while others think that although instability and insecurity play a major role in preventing sustainable growth but they believe that there are many other causes such as:

1. Operational factors: failure to effectively manage markets, finance, employees, prices and customer satisfaction.
2. Management skills, technical ability and leadership, decision making ability, motivation and aspiration values of managers.
3. Accepting change.
4. Financial constraints; lack of financial resources.
5. Limited marketing and human resource management expertise; lack of understanding marketing concept and lack of employees training and development.
6. Limited strategic planning; market segmentation, pricing strategies and environment analysis.
7. Limited incentives for innovation.
8. Ineffective information technology, lack of system knowledge.
9. Ignorance of life cycle cost, lack of education and knowledge in sustainable design, and client worries in profitability and pay-back period.

As a result, Palestine in need to develop green building practices; it needs to improve the environmental and economic performance of new and existing commercial, institutional, and residential buildings.

1.4 Research aim and objectives

The research aims promoting green building practices in Palestine. This would be achieved by the following objectives:

- **Objective 1:** To identify the challenges, barriers, applications and benefits which affect the implementation of greening buildings in Palestine.
- **Objective 2:** To suggest specific modifications to conventional building practices to optimize the delivery of cost-efficient green building projects through conducting practical simulation models.
- **Objective 3:** To develop mobile application prototype for promoting green building practices to use by owners and consultants and its main functions are :
- Cost estimation for greening residential buildings.
- Increasing the awareness about the concept of green building and its benefits and applications.

1.5 Research Importance:

To maintain and to increase the contribution of construction industry in sustainable development through:

- Economic sustainability – increasing profitability by making more efficient use of resources, including labor, materials, water and energy.
- Environmental sustainability – preventing harmful and potentially irreversible effects on the environment by careful use of natural resources, minimizing waste, protecting and where possible enhancing the environment.
- Social sustainability – responding to the needs of the people at whatever stage of involvement in the construction process (from commissioning to demolition), providing high customer satisfaction and working closely with clients, suppliers, employees and local communities.

1.6 Methodology

Research methodology refers to the principles and procedures of logical thought processes applied to scientific investigation (Fellows & Liu, 1999). This chapter discusses briefly the methodological approaches that are available and sets out the reasoning behind the methodology selected for this research project. It then details the research methods that were used and finally provides the overall research design. Combinations of quantitative and qualitative methods are intended to be used in the research study as methods complement each other and enables for more thorough analysis. Creswell and Miller (2000) stated that collecting, analyzing and mixing both the quantitative and qualitative data at some stage of research process within a single study allow understanding research objectives more comprehensively. On this basis, to perform research study on ***"Promoting Green Building Practices in Palestine"*** Both the quantitative and qualitative research methods will be adopted in this study.

To fulfill research objectives the following tasks were executed:

The problem was defined and supported by developing the research theme that included the general aim and objectives.

- Intensive literature review was conducted to review the previous studies made in this field in developing and developed countries :

- Green concept as well as its relation to construction industry to investigate the definitions for some common terms in green construction, for example green building.
- Focuses and process in green and conventional building in order to find the differences in green and conventional building.
- Green building challenges to investigate what barriers and drivers are significant in the green building process and what challenges exist in designing and constructing a green building during design and construction process.
- Project managers' roles and responsibilities in the building process that can be highlighted for the related challenges.
- The role of information technology to promote green buildings.
- Some case studies regarding the challenges for green building to find some examples of each challenge in order to make them more understandable.

1.6.1 Framework of the research methodology

This proposed first research aims to appraise the project developers' knowledge and understanding on green concept and explore the application of this concept within their practices.

Phase 1: development of theme - The first stage included definition of the problem, objectives development, and framework development.

Phase 2: Literature review on green building – to understand the philosophy, concept, principles, challenges and advantages of green building.

Phase 2: Review on the progress of green building in Palestine – to understand general efforts towards sustainable agenda and the progress so far, especially in construction industry through studying two practical case studies

Phase 3: Simulation Models: Two models which presented the benefits of applying green concept in residential building under current constraints:

Phase 4: Develop mobile application prototype: (Design Manager Application – To manage your green design home).

Phase 5: Conclusion and recommendations. The final phase of the research included the conclusions and recommendations.

1.7 Research Structure

This research report was organized into the following five chapters:

Chapter 1: It provides the general introduction of this study, in which the background, problem statement, aim and objectives of study, scope of the study, significance of the study, conceptual framework, methodology of study, and structure of the research are briefly described.

Chapter 2: It discusses the factors which affecting on the process of green construction management in buildings projects to be suitable with local environment in Gaza strip.

Chapter 3: It presents two case studies form Gaza strip and neighboring countries to present the challenges for green building to find some examples of each challenge in order to make them more understandable.

Chapter 4: It includes two models which presented the benefits of applying green concept in residential building under current constraints and these model are optimization model: Linear Programming for optimizing efficient allocation of budget for household energy conservation in Palestinian houses and second one is Simulation Model using Arena program for Water Management in Existing Residential Building in Palestine (Grey-Water System).

Chapter 5: Develop mobile application prototype for promoting green building which work as a help tool to Palestinian people to make the concept of green building understandable and help to give them initial cost estimation for whom small residential buildings projects .

Chapter 6: Conclusion and recommendations the final framework results were also discussed and the conclusion of the whole research study were made. Then, recommendations in both the personal and organizational aspects were included.

Chapter 2: Literature Review

2.1 Defining Green Building

Green building has now become a major of sustainable development in this century (Ali and Nsairat, 2009), different countries worldwide take responsibility to implement this concept in the construction industry and several definition can be found of the term "green building", this terms "... *Refers to the quality and characteristics of the actual structure created using the principles and methodologies of sustainable construction"*. Kibert, (2007) defined the green building as "healthy facilities designed and built in a resources-efficient manner, using ecologically based principles". Other definition can found and giving in the report of white paper on sustainability stated definition of green building given by the definition given by the Office of the Federal Environmental Executive defines green building as "*the practice of 1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and 2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal the complete building life cycl*e." (A Report on the Green Building Movement, 2003). Glavinich (2008), articulated in the define the terms of green building according to the term green building is defined in the American Society of Testing and Materials (ASTM) Standard E2114-06a *".. as a building that provides the specified building performance requirements while minimizing disturbance to and improving the functioning of local, regional and global ecosystems both during and after its construction and specified service life."*

There is no single, widely accepted definition for green building, but a survey of definitions reveals many common threads. green building is defined (also referred to as sustainable design, sustainable construction, and other terms previously listed) as a philosophy and associated project and construction management practices that seek to: (1) minimize or eliminate impacts on the environment, natural resources, and nonrenewable energy sources to promote the sustainability of the built environment; (2) enhance the health, wellbeing and productivity of occupants and whole communities; (3) cultivate economic development and financial returns for developers and whole communities; and (4) apply life cycle approaches to community planning and development.

2.2 Principles and benefits of green building

In the construction industry, awareness of sustainability among building professionals has increased (Bansal 2005). This can be seen where the green market has been promoted to bring major improvements through developing green buildings or where implementation of an energy rating guideline to assess environmental and energy performance of buildings has become more important. Benefits of adopting this concept in the construction industry include minimizing operating and maintenance costs, minimizing construction wastes, increasing occupant health and satisfaction, and so on (Ahn and Pearce 2007; Lapinski et al. 2006).

The environmental impact of buildings is often underestimated, while the perceived costs of green buildings are overestimated. Kats et al. (2003) comprehensively examined the costs and benefits of green buildings for the state of California in the United State. According to Kats, the average cost premium over just building to code is less than 2%. The Kats report found that "minimal increases in upfront costs of about 2% to support green design would, on average, result in life cycle savings of 20% of total construction costs more than ten times the initial investment". The majority of savings from green building are in the maintenance part and utility costs (CEA, 2011).

Table 2.1 Financial benefits of green buildings (per ft.$_2$). Source: Capital E analysis, www.cap-e.com

Category	20-year Net Present Value
Energy savings	$5.80
Emissions savings	$1.20
Water savings	$0.50
Operations and maintenance savings	$8.50
Productivity and health value	$36.90 to $55.30
Subtotal	$52.90 to %71.30
Average extra cost of building green	(-$3.00 to $5.00)
Total 20-year net benefit	$49.90 to $66.30

Vatalis et al (2013), stated the sustainability components affecting decisions for green building projects in Greece and based in their study on a questionnaire survey of thirty two participants who asked to assess nine sustainability components namely: Life cycle assessment, energy efficiency and renewable energy, water efficiency, environmentally preferable building materials and specifications, waste reduction, toxics reduction, indoor air quality, smart growth and sustainable development and environmentally innovative projects, which affect the decisions for green building projects. The respondent results indicate how participants prioritized the sustainability components ensuring a better quality of life inside buildings based on the principals of "green" buildings economy. Energy efficiency and renewable energy is considered of high priority followed by the reduction of toxic materials, indoor pollution and water saving (Vatalis et al, 2013).

Sustainable development or sustainability is the fundamental principle underlying various efforts to ensure a decent quality of life for future generations. This concept aims to meet the needs of the present without compromising the ability of future generations to meet their needs. This implies that the environment and the quality of human life are as important as economic performance (UNEP Industry and Environment 2003, Carter and Fortune 2007, Kibert 2008, Ali and Nsairat 2009 and others). It was agreed that the mainstay of sustainability thinking is to strike a balance between three dimensions: environmental, social, and economic impacts of the design. Finally, Hussein et al (2013) stated the principles of green building i.e. environment, economic and social aspect together as in table (2).

Table 2.2: The principles of green building. (Source: Capital E analysis, www.cap-e.com)

Environment aspect	Increase material efficiency by reducing the material demand of non-renewable goods
	Reduce the material intensity via substitution technologies.
	Enhance material recyclability.
	Reduce and control the use and dispersion of toxic materials.
	Reduce the energy required for transforming goods and supplying services.
	Support the instruments of international conventions and agreements.
	Maximize the sustainable use of biological and renewable resources.
	Consider the impact of planned projects on air, soil, water, flora, and fauna.
Economic aspect	Consider life-cycle costs.
	Internalize external costs.
	Consider alternative financing mechanisms.
	Develop appropriate economic instruments to promote sustainable consumption.
	Consider the economic impact on local structures.
Social Aspect	Enhance a participatory approach by involving stakeholders.
	Promote public participation.
	Promote the development of appropriate institutional frameworks.
	Consider the influence on the existing social framework.
	Assess the impact on health and the quality of life.

2.3 Greening project management practices for green buildings

Because of the negative environmental impacts of traditional building, green building has attracted more attention in recent years, and an increasing number of studies have been conducted on the project delivery of green building. However, the learning curve for the evolution of green building practices is still in its early phases (Korkmaz et al. 2010). Most of the previous studies primarily focus on drivers, barriers, and specific technical methods and engineering procedures (Papadopoulos and Giama 2007) for delivering green building (Wong et al. 2004; Pulaski et al. 2006). However, the nontechnical aspect is equally important for successful implementation of green building. Management is believed to be the factor that most often determines the success or failure of a project (Imada 2002). According to a survey conducted by Li et al (2011) to identify the controllable critical project management factors for delivering Green Mark certified projects to achieve higher Green Mark ratings architectural, engineering, and construction firms in Singapore, Li et al (2011) firstly identified from related literature the critical project management factors that effect on green building construction process as in table (3). The results show that the coordination of designers and contractors and technical and innovation-oriented factors are the most critical success factors, and possible reasons are discussed.

Table 2.3 Critical project management factors for delivering Green Mark certified projects. (Source: Li et al, 2011)

Components	Project management factors item
(1) Human resource–oriented factors	Commitment of all project participants
	Effective environmental compliance and auditing
	Adequate communication channels
	Project team motivation
	Effective feedback
	Strong/detailed plan effort in design and construction
(2) Technical and innovation-oriented factors	Innovative management approaches
	Innovative financing methods
	Effective and efficient software development and
	Advanced machinery and equipment
	Innovative technological approaches
(3) Support from designers and senior management	Skilled designers
	Adequate financial budget
	Cooperation between architects and engineers
	Support from senior management
(4) Project manager's competence	Troubleshooting
	Skilled project managers
(5) Coordination of designers and contractors	Contractors involved in design stages
	Designers involved in construction stages

The most significant challenge to delivering a financially successful green project is communication and coordination across a multidisciplinary team. Green building projects, more complex than conventional projects, increasing the need for cross-team interaction and communication. Green buildings also require more interdisciplinary coordination, due to the interconnectedness of green systems design. Lauren and Vittal (2011) developed guidelines should be adopted when pursuing a green construction project:

1. **Begin with the end in mind:** set specific sustainability goals and project priorities for green building features before initiating design and construction.
2. **Integrate the project team:** hire the project manager and the key members of the project team early in the project's feasibility stage to ensure collaboration. Host a charrette early in the process.
3. **Design with the whole team approach:** all members of the project team should continue to participate in the formal design phase, initial price estimating, and construction document development.
4. **Use bonuses and rewards in project contracting:** use cost plus- fee arrangement with special clauses to promote efficiency and incorporate incentives and bonuses for implementing sustainable practices and exceeding sustainability goals.
5. **Provide for training and communications throughout construction:** conduct kickoff and monthly meetings with the entire site workforce, including a sustainable education component in sessions.

Greening project management practices can significantly improve the ability of a sustainable construction project to be delivered within acceptable cost constraints. A matrix table (3) that developed by (Robichaud and Anantatmula, 2011) presenting specific adjustments to traditional project management practices based on the project management life cycle has been presented. The basis of the matrix revolves around the premise that a green project improves it chances for financial success if a cross-discipline team is involved at the earliest stages and throughout the project (Robichaud and Anantatmula, 2011).

Table 2.4 Green project management Approach to Construction versus Conventional Construction Matrix (Source: Robichaud and Anantatmula, 2011)

Project process	**Traditional construction**	**Green construction**
Phase 1: Feasibility		
Project need assessment	Define need based on market conditions, physical needs, or other narrow scopes.	Need definition, in addition to market conditions, physical needs, etc., includes environmental goal, LEED certification level, as well as the amount of capital investment toward green initiatives.
Project manager selection	Select an in-house manager or hire one to serve as the project manager. Selection may or may not happen this early in the project.	Hire an experienced green building consultant/ project manager who is familiar with the product type and market and has exposure to all phases of sustainable construction; a LEED accredited professional is optimal and strongly recommended.
Preliminary site analysis and plan	Develop a preliminary budget estimate based on past or Benchmarked traditional projects; unit costs are applied to a preliminary scope of work.	Finalize economic and ecological goals based on cost/benefit analysis. Consider site characteristics and weigh building needs against ecological issues. The preliminary budget is aligned with the project's unique goals, and is often accomplished by creating a cost model that aligns resources with program goals to ensure project priorities are not mismatched to resources (Matthiessen and Morris 2004). A LEED checklist and documenting system is developed for the remaining portion of the feasibility stage.
Design charrette	Charrettes may or may not be implemented during a conventional project. They are often perceived as economic waste or schedule inhibitors.	Must include all key external stakeholders, including surrounding property owners and other community representatives. Diverse representation from the project team functions (design, architecture, building contractor, environmental engineer, real estate consultant, etc) is optimal. The final report serves as one of the guiding documents for the design and construction process (Kibert 2005).
Final site selection	Select site based on traditional preform with little stakeholder involvement.	Select site based on stakeholder involvement including community input, At this point, the construction team is in place (the owner, the project manager, the architect and the contractor), and all parties have a stake in site selection.

Project process	Traditional construction	Green construction
Phase 2: Design		
Initial budget and schedule	Budgets are typically developed by an architect based on a formula or unit costs, which can vary as much as 15% from actual costs. They are often created and expended with little consideration of future operating and maintenance costs (Griffin 2005, unpublished).	Complete preconstruction estimates with input from the builder, project manager, architect, and real estate consultant. Estimating costs associated with specialized areas like green-building products require experience. The budget may also include an emphasis on life cycle costing, shifting focus from short-term return on investment (ROI) to long-term gains from operational savings.
Zoning approval	At this point in the project, this is often the first time regulatory agencies have seen design concepts or site plans. This can sometimes cause rework in the planning and feasibility stages if the concepts do not fit zoning ordinances or local land use goals.	The zoning approval process can often go more smoothly after an inclusive charrette process has been completed because the project will be less likely to face community resistance. The Charette process also encourages feedback from local government planners and other regulatory agencies in the early stages so that zoning considerations are factored into the site plan well in advance.
Design team selection	Select the architect or general contractor depending on the type of contract. All consultant's report to the architect or general contractor.	Usually, the core design team has already been selected by this time. Additional experts for technical systems may be interviewed and selected.
Construction document development	Although the design is finalized by this time, often green initiatives are considered, causing rework.	Because the integrated team has participated in the planning and design process, construction documents can be developed more efficiently and with little design modifications.
Government permitting review	Plans are often reviewed for the first time for engineering compliance (grading, erosion control, and storm water Standards), building codes, water and sewer systems, etc.	Government stakeholders are involved at earlier stages to ensure compliance with local, state and federal guidelines. The regulation of these important environment systems like wastewater and erosion control is significantly connected to LEED requirements.
Project bidding	"Hard bid" methods are most common, where the lowest bid cost is awarded and subcontracts are negotiated by the contractor on a closed-book basis.	Reed and Gordon (2000) recommend an "overhead/fee bid with an open-book subcontracting process" for green projects. Stipulations for minimum number of bids and cost savings allocations can also be included. "Open book" subcontracting allows the owner to have access to the estimates and pricing submitted by subcontractors.

Project process	Traditional construction	Green construction
Phase 3: Implementation		
Contracting	Traditional contracts like cost-plus-percentage or cost-plus-fixed fee are applied. Sometimes work is further divided into multiple contracts, depending on uncertainty surrounding the project (Bockrath 2000). The less confident the builder feels about the project, the higher the fee or risk premium will be.	Integrated development requires a different kind of client/ architect and client/contractor contract) Reed and Gordon 2000). Contracts should include performance agreements, incentives, and bonuses for implementing sustainable practices and exceeding sustainability goals (Pennsylvania State University 2004). Contracts should also include specific provisions for LEED points, Energy Star requirements, and the use of recyclable materials, on-site recycling requirements, and agreements to return unused materials to vendors, among others.
Construction	Weekly site inspections are typically reported by architect or builder. There is little cross-communication among the site workforce, including subcontractors.	Launch construction with kickoff meeting that includes a sustainable education component for on-site construction personnel; monthly on-site meetings are required by entire site workforce and include periodic education and training sessions on green building. Sustainability requirements are reviewed with each subcontractor prior to commencing work (Pennsylvania State University 2004).
Inspections	Field changes caused by fragmentation in the owner-architect-builder relationship can require additional government inspections, which create cost and schedule inefficiencies.	At this point, government regulators are working as a partner in the project, as opposed to an outside influence. Less rework and field adjustments decrease the chances of having to request re inspections.
LEED certification	Typically not applicable. If the project is seeking certification, documentation can be difficult to assemble from multiple sources.	The ongoing efforts of the project manager, coupled with the benefits of an integrated team and specialized technology, can make compiling and submitting documentation more efficient for the project's schedule and budget.
Phase 4: Close out Occupancy and operations	Minimal testing is performed before the building is turned over for operations.	Building commissioning is an essential step in ensuring the building systems function as intended and set forth in the project criteria. The commissioning authority has been hired from the onset and understands the owner's goals and investments .

2.4 Green Building in developed countries

In contrast with most developing countries that are still taking the initial steps towards achieving sustainable development, many of the developed countries are past this stage to a more mature phase where sustainability standards and regulations have been enacted and implemented, and are in constant change for the better.

For instance, there are many bodies in the United States of America that contribute to the implementation of sustainable development, most importantly the Environmental Protection Agency (EPA) which issues laws and regulations, compliances and enforcements. The EPA addresses the construction sector by monitoring air pollution, waste, and other hazardous pollutants resulting from construction. Many building codes are issued according to the specific conditions of each region or state. The most recent one is the “2012 International Green Construction Code” issued by the International Code Council and sponsored by the American Institute of Architects and by US green building council. This code constitutes a regulatory framework for new and existing buildings that establish sustainability requirements from the design phase to the construction phase and operation of the building (Environmental Protection Agency,2011).

Another regulating body aiming for the same goal is the US Department of Homeland Security which issued the “2011 Strategic Sustainability Performance Plan”. This plan works on studying lifecycle costs for new buildings while assessing environmental, economic and social aspects. Besides, there are several non- governmental organizations that provide major efforts to raise public awareness and encourage the green industry, the most important of which is the USGBC which provides consulting, monitoring and environmental impact assessment services for buildings through the LEED certification program. This certificate has become very popular over the years to expand over 120 countries (Environmental Protection Agency, 2011).

As for the United Kingdom, the government is directly involved in assisting and planning sustainable development. The Code for Sustainable Homes and the Energy Performance Certificate (EPC) for Construction set the minimum requirements for buildings in order to attain sustainability (energy and water efficiency). The code for sustainable homes is an environmental assessment rating method for new homes that evaluates the environmental performance of a building during design and post construction phases. The environmental impact of a building is measured according to nine categories including energy and carbon emissions, surface water runoff, water use, materials, waste, pollution, etc. This code is mandatory for all new dwellings and the assessment results are recorded on a certificate assigned to the dwelling (Department of Communities and Local Government, 2010).

Also, the EPC for construction targets both homes and commercial buildings. The evaluation targets energy reduction within appliances including heating, air conditioning and ventilation. Obtaining the certificate is required according to the building code. Besides, the "Sustainable and Secure Buildings Act 2004" is another legislation among many others that put the UK's on the right track towards achieving sustainability.

On the other hand, the European Union Member States have also formulated their long-term strategy to achieve economic, social and environmental sustainable development and have set certain targets to reach by 2020. Along its sustainability plan, the European Commission has issued many policies and legislations impacting the construction industry some targeting the energy efficiency of buildings, control over hazardous construction materials and others addressing workers' conditions. Among these regulations are the Waste Framework Directive which aims at providing a better management of wastes resulting from the construction industry, and the Energy Efficiency Package aiming at reducing energy consumption (European Union, 2011).

These frameworks emphasize the importance of monitoring construction products by classifying and regulating dangerous substances used in the construction industry such as chemicals, waste issues, indoor emissions, soil and groundwater releases, etc. Moreover, the European Commission has put into action several incentives that encourage its states and their local governments to improve their environment and commit to sustainable development. One of these initiatives is the European Green Capital award which is granted to the city that has the highest environmental standards and which can be a role model that inspires other European cities to compete for sustainability (European Union, 2011). For instance, both Nantes (France) and Vitoria-Gasteiz (Spain) were the winners of this price for 2012. Another such incentive is the One Billion Euros research investment entitled "Energy-Efficient Buildings" and financed jointly by EC and the industry. This program was launched in July 2009 and aims at promoting the integration of green technologies and energy efficient materials in new buildings in order to reduce CO_2 emissions and save on energy usage (European Union, 2011).

2.4.1 Environmental Building Performance Assessment Methods

Many of the tools for the environmental building assessment face the construction level and depend on some shape of life cycle assessment record. Tools divide into groups:

1) **Assessment tools:** to present quantitative performance indicators for design options.
2) **Rating tools:** to present performance level to the building in stars.

Table (2.5) mentioned the old and new methods for the environmental building assessment in different countries.

Table 2.5 Environmental Building Performance Assessment Methods. Source: (Seo et al., 2006, Assefa et al., 2005, CASBEE, 2006, CEPAS, 2006, U.S. green building council, 2007, BREEAM, 2006).

Assessment method	**Origin**	**Characteristics**
ABGR: Australian Building Greenhouse Rating	Australia, 2005	• Using star rating, one to five stars. • Based on 12 months of energy consumption. • Present a national approach to determine greenhouse performance.
BEPAC: Building environmental Performance assessment criteria.	Canada, 1993	• Like BREEAM method but a more comprehensive and detailed assessment method. • A voluntary tool. • Make use of a point system for rating.
CASBEE: "Comprehensive assessment system for building environmental efficiency".	Japan, 2004	• A co-operative project between government and industry. • Possibility to apply at predesign stage, new construction, and/or renovation to the building.
CEPAS: Comprehensive Environmental performance assessment scheme.	Hong King, , 2001	• For all types of new or existing buildings. • Having an eight performance categories.
GB Tool: Green building challenge	International, 1995	• The most comprehensive framework. • Worldwide collaboration of over 20 countries. • Four levels of weighting.
Green Star	Australia	• The first Australian comprehensive method to evaluate performance to the environmental building. • Just for commercial building only. • Rating system from 0 to 6 stars
HKBEAM: Hong Kong building Environmental assessment	Hong King, 1996	• Like BREEAM • Evaluate new building as 'as built' more that 'as designed'.

Assessment method	Origin	Characteristics
method		• Focus on life cycle effects of the environmental issues. • Rating system on a scale from fair to excellent. • Evaluation varieties under the global, local, and indoor scales.
LEED: Leadership in energy and Environmental design	USA, 2000	• Found by the US Green Building Council. • Possibility to apply at new and existing institutional, commercial, major renovation and high raise residential. • Includes five area of sustainability.
SBAT: Sustainable building assessment tool	South Africa	• Emphasis on social and economic issues. • Depends on the life cycle for building to make integration to all the buildings parts.
BREEAM (BRE Environmental Assessment Method)	UK, 1990	•BREEAM is a widely used means of reviewing and improving the environmental performance of buildings.
Eco Effect	Sweden	• Eco Effect is a national environmental assessment system focusing on the environmental effects of the use of energy and materials, indoor and outdoor environment and life cycle costs.
Energy-Efficient Buildings	France and Spain, 2012	• This programme was launched in July 2009 and aims at promoting the integration of green technologies and energy efficient materials in new buildings in order to reduce CO2 emissions and save on energy usage
GBI (Green Building Index)	Malaysia,2009	• GBI (Green Building Index) was launched in 2009 and it comprises of 6 key criteria for rating the green building in Malaysia. • The criteria are based on Energy Efficiency, Indoor Environmental Quality, Sustainable Site Planning and Management, Material and Resources, Water Efficiency and Innovation.

To summarize, it is clear that Western countries are taking a huge leap towards achieving green specification in their buildings due to the complementary efforts of their governments and non-governmental agencies. They mostly exhibit a dynamic platform for green building supported by public awareness and a legislative body that ensures the orientation of the industry in the proper direction.

2.4.2 Examples of green building projects in developed countries

Numerous projects have been carried out worldwide to achieve the benefits of sustainable and green development. Some of the examples are as follows:

- **Hong Kong Science Park :** uses solar glass of photovoltaic panels to reduce energy consumption. The park is able to save approximately 250MWh of electricity consumption annually as shown in figure 2.1

Figure 2.1: Hong Kong Science Park – Solar Glass (Source: www.google.com)

- **German Parliament** as shown in figure 2.2 is designed to use 100% renewable energy. The renewable energies are passive use of solar power and natural light and also bio-fuel generators. This leads to a 94% cut in its carbon emissions.

Figure 2.2 German Parliament (Source: www.google.com)

Figure 2.3 Punggol Eco-town (Source: www.google.com)

- **Singapore - Punggol Eco-town** as shown in figure 2.3 is designed with incorporating elements of nature and “green living by water”. Its features includes integrated public transport system, charging stations for electric cars, cycling lanes and 3.2 megawatt solar farm pumping straight into the grid and eliminates the use of batteries

2.5 Green Building in Arab Countries in the Middle East

Arab Countries in the Middle East Region green building concept is recently becoming one of the top concerns in the Middle East region. According to a study conducted by Merrill Lynch, one of the world's leading financial management and advisory companies, around 20% of the wealthy investors in the Middle East region, have already invested in green related technologies. In fact, green building councils have been established in most of the Arab states, and while some rely on previously established rating systems such as LEED, others create their own rating systems such as the ARZ system in Lebanon, Estidama in the United Arab Emirates and the QSAS in Qatar (Ekaruna Magazine, Lebanon, 2011).

Zooming further into the wealthier countries of the region, the United Arab Emirates exhibits a fast growing economy exposed to extreme heat conditions and desertification risks. This makes the conservation of energy vital and a strategic planning to reduce the environmental harm essential. On the bright side, the UAE benefits from a high GDP and a strong commitment to environmental duties making it one of the leading countries in strategic planning within the Arab countries. Unlike Lebanon, an in- creased wealth resulting from the extraction of natural oil allowed the UAE to invest in developing and implementing environmental regulations to varying degrees according to each emirate. Also, the UAE ratified several international conventions such as the Kyoto Protocol and the United Nations Convention to Combat Desertification, which shows its commitment to preserve the environment. Besides, the Emirates Green Building Council (EGBC) plays a key role in protecting the environment and in raising public awareness (Salama and Hana, 2010).

Among the United Arab Emirates, Dubai is taking a leading edge towards sustainable construction. In fact, the Government of Dubai, Dubai Electricity & Water Authority, and the Municipality of Dubai coordinated the creation and implementation of the "Green Building Regulations & Specifications". This code, inspired by the LEED system, is applicable to all the buildings in Dubai and targets areas such as ecology and planning, building vitality, and resource effectiveness in terms of energy, water, material and waste. Accordingly, more than 300 buildings are certified to be green today in Dubai alone (Salama and Hana, 2010).

As for the emirate of Abu Dhabi, its Urban Planning Council (UPC) has introduced a framework for sustainable design, construction and operation under the name of Estidama Pearl Rating System. All new buildings, villas, and government-owned and operated buildings are required to achieve a minimum sustainability score under the Pearl system. The Masdar development project, a sustainable city de- signed to house 50,000 people in a green environment with an investment of almost 25 billion USD, is the highlight of Abu Dhabi's commitment to sustainable development (Salama and Hana, 2010).

Saudi Arabia is another country in the Arab region exhibiting a high GDP and gaining further interest in sustainable development. Several initiatives were taken by the kingdom, most importantly, the adoption of the Green Building- EcoSENS program that aims to raise awareness and provides training for local engineers for the LEED certification program. Also, new buildings for Princess Noura University and the Ministry of Higher Education are applying LEED standards. The Saudi Green Building Council is also playing an important role in spreading awareness and providing a platform for various construction sectors to facilitate green construction. (Ekaruna Magazine, Lebanon, 2011).

On the other hand, Qatar who is living a period of economic prosperity and construction boom has been also one of the leading countries in the Arab region in the sustainability field. Qatar has combined regional and international certification systems into one comprehensive system, the Qatar Sustainability Assessment System; tailored to the country's conditions and vision. Furthermore, and according to the Ministry of Environment, the QSAS and the Qatar Building Standards of 2010 (QBS) should be applied to all public buildings in Qatar as well as residential and commercial complexes. Another huge leap to- wards leadership in sustainability is the fact that the country has started its project to host the 2022 World Cup in 12 stadiums presenting zero carbon impact and relying on solar power for all functions (Hope, 2011).

Other countries of the Arab world, with a GDP similar to Palestine, remain at an early stage of reaching sustainability, notably Jordan. Many efforts are put into the matter, and the Jordan Green Building Council has been established in 2009 taking part of the World Green Building Council. This organization is supported by the USAIDS and has been working on creating standards and recommendations while spreading awareness throughout the country.

The campaign is fully supported by the royal governing family along with the concerned ministries. Additionally, other bodies such as the Jordan Engineers Association are working closely with other regional bodies such as the Gulf Organization for Research and Development to promote sustainability. A promising initiative towards green construction is the development of Al-Mushatta Industrial City that aims to become the first green industrial city in the region. While these initiatives enlighten the public about the importance of sustainable development, Jordan, and similarly to Palestine, suffers from the lack of a proper judiciary body that can implement and enforce environmental legislations (Ekaruna Magazine, Lebanon, 2011).

One of the key players towards achieving sustainability in the Lebanese construction market is the Lebanese Green Building Council (LGBC) which is a non-governmental organization founded in 2008 to promote sustainability and the use of energy-saving materials for buildings.

To serve its purpose, LGBC organizes sustainability awareness campaigns and evaluates the energy efficiency of buildings through its own developed rating system (ARZ) for green buildings.

The ARZ rating system contains four levels of certifications with five-year validity that assess the efficiency of several components: orientation and structure design, energy, materials, water, building isolation, materials, indoor environmental quality, operation & maintenance optimization, and waste and toxics reduction (Ekaruna Magazine, Lebanon, 2011).

Egypt is another neighboring country to Palestine that is also at a preliminary stage of launching and implementing a strategic sustainable development plan.

The Egyptian Green Building Council was established in 2009 encouraging the implementation of already existing codes aiming to preserve the environment, combat desertification, and reduce energy consumption in buildings (Ekaruna Magazine, Lebanon, 2011).

Based on the aforementioned, the Arab countries are clearly divided into high and low income governments. And it is well observed that this particular status reflects on the development and implementation of strategic plans towards green buildings. This may be due to the elevated immediate cost of investing in sustainability, or even the fact that awareness comes hand in hand with the buying power of the government and its capacity to reflect on environmental considerations.

2.5.1 Sustainable Energy Performance Indicators of Green Building in Developing Countries

In order to reduce energy used and its effects on the climate, several strategies are necessary, including energy demand reduction, adoption of passive system and increased energy efficiency (Mwasha et al. 2011). Implementing these strategies in a green building would typically increase the initial capital cost of the building when compared with a conventional home. Yet, the added benefit of energy savings over time is believed to collectively offset part of this increased capital cost (Chang et al. 2011).

For these reasons, all building professionals should make energy efficiency a key part of their professional activities. Building professionals should help clients to develop a brief which sets out both user and client requirements and constraints, balancing these against capital costs, running costs, whole life costs and environmental objectives (Energy efficiency in buildings, CIBSE Guide F 2004).

There are a lot of studies related to energy and energy efficiency that suggest some optimal strategies for achieving to energy performance improvement and sustainable buildings. Alnaser et al. in 2008, in the Kingdom of Bahrain, selected two large buildings for make-over to sustainable buildings, and they used the solar energy, wind energy and the total solar electricity from the photovoltaic cells. Alnaser et al. in 2008, also, improved a model for calculating the sustainable building index. Their research concentrated on policies on renewable energy, renewable energy education, and incentives to Building Integrated Photovoltaic (BIPV) and Building Integrated Wind Turbines (BIWT) projects, environmental awareness and promotion to clean and sustainable energy for building and construction projects.

Yi-Kai Juan et al. in 2010, develop an integrated decision support system to assess existing office building conditions and to recommend an optimal set of sustainable renovation actions, considering trade-offs between renovation cost, improved building quality, and environmental impacts. Chang et al. in 2011, develop an optimal design for water conservation and energy savings that using green roofs in a green building. Taleb and Sharples in 2011, assessed the energy and water consumption practices of existing housing in Saudi Arabia, with the ultimate aim of establishing guidelines for delivering sustainable residential buildings in the near future. Mwasha et al. in 2011, focused to investigate the principal sustainable energy performance indicators for modeling the sustainable performance of the residential building envelope and develop an approach for determining the most appropriate sustainable energy performance indicators.

Gibberd (2005) stated that sustainable development in developing countries should address social and economic issues as a priority; he suggested, that environmental sustainable development objectives should be acknowledged and addressed in interventions designed to address urgent social and economic priorities. Libovich (2005) also believed that nations of the developing world, cannot afford to be looking at environmental performance only. The social and economic problems are at the top of these countries' agendas.

Ali and Nsairat (2009) in their research studied international green building assessment tools such as such as LEED, CASBEE, BREEAM, GB Tool, and others and defined new assessment items respecting the local conditions of Jordan and discussed them with (60) various stakeholders; 50% of them were experts of sustainable development. The outcome of the research was a suggested green building assessment tool (SABA Green Building Rating System) computer based program that suits the Jordanian context in terms of environmental, social and economic perspectives. LEED programs are considered the most fairly comprehensive in scope from landscaping to renewable energy to recycling building materials. (Ali and Nsairat, 2009).

Mwasha et al. in 2011, focused to investigate the principal sustainable energy performance indicators for modeling the sustainable performance of the residential building envelope and develop an approach for determining the most appropriate sustainable energy performance indicators. In this paper, by identifying the performance criteria of a sustainable building, these criteria evaluate according to principal aspects of construction in Iran as developing country.

Finally QaemI and Heravi, (2012) developed building sustainable performance criteria for green buildings in developing countries according to previous study these criteria contain 53 key elements grouped into 8 major areas as shown in Table (7):

Table 2.8. Key performance criteria for sustainable buildings. Source: QAEMI and HERAVI, (2012).

	Criteria		Criteria
Sustainable site	Site selection (1,2,3,4) Reduce pollution generation (2,4,5,6) Transport and accessibility (1,2,5) Construction activity pollution prevention(1,5) Reduce heat island effect (1,5) Development density and community connectivity (1) Brownfield redevelopment (1) Site development (1) Surface water runoff control (1) Light pollution reduction (1)	Water efficiency	Water use reduction (1,2,5) Water efficient landscaping (1,2,5) Wastewater technology (1,5) Water conservation (2,3) Water treatment
Energy efficiency	Renewable energy (1,3,6,7) Minimum energy performance (1,6,7) Reduce greenhouse gas emission (2,3,4,6) Fundamental commissioning of the building energy systems (1,2,6) Building envelope performance control (2,6) Energy efficient heating, cooling and air conditioning systems (2,5) Energy savings (4,6) Green power (1) Fundamental refrigerant management (1) Enhanced commissioning (1) Measurement and verification (1) Optimize energy performance (1)	Material and resources	Reduce waste generation (2,3,5,6,7) Renewable material use (1,2,3,6) Material reuse (1,2,7) Local material use (1,2,4) Storage and collection of recyclables(1) Material durability (3,6,7) Recycled material use (1) Building reuse (1)
Economical	Life-cycle cost (3,4,6,7) Life-cycle profit (2,3,4,6,7) Project budget (4,7)	Indoor environmental	Indoor air quality management (1) Outdoor air delivery monitoring (1,2,3,6) Daylighting and views (1,2) Indoor chemical & pollution sources control (1) Tobacco smoke control(1,5) Controllability of systems (1) Minimum indoor air quality (1) Acoustic & noise control (2) Thermal comfort (1) Low-emitting material (1)
Social	Aesthetic options (3,6,7) Effect on local development (4,7) Protection to culture heritage (3,4)	Innovation	Innovation in design (1,2,3,5)

(1)LEED 2009; (2) Ali and Al Nsairat 2009; (3) ALwaer and Clements-Croome 2010; (4) Shen et al. 2011; (5) Kai Juan et al. 2010; (6) Mwasha et al. 2011; (7) Ying Chen et al. 2010.

2.5.2 Example for green building application in Arab countries:

2.5.2.1 The Aqaba Residence Energy Efficiency (AREE) project - Jordan

- **Overview**

The Aqaba Residence Energy Efficiency (AREE) project is an environmentally-friendly pilot project built in Aqaba's 9th District. This project encourages better design and construction practices that promote passive and active energy efficiency, water efficiency, and environmentally friendly construction materials and techniques. One of the main purposes of the project is to demonstrate the cost effectiveness of energy efficient design, construction techniques, and installations for a typical residential building, particularly in a hot, dry climate.

Figure2.4: The Aqaba Residence Energy Efficiency (AREE) project

The building is developed by the Emtairah Consulting Corporation Amman, Jordan, and was designed by Florentine Visser, a Dutch architect and consultant for sustainable designs, who specializes in hot climate areas. The design was based on one of the winning entries from the Aqaba Housing Competition, a design competition organized in 2004 by the Center for the Study of the Built Environment (CSBE).The engineering design is by Mohammad Abu-Afefeh in Aqaba. Construction began in early 2007 and was completed in June 2008. The cooling system was installed in May 2009. The AREE building was selected by the EU-funded MED ENEC2 project as one of 10 Pilot Projects that aim at promoting energy efficiency in buildings in the Mediterranean region. The building accommodates 420 m² of residential space. The building focuses on reducing electricity costs for cooling, reducing water consumption, and reducing the environmental impact of construction materials where possible. This was achieved through careful consideration of the following aspects of the building construction process:

1.**Thoughtful design:** The architectural design carefully considered issues of orientation, floor plan layout, architectural detailing, and the use of architectural features and landscaping to best utilize the natural forces of sun and wind to achieve passive heating and cooling, shading, and natural ventilation, as well as to minimize water consumption.

2. **Building technology, construction techniques, and materials:** Improved construction detailing and the use of insulation in walls and roofs help create a well-insulated building envelop and minimize the energy demands for indoor climate comfort. Energy costs related to the manufacture and transportation of building materials were also taken into account during the selection of those materials.

Fig. 2.5: View of the roof garden

Fig. 2.6: Solar collecting panels on the roof.

3. **Electro-mechanical systems:** the building applied technologies that range from the low-tech to the contemporary state of the art, and that optimize the use of renewable energy and water resources. These include the installation of an experimental solar powered cooling system, and the installation of a gray water recycling system. The installation of electricity generating photovoltaic panels was also considered. In addition, modern technologies that minimize energy and water consumption were used, as with energy efficient lighting fixtures and water saving fittings (See Fig. No. 2.6).

4. **Building use – the behavioral aspect:** The building occupants play an important role in achieving energy and water saving. This includes the operation of shading devices for windows and doors to block the hot sun, the operation of opening to achieve natural and

night ventilation, the use of outdoor spaces, and setting indoor temperature controls. All these can provide a positive contribution to achieving energy savings.

- **Implementation Challenges:**

The implementation of this project created certain challenges in communication and coordination since it did not fit with the local contractors' 'business as usual' model. This is mainly due to the introduction of additional construction details not commonly addressed in standard construction in the region. The main challenges faced during the project's implementation are listed below:

1. Communication and Reporting:

A lack of capacity among the contractor and workers to understand drawings. This is partly because of language issues and partially because they are not used to working with drawings. The architect had to be available on site as much as possible, and had to explain the details on site. This required considerable planning for the coordination of upcoming work and drawings were needed for all details and were to be executed accordingly. The finishing coordinator made an effort to check many of the details with the architect. The architect ended up taking a bigger role than that of designer only.In spite of this, the quality of finishes was not satisfactory.

2. Availability of materials

Some plumbing materials for the solar cooling system and the gray water system were not available in Aqaba, which resulted in increased costs and the components used in the solar cooling device are unique and not widely used or known in Jordan or worldwide. It was very hard to locate the right suppliers and the right components for its application. The supplier had to redesigning the condenser for the new type of refrigerant to overcome this issue and also to improve its performance.

3. Lack of technical experience and knowledge:

The lack of knowledge by local contractors and builders of the effects of thermal bridges meant that the architect had to take on the role of tutor who would explain the importance of properly addressing this issue and also had to work with the finishing coordinator to find possible solutions. Local suppliers did not know much about the insulation qualities of the materials they sell. The architect therefore had to specify materials according to thickness and density in order to obtain the needed insulation value.

4. Project management and time Scheduling:

The weak planning skills of finishing partners made it difficult to get a realistic estimation of the needed time to complete the building. The agreement with the finishing coordinator had to be terminated due to the slow progress of the finishing work and its low quality. The owner's representative had to take over his role.

2.6 Potential Barriers for Green Building:

The situation is a more optimistic and positive response to calls for promoting sustainability in construction and design techniques (Morton, 2008). Due to the many benefits associated with sustainable design and construction, public governments and their agencies are increasingly incorporating sustainable design and construction practices into not only new buildings, but also existing buildings constructed (Ahn, 2013). In spite of these benefits, unsustainable design and construction processes as well as constant degradation of the environment for construction purposes still exist in most developing countries, of which Palestine is no exception.

Murillo-Luna et al. (2011) identified scarcity of information and lack of clarity on environmental legislation, rigidity of legislation and bureaucratic complexity, limited development of the environmental supply sector, high cost of environmental services/technologies, and difficulties derived from competitive pressure as possible barriers to the adoption of proactive environmental strategies.

Lam et al. (2010) discussed factors hindering successful implementation of green specification in construction. The factors identified are; lack of green technology and techniques, reliability and quality of specification, leadership and responsibility, stakeholder involvement, and guide and benchmarking systems. More recently, there has been growing interest in empirically analyzing the extent to which such barriers hinder development of sustainable construction (Samari et al., 2013; Hoffman & Henn, 2008; Bon & Hutchinson, 2000; Ayarkwa et al., 2010). According to (Häkkinen & Belloni, 2011; Zhang et al., 2011; Ahn et al., 2013), although various steps have been taken by the developed world to fully practice sustainable construction, there exist barriers.

The situation could even be more serious in this part of undeveloped world if there exist barriers to sustainable design and construction in the developed world. In order to endorse and drive the agenda of green construction within the Palestinian construction industry, the barriers that impede these practices must first be identified. The barriers identified in literature from developed countries, developing countries and Middle East can be grouped into four main categories: cultural, financial, steering and professional barriers:

2.6.1 Barriers to green building in developed countries

2.6.1.1 Cultural Barriers

The Palestinian construction process has been used over the past decades. As such, it presents itself as a sector which is traditionally very difficult to change especially with respect to construction methods practiced and building materials used. Construction in Palestine favors the use of blocks and reinforced concrete and discourages any other alternative to these building materials. This illustrates a typical resistance to change; a major barrier. This resistance to change results in a lack of demand by clients and stakeholders of construction projects affecting its eventual supply.

Williams and Dair (2006), in that same vain identified lack of green measure by stakeholder as by far the most commonly recorded barrier and further stated the lack of demand by the client as a commonly recognized barrier. Lack of demand was also cited as the most significant barrier by eighty-four per cent (84%) of respondents as a building project cannot be done along sustainable lines without the owner or developer's "full support for sustainable concepts" (Ahn et al., 2013).

The Toronto Green Development Standard (2006) also acknowledges that public awareness about green building has been an important component that led to high demand. Thus a continual public awareness of sustainable concepts on sustainable construction and its benefits will lead to increased demand, compelling products to be tailored to their needs to be produced.

2.6.1.2 Financial barriers

The fear of higher investment costs of green buildings compared to traditional building and the risks of unforeseen costs are often addressed as barriers to green buildings (Häkkinen & Belloni, 2011). The adoption of green building solutions may be hindered because clients are concerned about the higher risk (Nelms et al., 2005) based on unfamiliar techniques, the lack of previous experience, additional testing and inspection in construction, a lack of manufacturer and supplier support, and a lack of performance information.

Cost overrun is another hindrance faced by green projects. Green buildings tend to be more complicated because they use newer technologies and materials with less environmental impact. In addition, sustainability certification programs, such as Leadership in Energy and Environmental Design (LEED), have many requirements. Combined with the lack of understanding of the green concept, these characteristics tend to lead to cost overruns, project delays, and productivity losses (Construction Industry Institute (CII) 2008; Nalewaik and Venters 2008; Chong et al. 2009).

The promotion of green building practices in real estate development has developed more and more influence on society. Several factors play into uncertainties about future growth in green building practices. Most environmental impacts remain externalities for construction costs; green products are seen as expensive and technically unreliable by some practitioners; and environmental issues are of varying importance to consumers (Brick, 2003; Cassidy, 2004; Loftness, 2004; Seiter, 2005). Green building practices are often characterized as "high cost, high risk" (Dewick & Miozzo, 2004).

According to a survey conducted by Lam et al (2009) in Hong Kong, the three most significant barriers to green building practices were: the additional cost associated with green requirements is perceived to be the most dominant barrier for integrating green specifications in construction, followed by possible delay and a limited pool of competent suppliers.

Qualk and McCown (2009), stated that 85% of the respondents believed that green building costs are greater than for conventional buildings, and 1% said that green building costs are less when compared to conventional buildings. The study showed that:

- 32% believe that they are more 6% to 10% expensive,
- 23% believe that they are 3% to 5% more expensive,
- 18% believe that they are greater than 15% more expensive, and
- 5% believe that they are up to 2% expensive.

According to Kats et al. (2003), the average premium for green buildings is approximately 2%, and the main source of this premium is architectural and engineering design. Although the same report also asserted that the increased upfront costs to support green design result in life cycle savings of 20% of total construction costs, the extra upfront costs for green buildings remain burdensome to industry practitioners. Multiple sources of reports representing practitioners' perspectives have reported that the higher initial investment cost of green features is a severe obstacle to investment in green buildings (CII 2008; McGraw-Hill Construction 2010).

Kunzlik (2003) observed that the degree of environmental discretion in technical specifications for goods and services can be affected by whether the most economical advantage selection criterion is used. Meryman and Silman (2004) contended that cost is a principal barrier for green specifying. Similarly, Ofori and Kien (2004) identified that in Singapore, the perception of extra cost is a fundamental obstacle for architects to advice clients and other members of the design team to include environmental considerations into the design and construction processes. Since the direct cost of construction is related to time, any delay in work flow caused by green practice would have economic implications.

Many studies have reported a positive relationship between pre project planning and cost performance, indicating that a greater pre project planning effort correlates with better cost performance (Hamilton and Gibson 1996; Gibson and Pappas 2003; Menches et al. 2008; Hanna and Skiffington 2010). The correlation should be similar for green projects. It can be assumed that an even higher level of pre project planning is necessary for green buildings to succeed in terms of cost performance. In addition to the nature of green building projects described earlier, a lack of full understanding of green concept is another factor that should emphasize the importance of pre project planning of green building projects.

Another barrier increased indirect cost of green building project that some researchers also argue that green projects have higher injury rates (Rajendran et al. 2009; Fortunato et al. 2012). The selection of construction equipment for green projects is another new consideration because construction equipment is a major source of diesel exhaust emissions (Ahn et al. 2013).

2.6.1.3 Capacity/Professional barriers

According to the CIB Report (1999), the most critical barrier to green construction is the lack of capacity of the construction sector to actually implement sustainable practices. This is further reiterated by Häkkinen and Belloni (2011) who state that green building practices can be hindered by ignorance or a lack of common understanding about them. Although the knowledge base for green building has grown significantly in the past few years, it is still relatively new; and building professionals still lack knowledge of and experience with green building construction (WBCSD 2007; RSMeans 2010). This was echoed by Chong et al. (2009), who determined from a survey of practitioners that most respondents did not know how to initiate sustainability in their work. In addition, many contractors and designers have difficulty hiring employees with green skills (McGraw-Hill Construction 2012).

Zhang et al, (2011) examined 10 typical barriers encountered in the process of real estate development and facilities management by employing questionnaire survey and research results show that high cost for green appliance and lack of motivation from customers' demand are identified as the two major barriers. The government's lack of incentive programs and the slow progress in revising related regulations are major hindrances for institutional enablers. For technological aspects, the problem lies in the cost of importing products because of the lack of locally-produced green technology. Green projects require skillful and experienced contractors, designers, and subcontractors (Bayraktar and Owens 2010; Kats et al. 2010). However, most contractors and designers have difficulty hiring employees with green construction skills, and this problem will become more severe as the green market continues to grow (McGraw-Hill Construction 2012).

The results of a survey that was conducted in Singapore by Yuan Li et al., (2011) to identify critical project management factors facing architectural, engineering, and construction firms for delivering Green Mark certified projects to achieve higher Green Mark ratings was found that the coordination of designers and contractors and technical and innovation-oriented factors are the most critical success factors. The factor analysis revealed that the controllable project management factors could be grouped into five major components, namely, (1) human resource–oriented factors, (2) technical and innovation-oriented factors, (3) support from designers and senior management, (4) project manager's competence, and (5) coordination of designers and contractors.

Vanegas and Pearce (1997) argued that improving new green technologies should be two important strategies for the built environment. However, the same writers later admitted that detailed guidelines or specifications addressing multiple variables of construction were still evolving alongside the concepts of green (Pearce and Vanegas 2002). Tan et al. (1999)

stated that construction activities are difficult to assess and quantify owing to diverse and intricate environmental aspects. Moreover, the performance and life spans of new materials are difficult to determine (Berge and Henley 2000).

The limited knowledge on green technology and the durability of green materials could be an important barrier preventing the construction industry from implementing the strategies and specifying green construction. Another technical barrier is the unwillingness to change the conventional way of specifying existing materials and processes, as noticed by Meryman and Silman (2004). This coincides with the findings of Chen and Chambers (1999) in that deep rooted traditional ideas are the central barrier to green construction in China. Therefore, resistance to change would be included as one of the potential barriers.

The chain of command in construction affects the policy decisions which impose constraints in the adoption of green constructions (Meryman and Silman 2004). Arditi and Gunaydin (1997) identified that poor management practices resulting from luke- warm commitment from senior management directly or indirectly affect productivity and the realization of goals (i.e., “greening” construction).

Ball (2002) commented that the employees in the lower hierarchy of organizations have limited power to effect changes if the top management is uncommitted to environmental issues. Hence, the degree of support from the senior management on implementation should be positively correlated to the willingness of adopting green specifications.

The uncertainty of supply materials would be a barrier against good specifications since specifies face the risk of unavailability and substitution with unequal materials. Meryman and Silman (2004) asserted that the stakeholders’ attitude toward uncertainties in the introduction of green specifications owing to immaturity of the market and unknown adequacy of the new green clauses would affect the enthusiasm toward green construction. While Ball (2002) was concerned with the objectiveness of green criteria as influenced by manufacturers over eco-labeling (thus making the scheme less useful than it should be).

Kunzlik (2003) highlighted the possible infringement against non-discrimination in contract awards due to the additional green requirements. Therefore, in the questionnaire survey that follows this section, the relative importance of barriers such as “limited availability and reliability of green suppliers,” “low flexibility for alternatives or substitutes,” and “resistance from interested groups or market players in the market” should be construed as possible issues related to supply chain management.

Rydin et al. (2006) claim that while designers demonstrate confidence in their ability to access and use knowledge in general, this confidence falls when sustainable building issues are addressed. This presupposes that professionals within the built environment need to be fully acquainted with sustainable construction principles in order to implement its practice. Not only are they supposed to be knowledgeable, these professionals need to form an integrated team from conception to inception comprising of the developer/owner, project manager, contractor, architect, services engineer, structural engineer, civil engineer, environmental engineer, landscape consultant, cost planner and building surveyor. This team needs to have the best available information on products and tools to achieve sustainable construction; however,

Williams and Dair (2006) identified that, this was not the case. In their research, evidence of hindrance due to a lack of information was a factor common to most stakeholder groups. In several cases, stakeholders admitted to not being aware of sustainable measures or alternatives that fall within their remit.

Similarly, installing green technologies and materials requires new forms of competencies and knowledge; yet, it was evident from the research that not all those with responsibilities in this area had the necessary experience or expertise to meet the challenge. The workforce of every industry is its back bone; as such, the need to involve professionals who are not only knowledgeable but can promote sustainable construction working as a team is essential This barrier if unattended, will indicate a considerable knowledge and skills gap in the construction sector.

2.6.1.4 Steering barriers

A major characteristic of the construction industry is the involvement of a large number of individuals ranging from clients to the builder thus an effective steering or strategy will be required to implement green building. The lack thereof or wrongful steering may rather stifle green building whilst on the other hand, steering measures can promote it. Steering barriers include but not limited to the lack of building codes, government policies/support and measurement tools amongst others. The lack of methods is a barrier, but methods as such do not improve the sustainability of built environment. The impact will depend on the implementation of methods (Häkkinen & Belloni, 2011).

Understanding the barriers to green buildings development will help find ways to promote the green buildings. The world's successful labeling programs, e.g., Energy Star, or LEED, provide helpful information and guidance on green building to the public. Literature shows that the rating systems and labeling programs are crucial to promote green building (Qian and Chan, 2008). The existence of many unrecognized eco-labeling for green products as well as the lack of coordination or consistency in rating tools are holding back the interests of the potential stakeholders in green building (Qian and Chan, 2008c; Lee and Rajagopalan, 2008). The importance of the government's role in assisting energy efficiency and green buildings development are recognized (Varone and Aebischer, 2000, Ofori, 2006). However, there are complaints of insufficient fiscal incentives from the government to help offset the perceived higher upfront costs of green buildings and products, which decreases the attractiveness of green buildings. Different accounting methods, e.g., capital costs, or operating costs, may also create stumbling blocks for choosing between green and conventional buildings.

Also, researches show that it is inefficient to leave the building market on its own to absorb the cost for promoting the idea of ''green'' or ''energy efficiency'', due to the well-established economic theory of market barriers (Qian et al., 2006; Dennis, 2006). Government plays an essential role in advocating this idea to the public. ''Education'' on the part of construction professionals, ''awareness'' on the part of the public, and ''research and case studies'' for innovative green buildings are the common issues brought up by both the practitioners and the academia (Qian et al., 2006; Raftery et al., 2004). The importance of these underlying issues will be investigated in the context of Asia region.

2.6.2 Barriers to green building in developing countries

There are a number of systemic problems facing developing countries, such as rapid rates of urbanization, deep poverty, social inequity, low skills levels, institutional incapacity, weak governance, an uncertain economic environment and environmental degradation, which by themselves create a challenging environment within which to work.

Serpell et al (2013), stated that the main barriers towards green buildings are the lack of financial incentives, lack of integrated design, and affordability whereas company's tax reduction incentives related to the level of investment effort on green buildings would be a key governmental policy these barriers were found as the result of survey conducted in Chile to discusses the level of awareness and knowledge, barriers and drivers of green building that were found in building and infrastructure construction companies.

2.6.2.1 Barriers to green building in Southeast Asia

Many experts (Atsusaka, 2003; Samari, 2012) believe that the role of governments in promoting green building is undeniable and effective. Rules and regulations should be replaced with enforcing new ones to support green building development. Governments can facilitate green building development by a variety of instruments. However, there is question as to the most effective and efficient instruments among the specialists and researchers. Some studies stated that market base intensives are both effective and efficient tools to address market failure together with non-market problems to improve the situation for green buildings development (Dennis, 2006).

Shafii et al. (2005) points out that there are many barriers to developing sustainable development in Asia such as: lack of awareness, lack of training and education about sustainable design, higher cost, special materials, rules and regulation, lack of demonstration, lack of technology and lack of demand. Davis (2001) believed the most important barriers to green building development can be divided in three groups:

- Builder Incentives: Energy saving and worker productivity are common benefits of green buildings. These benefits have positive effect for final owners and impose extra cost for builder. Hence, being cost-effective is the main obstacle to green building development.
- Product information and sourcing: a common obstacle to green building development in developing countries is the lack of information about green products in high-performance building systems. This obstacle leads the developers to hire specialized consultants.

- Client Knowledge: the effective ways to remove this barrier are to introduce credible evidence of the advantages of green building and to conduct long-term studies to prove the benefits of green building.

Lack of credit resources to cover up front cost, risk of investment, lack of demand as well as higher final price were highlighted in a survey by Samari et al (2013) to investigate the barriers in developing green buildings in Malaysia. The cost factor and lack of "urgency" are the core problems in encouraging internal action, while the low demand by the potential buyers affects market influence. This is the result of survey conducted by Abidin et al, (2013) to investigate the barriers limiting the progress of a creating a viable environment for a sustainable housing industry. Shafii et al (2005) showed that the following points contributed to barriers facing green building in most countries in South-East Asia:

- Lack of awareness on green building: Sustainability is still a relatively new concept for the construction industry in the developing countries of South-East Asia. Generally, there is an increase in awareness on sustainable building and construction in the region however it is not across the whole spectrum of the construction sector.
- Lack of training and education in green design and construction: Many important stakeholders are not even aware of the concept of green building and so are naturally resistant to change. Hence the greatest barrier is the lack of understanding of the need for green design.
- The higher cost of sustainable building option: Many stakeholders have the opinion that the construction industries won't go green unless it saves them money somehow. A majority of the clients have not been interested in any green features except for energy efficiency aspects, which is believed to offer immediate paybacks.
- Procurement issues: Undue emphasis on lowest price rather than best value impacts negatively on industry performance in terms of time, cost and quality. It affects green enterprises and their ability to develop and retain a skilled workforce, and to actively promote safety, health and the environment.
- Regulatory barriers: Public policies and regulatory frameworks do not encourage the development of the construction sector.
- Lack of professional capabilities/designers: Green building requires another area of sub-specialization for architects and engineers. Sustainability takes too much

time to learn and design. Clearly, the architecture and design curriculum in existing schools and construction education is not sufficient to prepare future architects and engineers to understand such roles and responsibilities.

- Disincentive factors over local material production: One of the disincentive factors to green buildings is the involvement of the government in the supply of building materials. In order to meet the demand for building materials, many governments in SEA have played an active role in the supply of basic building material such as cement.
- Lack of demonstration examples: More demonstration examples are needed to convince stakeholders to adopt green building and construction options.

2.6.2.2 Barriers to green building in the Middle East

Salama and Hana (2010), in a questionnaire survey were distributed a questionnaire to a random sample of 120 practitioners representing clients, consultants, project managers, contractors and suppliers. This questionnaire investigates the level of awareness of the green building concept amongst the various categories within the key stakeholders in the construction industry in UAE have recognized the following 9 factors as main challenges facing green building as perceived by the key stakeholders in the construction industry in UAE: (1) lack of awareness of the benefits, (2) higher construction cost, (3) short-term budget horizons, (4) length of required payback period ,(5) difficulty in quantifying benefits,(6) lack of clear federal policy, (7) documentation and Cost of certification (8) more complex construction and (9) increased operating costs. The results of a survey that was conducted by Qaemi and Heravi (2012) that studied the current status of Iran as developing country about energy issues, renewable energy utilization enhancement, and their effects on improving the energy performance that the solar energy (active and passive forms) has the highest priority, advantage, and application for using in urban areas and buildings in Iran show that the passive solar energy has more application, but there are some obstacles for developing this system, such as: poor planning approach and lack of government support. Moreover, the government's incentive measures and improvement of public culture and awareness about building sustainable energy can be effective for developing the applications of renewable energy systems.

A survey was conducted in Kuwait by Al Sanad et al. (2013), to investigate the awareness of developers and other stakeholders regarding their understanding and use of green construction strategies. The results of the survey demonstrate that whilst there seemed to be a reasonable level of awareness amongst the stakeholders, this awareness is not currently well reflected in the design and construction practices actually being applied. It is therefore concluded is there is a pressing need for intervention from government in order for the use of sustainable green design and construction strategies becomes the norm in Kuwait.

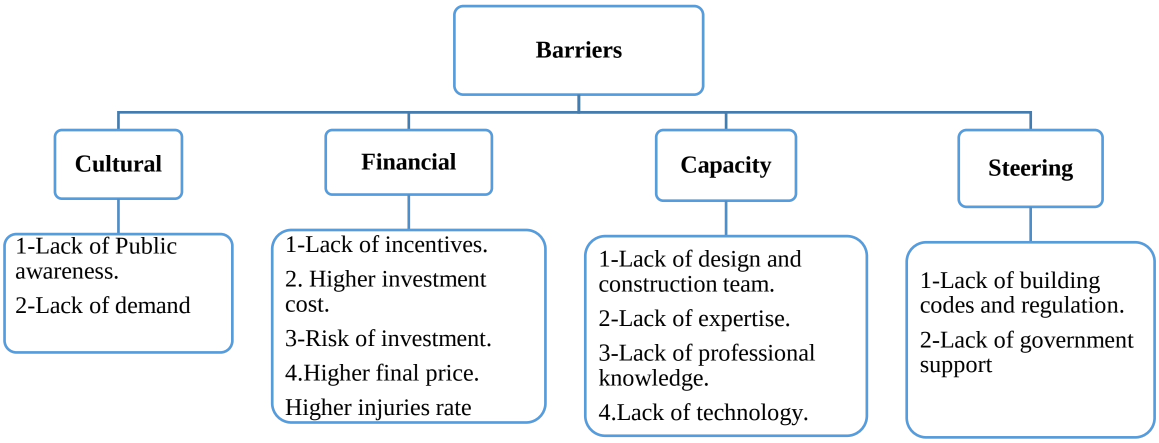


Figure 2.7: Barriers to sustainable construction

Table 2.9. Summary of Optional Barriers for Applying Green Elements in buildings projects

	Source	Country	Methodology	Potential barriers for green building														
				Steering		**Financial**					**Cultural**		**Capacity**					
				Lack of building codes and regulation	Lack of government support	Lack of incentives	Higher investment cost	Risk of investment	Higher final price	Lack of credit resources to cover up front cost	Lack of Public awareness	Lack of demand	Lack of strategy to promote green building	Lack of design and construction team	Lack of expertise	Lack of professional knowledge	Higher injuries rate	Lack of technology
(1) Potential barriers for green building in developed countries																		
1.	WBCSD (2007)	Switzerland	----------------															
2.	Williams and Dair (2006)	England	Questionnaire															
3.	Ahn, (2013)	USA	Questionnaire															
4.	Häkkinen & Belloni, 2011	Finland	interviews and case studies															
5.	Nelms et al., 2005	Canada	----------------															
6.	RS Means (2010)	USA	----------------															
7.	Chong et al. (2009)	USA	Questionnaire															
8.	McGraw-Hill Construction (2012)	USA	Questionnaire															
9.	Construction Industry Institute (CII) (2008)	USA	----------------															
10.	Nalewaik and Venters (2008)	USA	Questionnaire															
11.	Brick, (2003)	USA	----------------															

	Source	Country	Methodology	Potential barriers for green building														
				Steering		**Financial**					**Cultural**		**Capacity**					
				Lack of building codes and regulation	Lack of government support	Lack of incentives	Higher investment cost	Risk of investment	Higher final price	Lack of credit resources to cover up front cost	Lack of Public awareness	Lack of demand	Lack of strategy to promote green building	Lack of design and construction team	Lack of expertise	Lack of professional knowledge	Higher injuries rate	Lack of technology
12.	Cassidy, (2004)	USA	Questionnaire						■									■
13.	Loftness, (2004)	USA	----------------						■									■
14.	Seiter, (2005)	USA	----------------				■		■									
15.	Dewick & Miozzo, (2004)	Scotland	----------------				■		■									
16.	Lam et al, (2009)	Hong Kong	Questionnaire						■					■				
17.	Qualk and McCown (2009)	USA	----------------						■									
18.	Zhang et al, (2011)	Hong Kong	Questionnaire	■	■	■			■									■
19.	Kats et al. (2003)	USA	Questionnaire						■									
20.	McGraw-Hill Co. (2010)	USA	Questionnaire				■											
21.	Rajendran et al. (2009)	USA	Case study														■	
22.	Fortunato et al. (2012)	USA	Case study														■	
23.	Ahn et al. (2013)	USA	Case study															■
24.	Kunzlik (2003)	USA	----------------															■
25.	Meryman and Silman (2004)	USA	----------------						■									
26.	Ofori and Kien (2004)	Singapore	----------------						■					■	■			
27.	Bayraktar and Owens (2010)	USA	----------------											■	■			

	Source	Country	Methodology	Potential barriers for green building														
				Steering		**Financial**					**Cultural**		**Capacity**					
				Lack of building codes and regulation	Lack of government support	Lack of incentives	Higher investment cost	Risk of investment	Higher final price	Lack of credit resources to cover up front cost	Lack of Public awareness	Lack of demand	Lack of strategy to promote green building	Lack of design and construction team	Lack of expertise	Lack of professional knowledge	Higher injuries rate	Lack of technology
28.	Kats et al. (2010)	USA	----------------															
29.	McGraw-Hill Co. (2012)	USA	----------------															
30.	Yuan Li et al., (2011)	Singapore	Questionnaire															
31.	Lam et al. (2007)	Hong Kong	Questionnaire															
32.	Qian and Chan, (2008).	Hong Kong	----------------															
33.	Lee and Rajagopalan, (2008)	Singapore	----------------															
34.	Varone and Aebischer, (2000)	Canada	Comparative study															
35.	Ofori, (2006)	Singapore	Case study															
36.	Atsusaka, 2003																	
37.	Qian et al., (2006)	Hong Kong	Questionnaire															
38.	Davis (2001)																	
(2) Potential barriers for green building in developing countries																		
1.	Serpell et al (2013)	Cheli	Questionnaire															
2.	Samari, 2012	Malaysia	Questionnaire															
3.	Dennis, 2006	Argentina	----------------															
4.	Shafii et al. (2005)	Malaysia	Case study															
5.	Abidin et al, (2013)	Malaysia	Questionnaire															

	Source	Country	Methodology	Potential barriers for green building														
				Steering		**Financial**					**Cultural**		**Capacity**					
				Lack of building codes and regulation	Lack of government support	Lack of incentives	Higher investment cost	Risk of investment	Higher final price	Lack of credit resources to cover up front cost	Lack of Public awareness	Lack of demand	Lack of strategy to promote green building	Lack of design and construction team	Lack of expertise	Lack of professional knowledge	Higher injuries rate	Lack of technology
(3) Potential barriers for green building in Middle East																		
1.	Salama and Hana (2010)	UAE	Questionnaire															
2.	Qaemi and Heravi (2012)	IRAN	Questionnaire															
3.	Al Sanad et al. (2013)	Kuwit	Questionnaire															

2.7 Concept of green buildings in Gaza Strip – Palestine

Palestine is a developing country suffering from the global problems of energy and the increasing of pollution, especially with poor resources of energy and inefficient use of it. In light of this situation, the development plan in Palestine which is being implemented to improve the quality of life for the Palestinian expected that the demand for energy will grow to high levels reaching (5-10) % annually for the electric consumption shortage (ILO Gaza Strip Assessment, 2012).

Due to the absence of fossil fuel resources, Palestine has to import all its needs (100%) of petroleum products from Israeli market and about 92% of electrical energy from the Israeli Electric Corporation, a total energy bill of more than 385 M€ per year. Indigenous energy resources are quite limited to solar energy for photovoltaic and thermal applications (mainly for water heating), and biomass (wood and agricultural waste) for cooking and heating in rural areas. Potential of wind energy is relatively small but not yet utilized in Palestine.

Biogas also not yet utilized whereas its production is estimated at 33 million cubic meters, equivalent to 10 M€. Recent exploration of natural gas in Gaza gives hopes and new opportunities for gas industry in Palestine. The initial investment to develop this industry is evaluated to 310 M€ which necessitates marketing of 1.5 billion m3. The local demand is estimated to 1.1 billion m3 per year. Oil shale is available in substantial quantities (1200 MT), but a project in this area tends to be much more costly than other renewable energy sources and not politically feasible, at least at the moment (Palestinian Energy Authority, 2013).

Palestine has a range of geographic features, the location of Palestine is at the eastern coast of the Mediterranean Sea. Palestine is located to the south of Lebanon and to the west of Jordan. Palestine Geography consists of four regions in the country. The four regions of Palestine Geography are Jordan valley and Ghawr, coastal and inner plains, Mountain and Hills and Southern Desert.

1- The coastal plains of Palestine are divided by Saruunah plain, Mount Carmel plain and the Acre plain. In the category of the geography of Palestine the location of Jordan

Valley is below the sea level and Ghawr. It results in the quality of the soil to be of very high standard but the resource of water is very limited.

2- The climate of Palestine results in the growing of such types of vegetables in the last phase of winter season, which usually are grown in the summer season. The hills and the mountains of Palestine have rocky features and terraces are made in the mountains so that the tress can grow.

3- The geography in Palestine supports the growth of olive trees to a large extent. In some of the parts of Palestine patches of plain land are found which helps in the growth of barley, wheat, lentils. There are many rivers in Palestine and the weather of Palestine remains pleasant for the maximum part of the year.

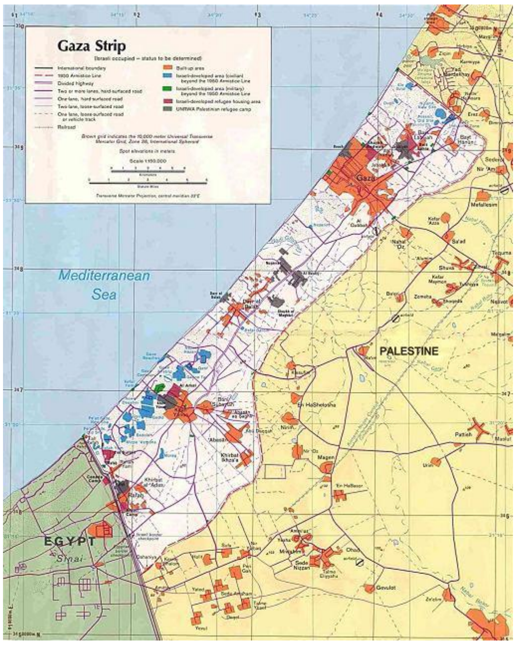


Figure 2.8: The Gaza Strip map. Source: palestinehistory.com, 2012.

Gaza Strip is 360 km2 with a high density population of about 3823 persons/km2 (Fig. 2.8), Palestine, is a narrow land area located in the South-eastern Mediterranean Sea, with a length of about 41 km and a width ranging from 6 to 12 km. At mid-2012 there were approximately 1.64 million inhabitants living in the Strip according to the Palestinian Central Bureau of Statistics (PCBS, 2013) in an area comprising 360 km2, which makes it one of the most densely, populated areas in the world. The Gaza Strip is linked to the outside world through five border crossings; four with Israel and one with Egypt. All materials and goods required for the people in the Gaza Strip are officially to enter through the (Israeli) border crossings, whereas the Egyptian crossing is only for persons' movement. Access to the Mediterranean Sea is limited to three nautical miles along the Strip coastline (ILO Gaza Strip Assessment, 2012).

Palestine is classified among few countries of the world with limited water resources and it is one of the lowest on a per capita basis. There is now a water crisis in Gaza Strip. According to one estimate, the people of Gaza over-pump approximately 160 million cubic meters (MCM) of water from the coastal aquifer per year, but the sustainable yield of the Gaza sub- aquifer is about 100 MCM/year (Bohamon ,2013) .

Because of the depletion of water and the declining economic situation, Gaza Strip is suffering from environmental problems such as salivation of fresh water, contamination of underground water resources (most wells in Gaza Strip produce non potable water by the standards of World Health Organization (Bohamon , 2006)), lack of adequate sewage treatment, desertification, soil degradation and depletion (cia, 2007) , and water-borne diseases. Besides salts, which cause kidney disease, nitrates from solid waste and fertilizers are the most common water contaminants. The nitrates cause blue baby syndrome (Bohamon ,2006), a fatal condition in which the hemoglobin (Fe^{2+}) in an infant's red blood cells is oxidized to methemoglobin (Fe^{3+}), which is unable to deliver oxygen. The lack of oxygen in the blood will result in a bluish discoloration of the skin and mucous membranes (Knobeloch et al, 2000).

In spite of the fact that these problems are caused by the depletion of water, it is worthwhile to mention that people in Gaza Strip consume 70 liters per capita per day (this includes the public use as hospitals, schools, business, and public institutions), while the World Health Organization and the United States Agency for International Development agreed that the minimum consumption per capita per day is 100 liters for public health and hygiene (Bohamon ,2006). As the population in Gaza Strip increases (population growth rate is 3.77%/year (cia, 2007)), the consumption of water and energy will increase and the deficit in water supply and energy resources will increase, leading to a severe economic crisis that will result in a significant rise in the probability of an outbreak of warfare. The scarcity of water in Palestine is the most important constrain to the country growth and development because water is not only considered a factor for food production but a very crucial factor of health, survival, social and economic development.

The concern of environment and sustainable development has been increased recently in Palestine. Therefore, Palestine established different institutions that concern sustainable issues – environmental, social, and economical beside other non-governmental organizations. Although these efforts but until now there is not found strategies for promoting green building practices between Palestinian people to become a culture.

In the last twenty five years, the construction practices in Palestine were shifted toward modern (western) building systems to cope with the modernization style of living. They replaced the mud and stone as major traditional materials with concrete, glass and steel to become dominant construction materials and systems. Thus, Construction practices shifted from craft to industry. Accordingly, there is an urgent need to return back to the vernacular systems into modern perspective, through establishing new building systems and practices based on green thinking and applications.

Figure 2.9: Gray building in Gaza city(Source: researcher, 2013).

Table 2.10: SWOT Analysis for the Construction Sector in Gaza Strip, Palestine

Strengths	Weaknesses
1. Good experience in dealing with different codes, contracts, specifications. 2. Flexibility 3. Contingency plans are always expected and prepared. 4. Working under pressure and for long hours. 5. Supported by international donors.	1. Lack of capital and internal financing 2. Absence of local currency 3. Subject to currencies fluctuation 4. Shortage of materials 5. High cost of construction 6. Lack of cooperation within supply chain 7. Lack of long term planning 8. Lack of sovereignty on borders 9. Movement and access in and out of Palestine 10. Land and sea blockade on the Gaza Strip 11. Instability.

Opportunities	Threats
1. Palestine is in need of rebuilding ; the need for all kinds of construction projects; a. Infrastructure b. Residential c. Engineering projects, highways, bridges, airports, etc. … d. Buildings; Hospitals, Schools ,etc e. Industrial engineering	1.Closures 2. Destruction.

2.8 Summary

There are numerous barriers preventing green construction in Palestine; most of the experts from engineers, contractors, developers and researchers attribute these barriers to the political situation while others think that although instability and insecurity play a major role in preventing sustainable growth but they believe that there are many other causes such as:

1. Operational factors: failure to effectively manage markets, finance, employees, prices and customer satisfaction.
2. Management skills, technical ability and leadership, decision making ability, motivation and aspiration values of managers.
3. Accepting change.
4. Financial constraints; lack of financial resources.
5. Limited marketing and human resource management expertise; lack of understanding marketing concept and lack of employees training and development.
6. Limited strategic planning; market segmentation, pricing strategies and environment analysis.
7. Limited incentives for innovation.
8. Ineffective information technology, lack of system knowledge.
9. Ignorance of life cycle cost, lack of education and knowledge in sustainable design, and client worries in profitability and pay-back period.

As a result, Palestine in need to develop green building practices; it needs to improve the environmental and economic performance of new and existing commercial, institutional, and residential buildings.

Chapter 3: Methodology

Research methodology refers to the principles and procedures of logical thought processes applied to scientific investigation (Fellows & Liu, 1999). This chapter discusses briefly the methodological approaches that are available and sets out the reasoning behind the methodology selected for this research project. It then details the research methods that were used and finally provides the overall research design. Combinations of quantitative and qualitative methods are intended to be used in the research study as methods complement each other and enables for more thorough analysis. Creswell and Miller (2000) stated that collecting, analyzing and mixing both the quantitative and qualitative data at some stage of research process within a single study allow understanding research objectives more comprehensively. On this basis, to perform research study on *"Promoting Green Building Practices in Palestine"* Both the quantitative and qualitative research methods will be adopted in this study.

To fulfill research objectives the following tasks were executed:

- The problem was defined and supported by developing the research theme that included the general aim and objectives.
- Intensive literature review was conducted to review the previous studies made in this field in developing and developed countries :
  - Green concept as well as its relation to construction industry to investigate the definitions for some common terms in green construction, for example green building.
  - Focuses and process in green and conventional building in order to find the differences in green and conventional building.
  - Green building challenges to investigate what barriers and drivers are significant in the green building process and what challenges exist in designing and constructing a green building during design and construction process.
  - Project managers' roles and responsibilities in the building process that can be highlighted for the related challenges.
  - The role of information technology to promote green buildings.
  - Some case studies regarding the challenges for green building to find some examples of each challenge in order to make them more understandable.

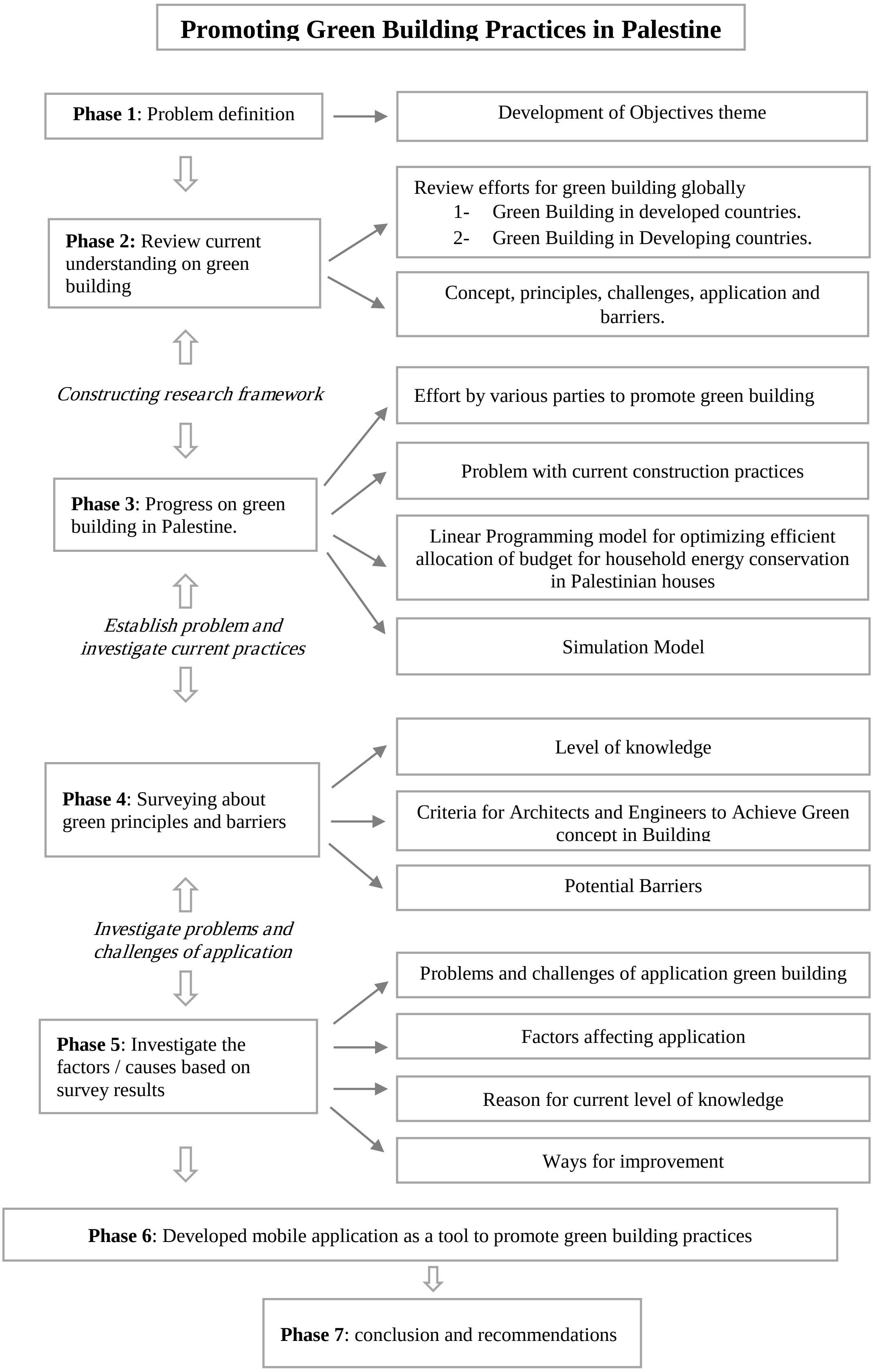


Figure 3.1: Research Map

3.1 Framework of the Research Design

This proposed first research aims to appraise the project developers' knowledge and understanding on green concept and explore the application of this concept within their practices. The detailed methodology of this study was illustrated in figure 3.1

a) **Phase 1: development of theme - The first stage included definition of the problem, objectives development, and framework development.**

b) **Phase 2: Literature review on green building – to understand the philosophy, concept, principles, challenges and advantages of green building.**

The literature review will pave the way for designing the study questionnaire. The interviews will be used to obtain their perspectives regarding the applicable data and most effective factors affecting implementation of greening construction management in Palestine. The obtained data and effective factors are needed for analysis and design to maintain greening construction in Gaza buildings through greening construction management use. The local culture also will be considered in this regard.

c) **Phase 2: Review on the progress of green building in Palestine – to understand general efforts towards sustainable agenda and the progress so far, especially in construction industry through studying practical case studies :**

Methodology for Case Study: Green School in Khanyounis

- **Purpose** – The objective of this case study is to study the strategies of achieving sustainability practices in green school at UNRWA construction projects in Gaza Strip; which submit the best solution for water and energy crisis problems in Gaza strip, this objective achieved through clarify the function of each system in green school and the elements of success for these practice.

- **Design/methodology/approach** – A case study methodology was adopted; with one construction project selected. Data were collected from archival records and from interviews with project participants working at different levels in the project.

- **Findings** – The information provided by the multiple informants figuring out that the important of sustainable elements in UNRWA green school which achieved through this project and agreed with the achieved the LEED (Leadership in energy and environmental design criteria in assessment of achieving sustainability for building ,some of these element were Reduced heating and cooling demands covered by energy produced on site with renewable ; Reducing water demand for cleaning, WC, irrigation and personal hygiene through applying to rain harvesting system; Using raw earth materials as building material in construction green school and Reduce of CO2 emissions.

- **Case Study limitations/implications** – This case study focused on the sector of construction projects at UNRWA only and limited to green school buildings where the infrastructure (Water, sewerage and drainage systems) was not included as separate projects.

  - **Practical implications** – To promote applying the principles of sustainable architecture in humanitarian and development interventions throughout the Green School design and construction process.

  - **Originality/value** – The case study theme is not original in itself; however, this endeavor (to the best of my knowledge) is the first attempt to focus on green school in UNRWA projects, also This architectural pilot project is not just for a single building, it is the first step towards a sustainable, carbon free, Gaza and, further than, the Palestinian Territory.

d) Phase 3: Simulation Models Chapter 4 included two models which presented the benefits of applying green concept in residential building under current constraints:

Methodology for First Model: Linear Programming for optimizing efficient allocation of budget for household energy conservation in Palestinian houses

In this model, linear programming method was used to optimize the allocation of budget in order to maximize the energy and water savings of a hypothetical household in Palestine. Linear programming is a mathematical method for determining a way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model for a list of requirements represented as linear relationships (Ravindran,1987) A linear programming model simply contains an objective function (to be maximized or minimized) and a constraint function. Linear programming method is a very convenient tool that it is used extensively to solve and optimize various types of economical and industrial problems.

Model details will be presented in the following chapter 4, accepts energy savings (W) as the objective function and the budget as the constraint function. There are various actions that result in energy savings in a house, each with a specified unit cost. The aim of the algorithm is to allocate the budget to these actions in order to obtain the maximum energy savings. Different budget values were used as constraint to get energy saving values as a function of budget.

While developing the method, our main idea was to analyze the issue of building energy efficiency from the household consumer's point of view. We wanted to create a simple, yet effective algorithm. Our algorithm was designed to answer the question of **"how much energy would be saved if certain amount of money was spent".** After obtaining the maximum possible energy savings values for each different budget, we calculated payback periods and profitability values to convert the output into a more understandable form for the consumer.

A further strength of this model is the realization of a detailed market research in order to get approximate cost values for each particular energy-saving measure. The readers can simply check the references listed at the end to get the actual cost values for any given item or method.

Methodology for Sconned Model: Simulation Model using Arena program for Water Management in Existing Residential Building in Palestine (Grey-Water System).

- **Model Objectives**

- Introduce a model for a family house that depends mainly on grey water system to run the appliances and human activities.

- Encourage owners and operators of existing buildings to implement sustainable practices and reduce the environmental impacts of their buildings especially in water consumption.

- **Model Methodology**

The methodology of this Project adapted the following methods to reach its aim and objectives:

- Define the water resources and water scarcity in Palestine (water crisis in Palestine).

- Study the environmental benefits of the grey water systems.

- Apply simulation model for the grey water system in a case study in Palestine using arena simulation and analyze the benefits of its application.

- **Simulation Model**

The sequential steps that were adopted for developing model:

1. Understand how the existing system operates; by observing the system components then capturing the logic of the product flow through the system.
2. Define the system constraints that result in specific assumptions which are applied to the simulation model development.
3. Collect cycle time data for the process.
4. Define the probability distributions of the cycle time data for each process using the Input Analyzer tool provided by the simulation software,
5. Develop the simulation model according to the existing system assumptions and constraints.
6. Verify the model during the development phase by checking the animation display in order to insure compatibility with the modeling assumptions

Phase 4: Develop mobile application prototype: (Design Manager Application – To manage your green design home).

Phase 5: conclusion and recommendations. The final phase of the research included the conclusions and recommendations.

Chapter 4: Case Study

Construction of Kuwait city school at khanyounis city

Figure 4.1: Kuwait city school at khanyounis city

4.1 Introduction

The objective of this case study is to study the strategies of achieving sustainability practices in green school at UNRWA construction projects in Gaza Strip; which submit the best solution for water and energy crisis problems in Gaza strip, this objective achieved through clarify the function of each system in green school and the elements of success for these practice.

A case study methodology was adopted; with one construction project selected. Data were collected from archival records and from interviews with project participants working at different levels in the project.

The information provided by the multiple informants figuring out that the important of sustainable elements in UNRWA green school which achieved through this project and agreed with the achieved the LEED (Leadership in energy and environmental design criteria in assessment of achieving sustainability for building ,some of these element were Reduced heating and cooling demands covered by energy produced on site with renewable ; Reducing water demand for cleaning, WC, irrigation and personal hygiene through applying to rain harvesting system; Using raw earth materials as building material in construction green school Reduce of CO_2 emissions.

This case study focused on the sector of construction projects at UNRWA only and limited to green school buildings where the infrastructure (Water, sewerage and drainage systems) was not included as separate projects.

4.2 Main Project information:

4.2.1 Description of project location

The school is located at khanyounis refugee camp which is located about two kilometers from the Mediterranean coast, north of Rafh. It lies west of the town of Khan Younis, a major commercial center and stop-off point on the ancient trade route to Egypt. According to the UNRWA, today the camp is home to nearly 72,000 refugees crowded within an area of 1,190 square kilometers. The camp infrastructure for basic services is severely underdeveloped, and more than 55% of the families residing in Khan Younis are classified by UNRWA as special hardship cases .according to (UNRWA infrastructure and camp improvement program, 2012) the school is part of a broader reconstruction and program implemented by UNRWA in one of Khan Younis neighborhoods. The Master Plan includes the construction of 1098 dwelling units, five schools, one health center, and other public facilities, along with the construction of the infrastructure for essential services (roads, sewer and water lines, storm water system and electricity network) Figure (4.2) shows map of school location.

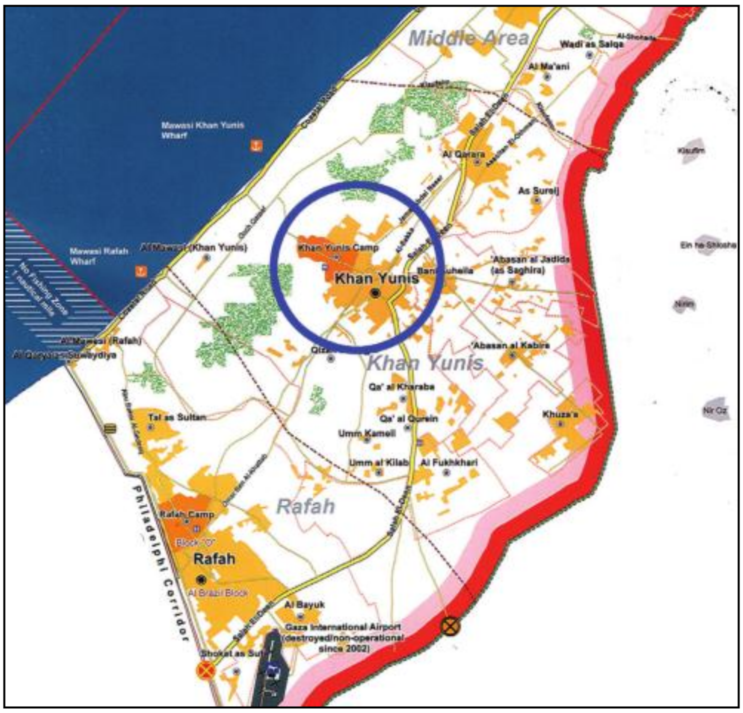


Figure 4.2 Location of Kuwait city school

4.2.2 Description of school component

School building complies with the functional requirements prescribed for standard UNRWA schools. The building consists of 32 classrooms distributed on three floors for a total capacity of 2050 children divided into two shifts (with an average of 32 children per classroom). The built up area (main building) 4263 m2 other information of project (as per table 4.1).

Table 4.1 Data of Kuwait school at khanyounis project

Project name	Construction of Kuwait school at khanyounis
client	unrwa
Source of fund	Islamic Development Bank - Kuwait Fund for Development.
location	khanyounis
supervisor	Un - supervision
contractor	A.l Company
project duration	308 day
Located budget /$	2,500000 $

4.3 Construction school objective

The "Kuwait City School In khanyounis city is a project which intends to address three main objective:

- Provide students in khanyounis with a more conducive learning environment resulting from architectural solutions that guarantee better ventilation, Insulation and visual comfort.
- Ensure equitable and sustainable access to electricity and clean water through green technologies, rain harvesting and water recycling systems.
- Encourage the adoption in Gaza of more sustainable building practices through processes of knowledge transfer benefiting UNRWA engineers and Gazan construction sector.

4.4 Why this project?

According to Amnesty International, the home water consumption per individual in Palestine is approximately 70 liters/day, below the minimum value of 100 l / day recommended by the WHO (World Health Organization). The Palestinian Water Authority

(PWA) expects demand for fresh water to grow to 260 million m^3 per year by 2020, an increase of some 60%.

The share of aquifer water that is safe for drinking is currently estimated at 10%. The aquifer could become unusable as early as 2016, with irreversible damage by 2020. Also 90,000 m3 per day or 33 million m3 per year of untreated or partially treated waste water that is dumped. The School introduces In Gaza low- tech/high performance building solutions and green technologies that, if integrated, can work as incentive for a human-centered transformation of Gaza Strip's urban environment and for the regeneration of its natural ecosystems.

Although no specific data are available on energy consumption in Palestine, in developed countries about one third of the energy produced is consumed by the buildings that are responsible for about 30% of CO2 emissions.

The Gaza Electricity Distribution Company (GEDCO) expects electricity demand to increase to 550MW by 2020, more than twice as much as is currently being provided.

Further than the lack of water and energy and the never-ending conflict with the Israelis, is also important to consider the high birth rate (2.18%, it is estimated that population doubles every 32 years), the high population density. By the year 2020 the population of Gaza will increase to around 2.1 million, from an estimated 1.60 million people today. The sustainable population growth rate will put additional pressure to living area, which is restricted and already heavily urbanized .440 additional school are needed to cover existing gapes and the projected increase in the student's population.

All these factors impact heavily on the dynamics of development and the continuing conflict between Israelis and Palestinians makes very uncertain the definition of any future scenario.

In view of the current emergency status, to ensure minimum quality of life and living the following actions should be carried out:

1. Establish a fair and direct use for both drinking water and water resources for agriculture. It is a priority to invest in urban-scale in water infrastructure adequate to the real needs of society. At the same time in the new and existing buildings must be

implemented the techniques of water management and water conservation. Such as rainwater harvesting, treatment and reuse of sewage and grey water for irrigation, toilet's cassette with dual expulsion, etc....

2. Reducing dependence on oil. The absence of fossil resources on Palestinian land, and the need to buy oil from Israel creates a strong economic dependence that slows growth and feeds the conflict between the parties. It is important to invest first in energy efficiency and then on renewable resources, giving priority to low cost and low technology interventions.
3. Using local materials, low-tech systems at low cost
4. Encourage national initiatives aimed to both saving water and energy and exploit renewable sources (rainwater, solar, wind etc .. in the built environment Especially in new construction and building retrofit it is very important to support over costs related to the installation of housing components and/or more efficient plant systems.

4.5 Case Study approach

This case study was conducted based on the case study approach, where a one big project [(2.5) million contract sum] has been chosen as a sample, it is the first project to be implemented by UNRWA at Gaza Strip for such scope of (Green Schools and Sustainability). It is still under construction and not finished yet due to borders closure. The data collection methods for the case studies include participant observation, archival research, and interviews. The archival research adopted in this study involved collecting primary data from UNRWA projects records, contract documents, and completion reports.

Other primary data for this study are obtained from the interview approach. Open ended questions are adopted for the interview. The open ended questions allowed interviewees greater freedom to share their experience and knowledge. The interviewees were free to expand on their answers or discuss other related issues. The interviews involved repeated face-to-face encounters between the researcher and informants directed toward understanding the informants' perspectives, experiences, and situations as expressed in their own words (Frechtling and Sharp, 1997).This interview included six UNRWA engineering which sharing in project design and implementation.

While the respondents' answered and comments were verbally recorded with no need for filling up any question papers or questionnaires, the interviews tended to give a higher participation rate. From each projects category, in-depth interviews were carried out with several participants, the selection of the interviewees based on the nature of the project and the interviewee characteristics (Designation & Experience) (as per Table 4.2). The approximate length of each interview was approximately one hour. six interviews were held, four were face-to-face and two by phone. All interviews were recorded on open ended questions.

Table 4.2: Characteristics of Interviewees

no	Designation	Party	Experience (Years)
1	Construction Engineer (Supervisor, top Management)	UNRWA	20
2	Area Engineer (Supervisor, top Management)	UNRWA	15
3	A Site Engineer (Direct supervisor, civil Engineer)	UNRWA	12
4	Architecture Engineer	UNRWA	10
5	Electrical Engineer	UNRWA	15
6	Mechanical Engineer	UNRWA	18

4.6 Data collection:

4.6.1 Green school Structure elements:

The construction system is composed by four main distinctive elements (as per figure 4.3)

- ***Concrete slab as foundation***: is cast in situ 700mm thick flat reinforced concrete structure with local lowered ducts to receive the horizontal below ground services sewage pipes. An allowance should be made for 1000mm of cement based earth fill below the raft in order to distribute the loads on the earth. This element acts as bioclimatic moderator.

- ***Pillars (external diameters of 2.2 m):*** hollow concrete columns are made with precast concrete rings slid onto the vertical reinforcement and grouted. The columns are filled with non-structural earth fill with an internal concrete lining to allow for the vertical distribution of the building services .this element minimize the thermal mass effect.
- ***Vaulted slabs:*** reinforced concrete slabs at 1st floor and roof level which are generally 350mm thick vaulted slabs and 280mm of solid concrete slab with locally thinner areas so as to facilitate the slab construction the slabs have curved soffits in places so as to

receive the brick soffit finish as requested by architect. This element facilitate the slab construction.

- ***Overhanging roof***: it is composed of steel beams and a reflecting metal sheet. This element provide with natural ventilation
- ***Geometry*:** The building is rectangular on plan and is 70m long and 32m wide, it is generally on a 7.5x8 mm column grid. The building comprises two stories built off ground level with floor to floor height of 345m, the overall weak height is 9.7

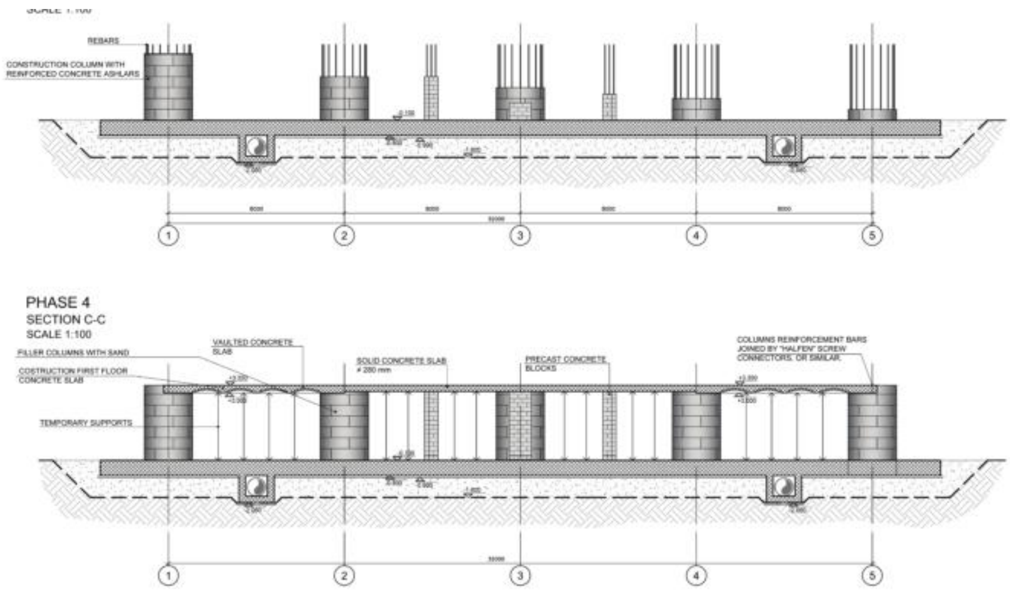


Figure 4.3: structure element of green school

4.6.2 Green school Energy:

- ***School thermal elements*:** To teach thermal comfort and reduce the dependence on oil different type of strategies have to be used from decided by the climate data (as per table 4.3 & figure 4.4)

Table 4.3: school elements which sharing in thermal comfort

No	Element	Strategies	Benefit
1	Concrete pillars	Thermal mass to increase inertia	Minimizes temperature swing of interior
2	Concrete slabs		Minimizes temperature swing of interior
3	Vaulted slabs		Minimizes temperature swing of interior
4	Overhanging roof	Shadowing systems optimization	To avoids overheating of the interiors
5	Shading panel		To avoids overheating of the interiors
6	Green courtyard	Natural ventilation	Reduce the heat effect &natural ventilation
7	Overhanging roof		Reduce the heat effect &natural ventilation

No	Element	Strategies	Benefit
8	Openable windows		natural ventilation
9	Black metal sheet		natural ventilation
10	Air heating	renewable resources	for heating the air in rooms in winter season
11	Amorphous photovoltaic		Provide green energy for electrical device

- ***Daylight* :** By depending in the information for light reflection surface like reflection of roof, walls ; pillars solar chimney light shelf and light transparency of polycarbonate and skylight the daylight comfort for classroom was determine . Attached in appendix II day lighting analysis.

- ***Energy renewable devices*:** The entire area for green school was provided by green energy. Photovoltaic cells, thermal solar panels and vegetable oil generator were installed. An amorphous photovoltaic cells plant (nominal power 25 KWp) was provide energy for all electrical devices (pumps, fans, etc. . .) A thermal solar panels plant will provide energy for winter and middle season heating. A vegetable oil generator will provide energy for back-up generator when a net fail is present or an insufficient generation of renewable energy. However, Figure (4.5) shows the energy consumption for the equipment and tools in green school.

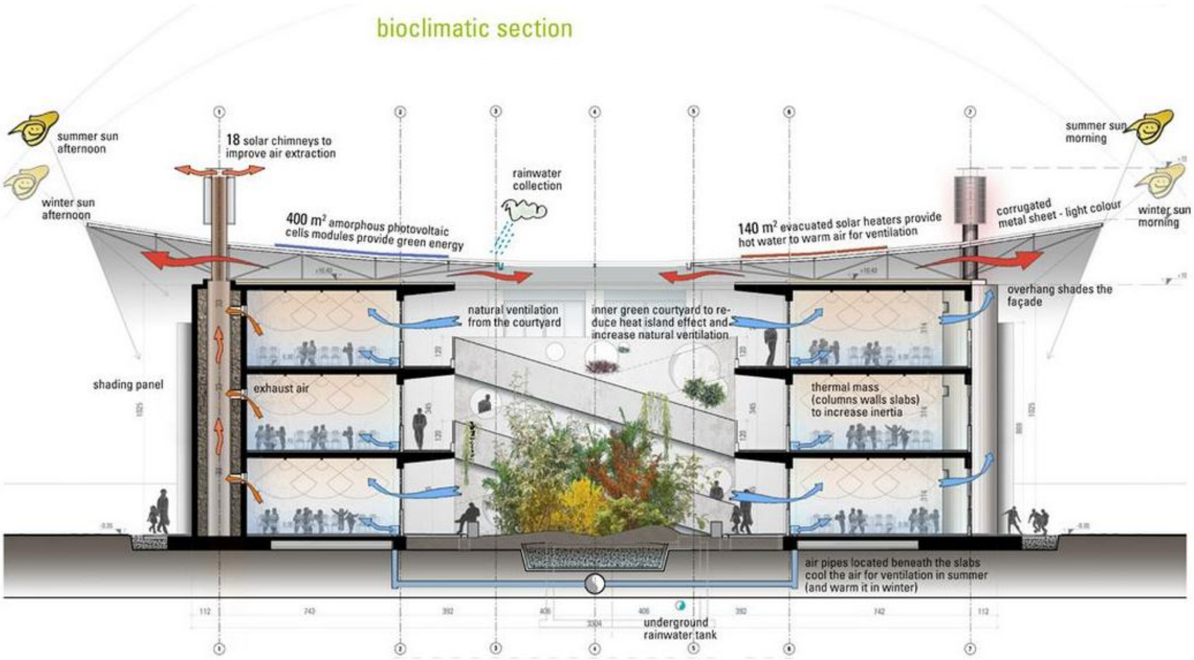


Figure 4.4: *School thermal comfort elements*

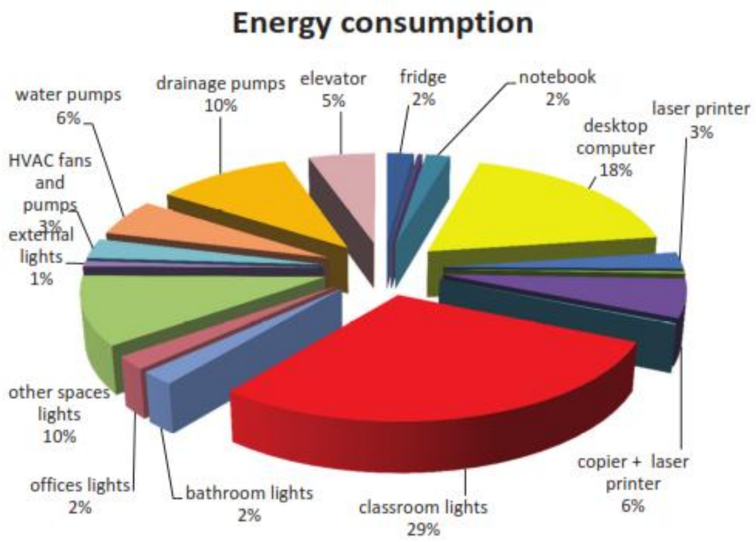


Figure 4.5: The energy consumption for the equipment and tools in green school

4.6.3 Mechanical system element:

- ***Ventilation system:*** *CL*. Chilling VRV station, units .The Technical data are External air flow rate 10m3/hr. x person, A variable fan located in the plant room will guarantee the fresh air ventilation during the winter and middle seasons. The solar panels (100 m2) will provide hot water for the heating coil located in the plant room. Between the hot solar panels and the coil there is a water tank that storages energy during the sunniest hours provide energy when the temperature in the school is below 20 C. The system consists or a simple air handling unit (fan, coil and filters), a big pipe under the ground. Risers inside the columns and air inlets in the rooms. Exhaust air goes outside through the solar chimney and through the windows. In every room there is an overpressure.

- ***Automation of mechanical plants (A T*):** This system controls technical building system. In particular it manages: automatic regulation of mechanical systems and commands, signals, alarms.

4.6.4 Electric system elements:

Biodiesel Green electric generator: A Biodiesel Green electric generator provides in case of net failure electric power (50%) for the design area. The storage tanks guarantee full autonomy for 2 days. The apparent power is 15 KVA.

- ***Photovoltaic cells*****:** The photovoltaic field is a 25 KWp plant with an estimated energy annual production of 37 MWh/Y .This plant satisfies the entire energy demand. It's composed by amorphous modules .This field is located in a horizontal position above the technical canopy.
- *Low voltage electric switchboards***:** are of the precast type with metallic sheath. The More significant technical features are: nominal tension 660 V; working tension 400 V and test voltage at 50 Hz 3.500 V. Light and MF terminal shunts: include normal light circuits which fed by area secondary switchboards (normal energy) and Light on and switch off foreseen typologies are: classrooms manual control; public areas manual control; technical areas manual control; staircases manual control; toilets manual control and external lights manual control

- ***Earthling system*****:** earth electrode system it is foreseen a steel zinc-coated plate in accordance with international standards. Conductor is connected on some points, to structure reinforced concrete, Used as natural earth electrode in accordance with international standers.

4.6.5 Green school water system:

- ***Rainwater collection*****:** To reduce water consumption, 12 rainwater pipes X 200 inside 6 central columns collect the water coming from the roof and they send it to the underground rainwater tanks placed in the courtyard. The rainwater is then used for cleaning and personal hygiene activities.
- ***Grey water treatment*****:** The grey water coming from hand basins is first treated in the external wetland and then used for WC flushing.
- ***Black water treatment*****:** The black water coming from WC flushing is first treated in the external wetland and then used for the green areas through a drip irrigation system.

4.6.6 Main materials and elements used in green school:

- ***Compressed stabilized earth block technology (CSEB)*****:** this type of block used in internal walls instead of hollow block cement for main building also in circular column's. among of advantage this type of block : local materials is made on site itself ,easy in use where allow to unskilled and unemployed people to learn a skills, flexible production scale, cost efficiency , efficient in saving energy , eco – friendly and sustainable . The main disadvantages are low teaching performance compared to concrete; low social acceptance and in wide spans, high & long buildings are difficult to do.

- ***Vaulted structures (arch slabs)*****:** this type of roof used in slab of green school. The main objective of these slabs to optimize the structures by increasing the span of roof, decreasing its thickness, and creating new shapes.
- ***Polycarbonate windows*****:** used instead of glasses in windows. Among of its advantage make good lighting, resistance to radiations and against breakage.
- **Mashrabiya panel**: some traditional Arabic mosaics fixed around circular column's in order to reduce the overheating and glare risk in case of sunny sky in additional to beautiful view.
- ***Handrails*****: is** made as pedestrian entrance, it is fixed for staircase to protection.

4.7 Discussion and analysis:

The case study submitted the answers of six question in this research to study the strategies of achieving sustainability practices in green school building at UNRWA construction projects in Gaza Strip. The recorded interviewee's responses on the open – ended question are summarized in below for further analyses and discussion purpose. Wherever, the analysis of the answers of these question will investigate the sustainability requirement according to LEED (Leadership in energy and environmental design requirements in assessment of sustainability achieved or not.

Question 1: Does your school projects have achieve sustainable solution through building structure element and building location? If the answer was yes? Define these elements with the main practical strategies works of this structure and its benefit?

For the first question of green school structure and figure (4.2): The research shows that the structure of the Green Gaza School project is a robust and versatile structure which can be used as a typical school structure sites of varying locations and conditions. It is designed for the earthquake loadings with a value of 0.2 PGA although Gaza value is 0.075 according to UNRWA studies due to use vaulted roof which built with compressed stabilized earth block. The building's structure also gives a significant degree of the building use flexibility as well as flexibility of the distribution of the services and stability provided by the vertically cantilevering large column circular sections tied by the floors acting as stiff diaphragms at ground, 1st floors and the roof level.

The Thermal mass in the building is to increase inertia and minimize temperature swing of Interiors created by the following structural elements: concrete slabs. concrete pillars with an external diameter of 2.2 m and an inner cavity filled with excavation ground, earth-brick walls used as partitions between classrooms and as external opaque facades, where Concrete slab as foundation: its thermal mass and the air pipes located beneath the slab act as bioclimatic moderators; Pillars are made of concrete- earth blocks precast on site. The inner cavity is then filled with excavation ground in order to reduce the excavation cost and maximize the thermal mass effect; Vaulted slabs: compressed earth block floor made of jack arches acts like lost formwork.

This kind of roofing optimize the structure by increasing the span of the roof, decreasing its thickness, and creating new shapes. The floor is finished by filling it with stabilized earth concrete or light concrete and overhanging roof it is composed of steel beams and a reflecting metal sheet. Its design enables natural ventilation through the cavity between the vaulted ceiling and the metal layer. The sustainable solution achieved in using affordable and local available materials like earth blocks and Eaton block in slabs as well as simple construction system, minimizing the need for advanced and expensive technologies. These elements combine to achieve a cheap and viable construction that can be built by the refugee people themselves. Minimizing of temperature swing and avoids overheating of interior are others sustainable solutions were achieved through concrete structure elements of green school.

This school is one of the distinguished samples of green buildings that achieved sustainability in architectural design for its buildings and in the environmental design for its special location in an unprecedented way. It affected the environmental, economic and social aspects. The school applied sustainability in its architectural design based on different strategies. The analysis for green structure component and location is achieved the LEED (Leadership in energy and environmental design requirements in assessment of achieving sustainability from this perspective).

Question 2: Does green school project used the solar energy to mitigate the need to electricity, if the answer was yes? Please describe the practical strategies works of this system and its benefit?

For the second question and the data collection of the energy system in green school in figure(3&4) and table (6) show that :we can benefit from the energy in green school through renewable energy like using solar heater and photovoltaic cells .Reduce energy consumption, improve lighting and HVAC energy efficiency, use renewable energy and obtain the energy independence from local providers are the main project goals , 457 m2 of amorphous photovoltaic cells integrated in metal roof which provide green energy for all electrical devices and lighting system of school this is the sustainable solutions for lack of electricity . 101 m2 of evacuated solar heaters integrated with the metal roof provide hot water for heating coil located in the technical rooms this is another sustainable solution in winter .the air pipe located beneath the slab channel the hot air (or the cold air in summer) into the classrooms .

School thermal elements in green school and daylight were studied. However, the analysis for solar energy system, thermal comfort elements and daylight is achieved the LEED (Leadership in energy and environmental design) criteria in assessment of achieving sustainability from this perspective. This results matching to Tam and Zeng (2013) result's which state that improving natural daylight to the building is considered as the major indicator to improve sustainable performance.

Question 3: Does your green school project have contain sustainable solution to mitigate ventilation problem. If the answer was yes? Please describe the practical strategies works of this system and its benefit?

For the third question and data collection of ventilation system as showing in table (6) and photos attached in appendix (II) of green school : The benefit of The ventilation system, in summer classrooms' temperature is cooled down through thermal mass which increase inertia and minimize temperature swing of interiors created by structural elements and natural ventilation by the inner green courtyard , the operable windows and solar chimneys will increase this ventilation and extraction of exhaust air. Also the roof overhangs and vertical panel placed by the classroom windows play big role in the ventilation at summer season. In winter classrooms are heated by solar powered air conditioning, this system achieved sustainable solution for the ventilation of classrooms school through the session of year which not used in traditional school. This agree with the achieved the LEED (Leadership in energy and environmental design) criteria in assessment of achieving sustainability for building.

Question 4: does your green school project have contain sustainable solution to mitigate electricity problem. If the answer was yes? Please describe the practical strategies works of this system and its benefit?

For the fourth question and the data collection of the electrical system in green school, the study shows that the Electric system is subdivided to more circuits in order to make it easier and limit possible inconveniences caused by failure or maintenance interventions. Also, the earthling arrangement completion must be done together with civil works. Electricity is supplied 24- 7 through photovoltaic panels placed on the school roof. The sustainable solution achieved through reduces both of the dependence in oil and CO2 emissions by using biodiesel green electrical generator instead of Diesel generator which is used in traditional school in case of failure solar system. Other type of electrical lights was installed in green school called LED, which works with high efficiency and its consumption of energy is lesser than traditional electrical lights. Fixing of external sensitive electrical reflector which works with thermal, it's the most sustainable solution for saving energy during night. These analysis and results agree with the achieved the LEED (Leadership in energy and environmental design) criteria in assessment of achieving sustainability for building from this side.

Question 5: Does your green school project have contain sustainable solution to mitigate water shortage problem. If the answer was yes? Please describe the practical strategies works of this system and its benefit?

For the question five and the data collection of the rain harvesting system in green school, the study show that green school overcome the shortage in water in Gaza strip, this system enable to reduce every year 58% of the water demand from municipal network and to save 10.011 S/year according to UNRWA studies. Parts of the water are used in cleaning while other parts are used in irrigation. by comparing this school with the traditional school , this system not used in traditional school , so these school still suffering from losses of water . 18% saved by this system on personal hygiene and cleaning demand; 71% saved on wc flushing demand and 97 %saved on irrigation demand. These analysis and results agree with the achieved the LEED (Leadership in energy and environmental design) criteria in assessment of achieving sustainability for building from this side.

Question 6: Does your green school project have contain sustainable solution through using sustainable materials. If the answer was yes? Please define these elements and the technology used also the advantage of these material.

For the question six and the data collection for materials used in this project, this study show that: appropriate building technology based on soil was discuses. the aim of this part in this study to make extensive use of raw earth as the main building materials in addition to other important element were used in green school like vaulted structure ; polycarbonate mashrabiya and handrails. The idea is to use resource which can help developing technologies that are saving energy and, are eco – friendly and sustainable. In this study we tries to minimize the use of steel and cement. among of these technologies were :stabilized rammed earth foundation ;stabilized rammed earth walls ; composite beams ; stabilized earth mortars and plasters ; wide verity of composed stabilized earth blocks ,various vaults with compressed stabilized earth blocks , alternative stabilizers to cement and alternative waterproofing with stabilized earth (mixes of soil , sand , cement , lime , alum and juice of local seed) . However, use of material with low embodied energy when manufactured and reparability of positions are not considered to be significant indicators according to (Tam and Zeng, 2013). These analysis and results agree with the achieved the LEED (Leadership in energy and environmental design) criteria in assessment of achieving sustainability for building from this side.

4.8 Results and finding:

It can be concluded from the collected and analyzed data Gaza Strip suffers from many problems. One of the most important problems is population density and limited sources and not applying the conceptions of sustainability in a way that achieves balance. But, in this project a school environment-friendly was created, matching to LEED (Leadership in energy and environmental design) criteria in assessment of achieving sustainability for building from several side, where this project include sustainable solutions were achieved through the following:

- Reduced heating and cooling demands covered by energy produced on site with renewable.
- Reduced water demand for cleaning, WC, irrigation and personal hygiene through applying to rain harvesting system.
- Using raw earth materials as building material in construction green school.

- Reduce of CO_2 emissions.
- In summer classrooms' temperature is cooled down through thermal mass and natural ventilation while In winter classrooms are heated by solar powered air conditioning
- Better learning environment (classrooms with lower temperatures in summer and warmer in winter).

Chapter 5: Simulation Models

5.1 Linear Programming for optimizing efficient allocation of budget for household energy conservation in Palestinian houses

Introduction

Linear programming method was used to optimize the allocation of budget in order to maximize the energy savings of a hypothetical household in Palestine. The energy conservation methods involved in this study were installing photovoltaic solar cells, replacing regular windows with double-glazed ones, replacing incandescent bulbs with compact fluorescent light bulbs ,replacing traditional block with double wall from CEB blocks, . The costs of these different energy conservation methods were obtained from the manufacturers' or distributors' websites. The annual energy savings of these methods were either obtained from available sources or calculated when necessary. The results showed that installing double-glazed windows, installing double wall, installing solar water heating and purchasing compact fluorescent light bulbs are the proper choices for low budgets. When budget increased, solar panel installation emerged as the feasible choice. Payback periods were found to be less than one and a half years, even at the highest budget. A budget decision of $ 31500 was found to be the optimum decision for short term investments, whereas a budget decision of $ 70, 000 was found to be the optimum decision for long term investments.

5.1.2 Data collection

Efficient use of energy is a very important concept, not only because it favors a more stable economy, but it also helps prevent environmental pollution, and the combination of these two facts is essential for sustainable development. Buildings are responsible for the consumption of approximately 40% of all commercial energy supplied as processed fuels or electricity in developed countries (Laustsen, 2008 and Lombard et al, 2008). For thousands of years, mankind has tried to improve the energy efficiency of buildings via simple methods such as choosing the ideal geographic location or by using appropriate building and insulating materials depending on the climate.

As the technology developed, the measures to minimize energy loss have become more complex. However, it was the 1973 global energy crisis that triggered a worldwide pursuit in designing buildings with less energy consumption, by incorporating energy efficiency and renewable energy resources (Hunn, 1996). Since then, many countries adopted laws and regulations on how to use energy more efficiently and energy efficiency in residential and commercial buildings have become a common area of interest (Dixon, 2010 , Hamza,2009 , Lee,2004 , Ekins,2008 and Wiel,2006)

Gaza Strip depends on three main sources of electricity suppliers including Israel Electricity Company, Egyptian Electricity Company, and the local Gaza Power Plant. It also imports the fossil fuels by two ways either directly from Israel or indirectly from Egypt.

It's clear that electricity needs increased by about 10-15 MW annually, as a result of the natural population growth and the expansion in the different sectors requiring electricity supply (Muhaisen,2007) Unfortunately, the main problem of energy in the Gaza Strip is that it has almost no conventional energy sources.

This problem becomes worse by the high density pollution of the Gaza Strip and the difficult political status caused by the Israeli occupation. According to Kandeel (Kandeel, 2010), Gaza Strip needs (360) MW of electricity while the available supply is (197) MW. The large share of this supply about (60%) with an average load of 120 MW is provided by the Israeli Electricity Company. Locally, about (32%) with an average load of 60 MW is provided by Gaza Power Plant.

In addition, about (8%) with an average load of 21 MW is provided by Egyptian Electric Company. In the light of previous statistics, the Gaza Strip has been suffering from a real shortage in electricity supply estimated between 30% to 50%. This led to scheduled cuts of electricity supply for several hours per day which has negative effects on all aspects of the Palestinians life and make it very hard to go about normal life. This shortage rate of electricity supply will increase by the time if other options are not found. Considerable options to solve this problem available in the Gaza Strip are renewable energy sources such as solar and wind energy and energy saving measures.

In order to achieve this goal, home-owners or tenants must take suitable actions to reduce their energy consumption without having to compensate from their quality of living. Therefore, the solution must satisfy energy-related, environmental and financial aspects of the problem. When the great number of possible actions that can reduce the energy consumption of a building is concerned, using a sophisticated method to determine the optimum choice(s) is inevitable. Before proceeding with linear programming, which is our choice of method, we would like to briefly review similar studies in the field.

5.1.3 Justification of the method

In this study, linear programming method was used to optimize the allocation of budget in order to maximize the energy and water savings of a hypothetical household in Palestine. Linear programming is a mathematical method for determining a way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model for a list of requirements represented as linear relationships (Ravindran,1987) A linear programming model simply contains an objective function (to be maximized or minimized) and a constraint function. Linear programming method is a very convenient tool that it is used extensively to solve and optimize various types of economical and industrial problems. Model details will be presented, accepts energy savings (W) as the objective function and the budget as the constraint function. There are various actions that result in energy savings in a house, each with a specified unit cost. The aim of the algorithm is to allocate the budget to these actions in order to obtain the maximum energy savings. Different budget values were used as constraint to get energy saving values as a function of budget.

While developing the method, our main idea was to analyze the issue of building energy efficiency from the household consumer's point of view. Our algorithm was designed to answer the question of **"how much energy would be saved if certain amount of money was spent".** After obtaining the maximum possible energy savings values for each different budget, we calculated payback periods and profitability values to convert the output into a more understandable form for the consumer.

A further strength of this study is the realization of a detailed market research in order to get approximate cost values for each particular energy-saving measure. The readers can simply check the references listed at the end to get the actual cost values for any given item or method.

We can added another model with the same previous methods but for saving water through considering the harvesting system which consist of rainwater collection, gray water treatment and black water treatment. Those system enable to reduce every year 60 % of water demand and to save 20 $/year. But because the time not enough for this course project, so we will focus on this study in energy saving were the water saving system very complex system needed to large area in injection and treatment also others expensive materials and tools will use in establishing in the construction building.

5.1.4 Energy conservation methods in buildings

The materials and techniques employed in order to improve the energy efficiency in buildings vary greatly. Jaber and Ajib, (2011) listed the main steps to achieve energy conservation in residential buildings as follows:

- Passive design by considering climate effects so as to decrease heating, cooling, dehumidification, lighting, equipment and hot water loads.
- Improving the efficiency of the mechanical and electrical equipment used in the building.
- Replacing fossil fuels with renewable sources for the supply of primary energy.

Heating and cooling systems make up for a significant portion of the total expenditure of households. Heating systems like boilers, heat pumps and cooling systems like air conditioners are expensive to install and operate; consequently the entire energy requirement of a building cannot solely be met by using such equipment as far as energy efficiency is concerned. Therefore, using insulation materials to minimize heat loss (or gain) is essential to achieve meaningful energy conservation. Windows lose energy more readily than walls or a floor, therefore using insulation materials in windows is the most straightforward approach to minimize heat loss.

The most common technique applied for insulating windows is double glazing, in which double or triple glass window panes separated by an air-(or other gas)-filled space are used to reduce heat transfer across a part of the building envelope. Double glazing is not only an effective method to reduce heat losses but it also promotes acoustic insulation. Thermal conductivity, k (W/m ◦C) and cost are two important properties of insulation materials as far as performance is concerned (Ozkan et al, 2011)

Solar energy is the most abundant, inexhaustible and clean of all the renewable energy resources. Solar energy can be used in buildings by installing thermal solar collectors on the roof and then using the absorbed energy to heat utility water (Parida, 2010). Solar energy can also be directly converted into electricity via photovoltaic cells. Photovoltaic cells are designed to transfer the energy contained in individual photons penetrating the panel to electrons that are channeled into an external circuit for powering an electrical load (Vanek, 2008) Photovoltaic cells can be connected in series to form a module and then placed on the roofs, or where available, to provide electricity to households. Unlike thermal solar collectors, photovoltaic cells do not require a continuous and abundant reception of sunlight; therefore they can be employed more generally as far as location is concerned. In addition to being used to provide power for buildings, they are also used for water pumping, communications, satellites and space vehicles, reverse osmosis plants, and for even large power plants (Parida, 2010). One disadvantage of photovoltaic cells is their high initial cost, and this slows down the penetration of photovoltaic technology into building sector.

Ever since electricity was first used as the primary source to provide lighting around at the end of the 19th century, incandescent bulbs have always been the most common type of bulb in the market. However, approximately 90% of the power consumed by an incandescent light bulb is emitted as heat, rather than as visible light. Thus, in the recent years consciousness has risen on the low efficiency of incandescent light bulbs in international scale. For instance, the European Commission gradually prohibits the usage of incandescent light bulbs via decree. Starting September 1, 2009, Regulation 244/2009 introduced a gradual phase-out for almost all kinds of incandescent bulbs until September 2012. As of September 2012, only energy-efficient lighting sources will be allowed for sale. Among these are halogen light bulbs, light-emitting diodes (LED), or compact fluorescent light bulbs (CFL) – often referred to as energy- saving light bulbs (Frondel, CFL bulbs consume 25% of the electricity incandescent bulbs consume in order to provide the same level of illumination, and their approximate lifespan is 6 times of that of incandescent light bulbs. Nonetheless, CFL bulbs are significantly more expensive than incandescent light bulbs, with an approximate price ratio of 7:1.A considerable portion of residential electricity consumption belongs to major household appliances.

Before proceeding to the next section, we would like to emphasize that while there are many other possible methods that can be applied to improve energy efficiency in households, the ones mentioned above were particularly chosen as they are available to the common user, regardless of his/her socioeconomic status or the location of the building the user resides in.

5.1.5 Why This Model?

This model aimed at employing linear programming technique for optimizing the allocation of budget to be spent on improving energy conservation in a domestic household in Palestine. All the data regarding the costs of each method was obtained from local sources, with the cost units being Israel Shekil (NIS). The costs were then converted to dollar ($) that is why cost values shown in the tables or mentioned in the text are not all rounded figures. As of Jan 1st 2014, 1 NIS is equivalent to 0.28 U.S. Dollar. While the general accommodation trend in Gaza Strip - Palestine is living in multi-story apartment buildings, we preferred to select our hypothetical building as a Five-floor detached house. This choice was made mainly for the sake of convenience, as heat loss calculations would have been much more difficult in the case of an apartment, since the environment would be non-uniform in terms of temperature. Furthermore, it would also be difficult to calculate energy savings per household when more than one household would benefit from that particular investment.

In terms of the dimensions of the building, total roof area, window area, wall area, heating solar system and drinking water must be known. These values would be the physical constraints for the maximum number of solar cells, maximum area of double-glazed windows, and maximum area of double wall respectively. Persson et al. claimed that total window area of a one-floor house is nearly 8% of the total floor area (Persson, 2006). For a realistic approximation of 200 m2 total floor area, the total window area can then be approximated as 16 m2.

Thus, for an estimated basal area of 125 m2 (10 m× 12.5 m), total roof area can be calculated approximately as 208 m2, by taking into account the fact that the width of the roof needs to be slightly greater than the base width, approximately by 1 m. However, due to reasons related to the strength and durability of the construction, it would be hazardous to cover the entire roof with solar panels. A realistic approach would be to allocate a maximum area of 40% of the total roof area for solar panel installation. Therefore the area available for solar panel installation was found as 88 m2. If the house is assumed to have one guest room one living room, three bedrooms, three bathrooms and one kitchen, a total of ten 100-W incandescent light bulbs would be enough to provide sufficient lighting in the initial stage. Table 1 below contains the physical characteristics and layout details of the house that would be included in the linear model as constraints.

5.1.7 Costs and energy savings

In this study, the following methods were chosen to improve the energy conservation in a household:

Table 5.1 Physical characteristics and layout details of the house.

House characteristic	Value		Area (m2)	Total No. of rooms	Lighting req. 100 W incand. bulbs	Wall Area	Total window area, m2	Area of solar Heating system M2
Total basal area, m2	340 m (17m*20m)							
Building Area ground,m2	F=3m, B=2m, S1=2, S2=2 195 m (15*13)							
Area for typical floor,m2	208 m (16*13)							
Roof Area,m2	0.60 * 208 = 125m							
Services Area,m2			20	1	15	46.5	10	
Floor No.	Ground Floor (F)	E + L+ +WC+ MB+1bath +Balc+ K+G	175	7	9	200	16	4
	First Floor (F1)	E + L+ +WC+ MB+2 B+ 2bath +Balc+ K+G	188	8	10	153	16	4
	Second Floor (F2)	E + L+ +WC+ MB+2 B+ 2bath +Balc+ K+G	188	8	10	153	16	4
	Third Floor (F3)	E + L+ +WC+ MB+2 B+ 2bath +Balc+ K+G	188	8	10	153	16	4
	Fourth Floor (F4)	E + L+ +WC+ MB+2 B+ 2bath +Balc+ K+G	188	8	10	153	16	4
	Fifth Floor (F5)	E + L+ +WC+ MB+2 B+ 2bath +Balc+ K+G	188	8	10	153	16	4
	Roof (F6)	E + L+ +WC+ MB+2 B+ 2bath +Balc+ K+G	125	8	10	115	16	4
Total roof area available for solar panel installation, m2			84					
Total roof area available for solar water heating,m2			24					
Total roof area available for treatment water			8					
Total roof area available for drinking water			4					
Total							122	28

E: Entrance, L: Living room, MB: Master Bedroom, B: Bedroom, Balc: Balcony, K: Kitchen, G: Guest room

- **Solar System**

Table 5.2. Capacities, areas and average prices of photovoltaic solar modules.a

Capacity(w)	Area(m2)	Price ($)	Performance (W/$)
50	0.43	258	0.175
65	0.53	323	0.201
120	0.91	470	0.255
140	1.03	590	0.237
180	1.32	643	0.280
200	1.45	776	0.257

Table 5. 3. Capacities, areas and average prices of photovoltaic solar modules in Gaza strip

Capacity(w)	Area(m2)	Solar Panel No.	Inventor Capacity VA	Battery		Devices can be turned on							Hours		Price ($)	Performance (W/$)
				No	Capacity	RFG	TV	Lamp	Water Pump	Iron	Washing machine	Fan	Day light	night		
290	4	2	1000	1	12V,200AH	0	1	3	0	0	0	1	8	5	1250	0.232
500	4	2	3000	2	12V,200AH	0	1	5	0	0	0	1	10	5	1800	0.278
1000	8	4	3000	2	12V,200AH	1	1	2	0	0	0	1	14	7	2800	0.357
1500	12	6	5000	4	12V,200AH	1	2	5	1	1	0	1	14	7	4800	0.3125
2000	16	8	5000	4	12V,200AH	1	2	6	1	1	1	1	14	8	5500	0.363
2500	20	10	5000	8	12V,200AH	1	2	6	1	1	1	1	14	8	8200	

5.1.7.1Objective Function

- Installing photovoltaic cells on the roof where the area occupied is a variable
- Installing double-glazed windows where the window area is a variable.
- Replacing incandescent bulbs with compact fluorescent bulbs where the number of bulbs is a variable.
- Installing double wall where the wall area is a variable.
- Replacing water heating system by electrical with water heating by solar system.

- **Solar Panels**

The prices, areas and power outputs (capacities) of solar panels were obtained from three different international distributors' websites .The brands were Evergreen TM, BPTM, Kyocera TM, Sanyo TM, Sharp TM, Kaneka TM, Bright Watts TM, and Mitsubishi TM. The price values of different products with same capacities (in Watts) were gathered and their averages were taken to calculate the final price. The values are tabulated below in Table 2. Prices of double-glazed window units were also obtained from local manufacturers'. In double-glazing technology, the thickness of the glass and the layer of air (or other gas) can vary, and in this study we decided to select the air layer thickness as 12 mm and the glass thickness on either side as 4 mm. Then, the average purchase and installation cost for 1 m2 of double-glazed window was found to be approximately \$57 (≈200 NIS). The energy saving calculations was performed by taking into account both conductive and convective heat transfer mechanism while neglecting any possible contribution of radiation. The calculations are given below:

$$Q = \frac{T}{1/A(\frac{1}{h} + \frac{dglass}{kglass} + \frac{dair}{kair} + \frac{dglass}{kglass} + \frac{1}{h})}$$

Where
Q, heat transfer rate through the window unit, W.
T, average temperature difference between inside and outside during winter, ◦C.
A, surface area of double-glazed window to be installed, m2.
H, heat transfer coefficient of air, W/ (m2 ◦C).
D glass, thickness of glass layer, m.
K glass, thermal conductivity of glass layer, W/ (m ◦C).
D air, thickness of air layer, m.
K air, thermal conductivity of air layer, W/ (m ◦C).

- **Double- glazed window unit**

In the equation above, Q defines the heat flux through a double- glazed window unit. However, we are interested in calculating the savings when compared to regular windows. Hence, we also need to calculate the heat flux value without the presence of any air (d air = 0) and then the difference between those two values would give us the saving in terms of flux.

The average winter temperature of Gaza region was obtained from the website of weather online as approximately 7 ◦C. If the ideal living temperature inside a house is taken as approximately 22 ◦C (72 ◦F), then T value can be found as 15 ◦C. Surface area of total window installation is a variable in this study. As stated above, the glass thickness is 4 mm (0.004 m) and air thickness is 12 mm (0.012 m). Thermal conductivity and heat transfer coefficient values were gathered from available literature (Incropera, 2002). Table 3 below summarizes the calculation parameters, energy saving in terms of heat flux rate and cost of double-glazed window purchase and installation.

Table 5.4 Energy saving calculation parameters for double-glazed windows.

T (◦C)	h W/(m2◦C)	dglass (m)	kglass W/(m◦C)	dair (m)	kair W/(m◦C)	Qreg (W/m2)	Qdg (W/m2)	Qsave (W/m2)	Cdg ($/m2)
15	50	0.004	0.96	0.012	0.026	310.3	29.4	280.9	30

Q reg is the heat transfer flux through regular windows, Q dg is the heat transfer flux through double-glazed windows, Q save is the energy saving as a result of installing double-glazed windows (Qsave = Q reg – Q dg) Cdg is the cost of double-glazed window purchase and installation per square meter.

- **CFL Light**

The prices and power consumptions of CFL light bulbs were obtained from a distributor company’s website. The brands whose products were investigated were OSRAMTM, Philips TM, Greengo TM, and Wellmax TM. While choosing the CFL bulbs that would replace the existing incandescent bulbs, the criterion was to achieve the same level of lighting as in the case of a 100-W incandescent bulb. The average power consumption of a CFL bulb that would provide the same level of lighting as that of a 100-W incandescent light bulb (≈1400 lumens) was found as 19.5 W. Hence the energy gain by replacing incandescent bulbs with CFL bulbs was found as 80.5 W per bulb. The average cost of a single CFL bulb was found as $ 3.3 (≈11.6 NIS).

- **Solar water heaters**

Solar thermal energy there are many applications for the direct use of solar thermal energy, such as space heating and cooling, water heating, crop drying and solar cooking. It is a technology which is well-understood and widely-used in many countries throughout the world. Most solar thermal technologies have been in existence in one form or another for centuries and have a well-established manufacturing base in most sun-rich, developed countries.

The most common use for solar thermal technology is for domestic water heating.

- Solar water heaters (SWH) are used globally, especially in places where there is high solar insulation - for example, in Palestine. (Average energy from the sun is 5.4 KWh/m2-day).
- More than 90% of installed SWH in the West Bank and Gaza are manufactured locally by Palestinians.
- The flat plate collector efficiency ranges between 30 and 45%, depending on manufacturer and production materials.
- The average price of locally-produced SWH units consisting of two flat plate collectors (90 cm 190 cm each) and a 200 liter insulated tank range between $ 400 and $500 depending on the quality and manufacturer.

5.1.7.3 Linear programming model

In this study, Lindo 6.0 software was used to obtain the results. The linear model, which was created by using the costs and savings data and considering the physical constraints, all of which were presented in the previous sections, is given below. x, yi, z, r, h, d, t are the decision variables of the model.

- **Objective Function**

Objective function for maximization energy savings

Max Z = F0 [(Qx * X) + ($\sum_{i=1}^{n} QYi * Yi$) + (Qz0*z) + (Qr*r) + (Qh*h)]

+ F1 [(Qx0 * X) + ($\sum_{i=1}^{n} QY * Y$) + (Qz*z) + (Qr*r) + (Qh*h)]

+ F2 [(Qx0 * X) + ($\sum_{i=1}^{n} QYi * Yi$) + (Qz*z) + (Qr0*r) + (Qh*h)]

+ F3 [(Qx0 * X) + ($\sum_{i=1}^{n} QYi * Yi$) + (Qz*z) + (Qr0*r) + (Qh*h)]

+F4 [(Qx0 * X) + ($\sum_{i=1}^{n} QYi * Yi$) + (Qz*z) + (Qr0*r) + (Qh*h)]

+F5 [(Qx0 * X) + ($\sum_{i=1}^{n} QYi * Yi$) + (Qz*z) + (Qr0*r) + (Qh*h)]

+F6 [(Qx0 * X) + ($\sum_{i=1}^{n} QYi * Yi$) + (Qz0*z) + (Qr0*r) + (Qh*h)]

Subject to

1) F1+F2+F3+F4+F5+F6= 1………………………….………… To identify floor no.
   When select number of floors otherwise = 0
2) (Cxi *x) + $\sum_{i=1}^{n} Yi * Yi$) + (Cz*z)+(Cr*r)+(Ch*h) ≤ W ………….….Available budget
3) X ≤ K …………………………………………….…………..total available area.
4) $\sum(Yi * ai)$) ≤ q ………………………………………Total available roof area
5) z ≤ v ……………………………….…………..Maximum number of CFL light bulbs
6) r ≤ b ………………………………………..…………….…..total wall area.
7) H =0 or 1 ……………………………………………......... solar heating system.

- X, Yi, Z, r, h ,d ,t are non – negative
- X ≥ 0, Yi ≥ 0, Z ≥ 0, h ≥ 0, d ≥ 0, t ≥ 0, Yi is integer .
- d, t are binary variables and I = 1,2,3,…. N

Where

- Xi, double – glazed window area.
- Yi, the number of ith type of photovoltaic solar panel to be purchased.
- Z, number of incalescent light bulbs to be replaced with CFL bulbs.
- R, double – wall area.
- H, Solsar heating system.
- Qx, energy saving rate by installing 1 m2 of double glazed window.
- Qi, electricity production rate of solar panel type I, w.
- Qz , energy consumption rate difference between incandescent and CFL light bulbs , w
- Qr , energy saving rate by installing 1 m2 of cement blocks wall 20 cm .
- Q h energy saving rate by installing water heating system with solar energy.
- Cx , average purchase and installation cost of 1 m2 double glazed window , $
- Cyi , average purchase and installation cost of solar panel type i , $
- Cz, average cost of one CFL light bulb , $
- Cr, average cost of purchase and installation cost of 1 m2 of cement blocks wall 30 cm.
- Ch, average cost of purchase and installation cost of heating solar system.

- K, total window area (physical constraint for double – glazed window installation), m2.
- ai , area of solar panel type i
- q, total available roof area (physical constraint for solar panel installation , m2
- v, maximum number of CFL light bulbs that can be purchase for the house .
- b, total wall area (physical constraint for cement blocks wall 30 cm).

Objective Function

Max 280.9x + 50y1 + 65y2 + 120y3 + 140y4 + 180y5 + 200y6 + 80.5z + 424r + 2160h

Subject to

F0+F1+F2+F3+F4+F5+F6=1

F6=1

(1) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=3500

(2) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z +120r + 500h <=7000

(3) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=10500

(4) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=14000

(5) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=17500

(6) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=21000

(7) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=24500

(8) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=28000

(9) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z +120r + 500h <=31500

(10) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z +120r + 500h <=35000

(11) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=42000

(12) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=49000

(13) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=56000

(14) 30x + 258y1 + 323y2 + 470 y3 + 590y4 + 643y5 + 776y6 + 2.32z +120r + 500h <=63000

(15) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=70000

(16) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=77000

(17) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z + 120r + 500h <=84000

(18) 30x + 258y1 + 323y2 + 470y3 + 590y4 + 643y5 + 776y6 + 2.32z +120r + 500h <=91000

x<=122

0.43y1+0.53y2+0.91y3+1.03y4+1.32y5+1.45y6<=84

z<=84

r<=1126.5

h<=24

X>=0, y1>=0, y2>=0, y3>=0, y4>=0, y5>=0, y6>=0, z>=0

End

Gin y1, Gin y2, Gin y3, Gin y4, Gin y5, Gin y6

5.1.8 Results and discussion

During the allocation analysis, three budget regions for one family were defined:

(i) Low budget: budgets up to $5000 (≈17,500 NIS)

(ii) Medium budget: budgets between $ 5000 and $ 16,000 (≈17,500–52,500 NIS)

(iii) High budget: budgets between $16,000 and $30,000 (≈52,500 –105,000 NIS)

The increment between budget values for the low budget range was selected as $500 (≈1750 NIS) whereas the increment for medium budget range was selected as $2000 (≈7000 NIS) and the increment for high budget range was selected as $2000 (≈7000 NIS). The optimum allocation of the budget amongst available options is given in Tables 5.5–5.77 below:

Table 5.5. Budget optimization and energy savings, low range budgets.

Budget ($)	Double – glazed windows (m2)	Solar panel installation (#)						CFL bulbs (#)	Double – Wall (m2)	Solar heating Water system	Total energy savings (w)
		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6				
3500	0	0	0	0	0	0	0	84	110	0	53474.36
7000	0	0	0	0	0	0	0	84	227	0	102941.0
10500	0	0	0	0	0	0	0	84	343	0	152407.7
14000	60	0	0	0	0	0	0	84	400	0	193263.9
17500	122	0	0	0	0	0	0	84	400	0	217738.7
21000	122	0	0	0	0	0	0	84	400	10	232858.7
24500	122	0	0	0	0	0	0	84	400	17	247978.7
28000	122	0	0	0	0	0	0	84	400	24	247978.7
31500	122	0	0	1	1	4	0	84	400	24	263451.8
35000	122	0	0	0	0	11	0	84	400	24	264451.8

Table 5. 6. Budget optimization and energy savings, medium range budgets.

Budget ($)	Double – glazed windows (m2)	Solar panel installation (#)						CFL bulbs (#)	Double – Wall (m2)	Solar heating Water system	Total energy savings (w)
		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6				
42000	122	0	0	0	0	22	0	84	400	24	266428.0
49000	122	0	0	0	0	32	0	84	400	24	268351.8
56000	122	0	0	0	0	43	0	84	400	24	270331.8
63000	122	0	0	0	0	53	0	84	400	24	272271.8

Table 5. 7. Budget optimization and energy savings, medium range budgets.

Budget ($)	Double – glazed windows (m2)	Solar panel installation (#)						CFL bulbs (#)	Double – Wall (m2)	Solar heating Water system	Total energy savings (w)
		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6				
70000	122	0	0	0	0	46	16	84	400	24	273951.8
77000	122	0	0	0	0	1	57	84	400	24	**274051.8**
84000	122	0	0	0	0	1	57	84	400	24	274051.8
91000	122	0	0	0	0	1	57	84	400	24	274051.8

When the data in Table 5 is analyzed, it can be seen that at low budgets the most feasible methods to improve energy efficiency are purchasing CFL bulbs and having double wall and double-glazed windows installed. Once all the bulbs in the house are replaced and all the windows are renewed, the next logical step appeared to be installing solar panels. Amongst the six different types of solar panels, “type v” emerged as the most preferable one as its performance value (capacity/price – W/$) is the highest. It was interesting to see that renewing the appliances did not appear to be a profitable choice. This result mainly arose from the fact that solar panels offer a significant amount of energy saving, despite their high cost when installed in multiple units. Table 6 reveals similar results to those tabulated in Table 5. Again, renewing the appliances did not seem to be an economical option, and installing most of the excess budget that remained after double-glazing, double wall and lighting improvements on “type 5” solar panels returned the highest energy savings.

It was only at very high budgets (around $70,000) that renewing the appliances started to emerge as reasonable options. As it can be seen in Table 7, the maximum amount of energy saving (19,496.9 W) that can be obtained when the pre-defined physical constraints are concerned was reached in a budget range of $77,000–$91, 000. The combination that yields to the maximum energy saving is as follows:

- 122 m2 of double-glazed window installation.
- 400 m2 of double-glazed window installation
- Purchasing 84 CFL light bulbs.
- Installing 1“type 5” and 57 “type 6” solar panels.
- Installing 24 m2 solar panels for water heating.

This combination cost a total amount of $77,000 (≈269,500 NIS), which is the maximum amount of money that can be spent to improve the energy efficiency our hypothetical house. Fig. 1 below shows the energy savings as a function of budget as well as the budget utilization (actual money spent divided by the given budget). As expected, energy savings increase with respect to budget up to a maximum point. Budget utilization is approximately 100% with a clear exception of $1200 budget, where only 93% of that much budget (≈$1120) would yield the maximum possible energy saving.

Since this particular study aims at developing a consumer focused approach to maximize energy savings as a function of budget, the payback period of the investment and the profitability rather than the energy savings would be more accurate indicators of feasibility. Therefore the payback period for each budget value was calculated by converting the power values to kWh via assuming that energy gain processes involved in this study are continuous throughout the year. Average cost of electricity in Palestine (neglecting the slight variation between day-time and night-time rates) was obtained as \$0.14 (≈0.5NIS) per kilowatt-hour from the work of. Time value of money was neglected. The calculation of the payback period is given in Eq. (5) below.

$$\mathrm{PP} = \frac{1000 * B}{365 * 24 * Es * 0.12}$$

where PP is the payback period (in years); 1000 is the conversion factor from kW to W; B is the budget (\$); 365 and 24 denote the numbers of days in a year and hours in a day, respectively; ES is the energy savings (W); and 0.14 is the cost of electricity in Palestine (\$/kWh).

Such a quick payback proves that investing on energy-efficient buildings would be a sound investment. As part of a developing a customer-focused approach, the final step was to calculate profitability. Profitability was calculated by assuming the same level of financial savings as a result of energy saving measures each year. The maintenance and operation costs of the measures were neglected. The calculation details of profitability can be found in Eq. (6) below:

$$\mathrm{PR} = \frac{n * (ES * 365 * 24 * 0.12)}{1000 - B}$$

where PR is the profitability (in \$); n is the number of years; ES is the energy savings (W); 365 and 24 denote the numbers of days in a year and hours in a day, respectively; 0.15 is the cost of electricity in Palestine (\$/kWh); 1000 is the conversion factor from kW to W; and B is the budget (\$).

The profitability analysis results are given in Table 8 below. The values in Table 8 indicate that instead of a steady trend, there is a maximum profit value for every budget. For short term, investing \$31500 seems to be the optimum decision, returning a profit of \$245440.53 at the end of the first year and \$522,381 at the end of the second year. For longer terms,

$70000 budget emerges as the optimum decision, returning profits of $1081912.53 and $1369890.66 at the end of the fourth and fifth years, respectively.

Table 5.8. Profitability results over 5 years as a function of budget.

Budget ($)	1st year profit ($)	2nd year profit($)	3rd year profit($)	4th year profit($)	5th year profit($)
3500	52712.25	108924.49	165136.74	221348.99	277561.24
7000	101211.58	209423.16	317634.74	425846.32	534057.90
10500	149710.97	309921.95	470132.92	630343.90	790554.87
14000	189159.01	392318.02	595477.04	798636.05	1001795.06
17500	211386.92	440273.84	669160.76	898047.69	1126934.61
21000	223781.07	468562.13	713343.20	958124.26	1202905.33
24500	236175.21	496850.42	757525.63	1018200.84	1278876.05
28000	232675.21	493350.42	754025.63	1014700.84	1275376.05
31500	245440.53	522381.06	799321.60	1076262.13	1353202.66
35000	242991.73	520983.46	798975.20	1076966.93	1354958.66
42000	238069.11	518138.23	798207.34	1078276.45	1358345.57
49000	233091.41	515182.82	797274.24	1079365.65	1361457.06
56000	228172.79	512345.58	796518.36	1080691.15	1364863.94
63000	223212.12	509424.23	795636.35	1081848.46	1368060.58
70000	217978.13	505956.26	793934.40	1081912.53	1369890.66
77000	211083.25	499166.50	787249.76	1075333.01	1363416.26
84000	204083.25	492166.50	780249.76	1068333.01	1356416.26
91000	197083.25	485166.50	773249.76	1061333.01	1349416.26

It must not be overlooked that Fig. 2 and Table 8 were prepared by assuming all the financial outputs regarding the energy savings were calculated in electricity units ($ per kWh of electricity), however the energy savings from double-glazing would compensate for central heating, for which natural gas or coal rather than electricity is used. This assumption can be expected to introduce a slight error as far as payback periods and profitability values are concerned.

5.1.9 Summary

In this model, linear programming method was used to maximize energy savings subject to budget for a hypothetical household in Gaza city in Palestine. The subject house was selected to be a five-floor, detached building. The methods involved to decrease the building's energy consumption were installing photovoltaic solar panels on the roof, replacing incandescent light bulbs with compact fluorescent light bulbs, installing double-glazed windows, installing double wall and installing solar heating water. The physical constraints of the house in regards to the above-mentioned methods were as follows:

- A total window area 122 m2
- Total roof area allocated for solar panel installation: 84 m2
- Total number of light bulbs to be replaced: 84
- A total wall area 400 m2
- Total roof area allocated for solar panel installation: 84 m2

The energy savings were calculated in power units (Watts). Energy savings induced by each individual method were either obtained from manufacturer or distributor companies' websites, or calculated where applicable. The purchase and installation costs of each of the energy saving methods were obtained by taking the averages of various values gathered from the manufacturer or distributor companies' websites. Lindo 6.0 software was used to for linear optimization. The energy savings were calculated as a function of total allowable budget, and budgets ranging between $3,500 and $91,000 were used as inputs for the model.

The results indicated that installing photovoltaic solar panels is the optimum choice throughout the entire budget range, as a result of the high energy saving opportunity. Renewing household appliances did not emerge as very profitable options, due to the low energy savings when compared to other techniques. Double glazed window installation, double wall installation and purchasing compact fluorescent light bulbs was the optimum combination because of the relatively low cost.

For the given constraints the maximum amount of energy savings was found to be 274051.8 W, at a budget of $77,000 as the researchers, The most significant contribution of this particular work to building energy research is the methodology developed rather than the results themselves. The model presented can be modified as desired for different households, climate conditions, or countries so that the final results would be completely different. The reason we decided to implement the model by using data obtained from local sources was to ensure consistency, yet we believe the model can be applied globally as long as the required data can be provided.

5.2 Simulation Model using Arena program for Water Management in Existing Residential Building in Palestine (Grey-Water System).

Throughout history much of the world has witnessed ever-greater demands for reliable, high-quality and inexpensive water supplies for domestic consumption, agriculture and industry. In recent decades there have also been increasing demands for hydrological regimes that support healthy and diverse ecosystems, provide for water-based recreational activities, reduce if not prevent floods and droughts, and in some cases, provide for the production of hydropower and ensure water levels adequate for ship navigation.

Water managers are challenged to meet these multiple and often conflicting demands. At the same time, public stakeholder interest groups have shown an increasing desire to take part in the water resources development and management decision making process. Added to all these management challenges are the uncertainties of natural water supplies and demands due to changes in our climate, changes in people's standards of living, changes in watershed land uses and changes in technology.

Palestine is approaching the point where water demands are exceeding supplies. This situation will necessitate improved decision making for water resources planning. Integrated management represents a unique approach, incorporating both temporal and spatial variations of the problem. To achieve an integrated procedure, efforts are being made to resolve numerous issues.

The first part of this Project describes the water resources and the water scarcity in Palestine. The second part describes the application of integrated management to water planning and water quality. Grey water is one of the promising solutions for reducing the water consumption in the residential sector in Palestine. The case study applied the grey water simulation model using arena program in a small five floor residential building in Gaza City.

5.2.1 Data Collection

As per a recent study, by the year 2020 water shortage will be a serious worldwide problem. Our water resources will not be sufficient anymore. So an environmental approach is not only a good thing, it is necessary if we want our children to have water when they grow up. Of all the water in the world, only 3% is fresh. Less than a third of 1% of this is available to humans. The rest is frozen in glaciers or polar ice caps, or is deep within the earth, beyond our reach. To put it another way, if 100 liters represents the world's water, little more than half a tablespoon of it is fresh water available for our use. However, fresh water is essential to our existence, it allows us to produce food, manufacture goods and sustain our health. In fact, about 70% of our body is comprised of water. Global water consumption has risen almost tenfold since 1900, and many parts of the world are now reaching the limits of their supply. World population is expected to increase by 45% in the next thirty years, while freshwater runoff is expected to increase by 10%.

Gaza city has very limited water resources, groundwater is a major resource, which plays an important role in the support of natural ecosystems and as a source of water supply for agricultural, industrial and domestic needs. Over the last forty years, the recognition of the important challenges and threats which have been accrued as depletion of groundwater storage and deterioration of quality which has led to many changes to water resource. As a part of facing these challenges, proper management of the demand is an important step to achieve the water balance and ensure that water use for a range of beneficial purposes is sustainable.

Gaza strip is located at (34.5º - 35.5º) longitude, 25 minutes east and 31º latitude, 30 minutes north, its area is about 360Km2 . The length is about 45 Km on the western Mediterranean cost and the width varies from 7 to 12Km. The Sinai Desert is located in south, the Naqab Desert in the east and Mediterranean Sea in the west. With dense population in the Gaza strip is considered the highest in the world with a population of 1.8 million people and a growth rate (3.5 %) annually.

5.2.2 Problem Identification

One third of the world's population is already facing problems due to both water shortage and poor drinking water quality. Effects include massive outbreaks of disease, malnourishment and crop failure. Furthermore, excessive use of water has seen the degradation of the environment costing the world much more of money. UNESCO has predicted that by 2020 water shortage will be a serious worldwide problem. Palestine is approaching the point where water demands are exceeding supplies.

The population of Gaza strip at present is 1.3 million inhabitants, and they create a demand for water of 140 MCM by the year 2005. This amount of water comprise nearly (60-70%) for agriculture use, (20-30 %) for municipal use and the remaining for industrial use .The per-capita water supplied varies from 100 to 120 L per Capita per day(2004-2005). By the year 2020 it is expected to be 165 L per Capita per day and the demand for water is expected to reach 265 MCM per year. Clearly this means that, there is an immediate need to implement water demand management WDM programs for utilizing the available water resources.

In Gaza strip the water demand exceeds supply and the water deficit is continually increasing as results of combination of factors that influenced the water demand due a rapid population growth, continued exploitation of water resources that causing their depletion. This means that there are urgent and clear needs for drastic action to close the gap between supply and demand by controlling the demand side through water demand management or ensuring additional quantity of water to cover the water deficit and fulfill the water balance.

5.2.3 Water system principles

5.2.3.1 Water Supply

- **Rainfall:** It is insufficient to sustain planting.
- **Surface water:** It is the main traditional source of water; it is abstracted from rivers, or lakes.
- **Ground water:** It is abstracted from wells using simple suction pumps.
- **Grey water:** Which is reused water particularly treated sewage effluent (TSE).

5.2.3.2 Grey Water Systems

Gray water is water that is mildly soiled from washing, bathing or showering, as opposed to "black water", which is water flushed from toilets as shown in fig. 1. Water from kitchen sinks, dishwashers, and washing machines also counts as black water due to its high level of combination from detergents, grease and organic matter. Grey water cannot be simply collected and reused; it must first be filtered and treated. There will be a risk of disease and plumbing blockages, after treatment, it can be used for grey water is first coarsely filtered through crushed stone or gravel, then run through reed beds to be biologically purified by microorganisms feeding among the roots of the plants.

5.2.3.3 What is gray water?

Any water that has been used in the home, except water from toilets, is called grey water. Dish, shower, sink, and laundry water comprise 50-80% of residential "waste" water. This may be reused for other purposes, especially landscape irrigation.

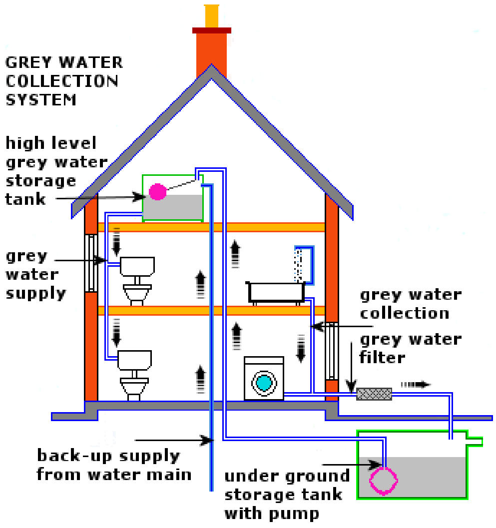


Fig. 5.1. Grey water systems

5.2.3.4 Why use gray water?

It's a waste to irrigate with great quantities of drinking water when plants thrive on used water containing small bits of compost. Unlike a lot of ecological stopgap measures, grey water reuse is a part of the fundamental solution to many ecological problems and will probably remain essentially unchanged in the distant future.

The benefits of grey water recycling include:

- Lower fresh water use
- Less strain on failing septic tank or treatment plant
- Grey water treatment in topsoil is highly effective
- Ability to build in areas unsuitable for conventional treatment
- Less energy and chemical use
- Groundwater recharge
- Plant growth
- Reclamation of otherwise wasted nutrients

- **Saving cost**

Grey water systems can help you save 35% to 40% on your annual water bill, and while saving money, you will also help save the environment and provide a better future for our children and their children to come. With this amount of savings, your Grey water Recycling System pays for itself.

5.2.4 Simulation model aim

Simulation Model using Arena program for Water Management in Existing Residential Building in Palestine (Grey-Water System).

5.2.5 Model objectives

- Introduce a model for a family house that depends mainly on grey water system to run the appliances and human activities.
- Encourage owners and operators of existing buildings to implement sustainable practices and reduce the environmental impacts of their buildings especially in water consumption.

5.2.6 Model Methodology

The methodology of this Project adapted the following methods to reach its aim and objectives:

- Define the water resources and water scarcity in Palestine (water crisis in Palestine).

- Study the environmental benefits of the grey water systems.

- Apply simulation model for the grey water system in a case study in Palestine using arena simulation and analyze the benefits of its application.

5.2.7 Simulation Model

The sequential steps that were adopted for developing the simulation model are depicted in Figure (5.2):

1- Understand how the existing system operates; by observing the system components then capturing the logic of the product flow through the system.
2- Define the system constraints that result in specific assumptions which are applied to the simulation model development.
3- Collect cycle time data for the process.
4- Define the probability distributions of the cycle time data for each process using the Input Analyzer tool provided by the simulation software,
5- Develop the simulation model according to the existing system assumptions and constraints.

6- Verify the model during the development phase by checking the animation display in order to insure compatibility with the modeling assumptions

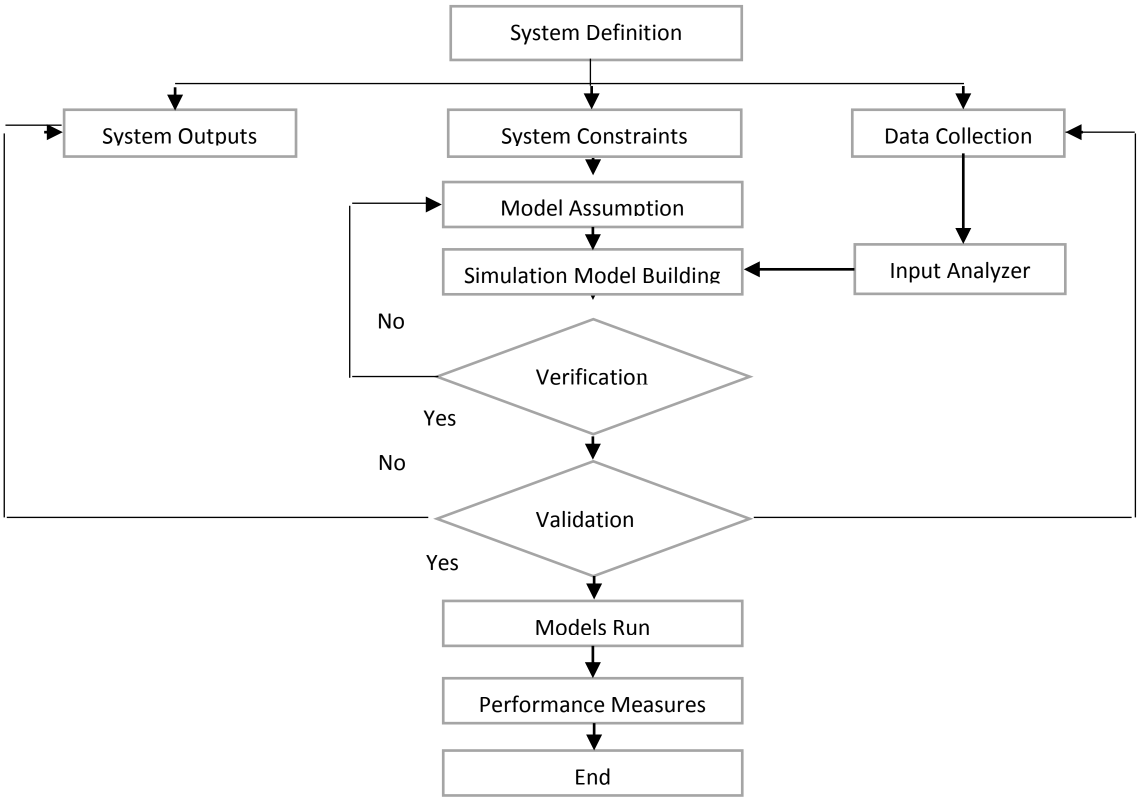


Figure 5.2. Methodology of developing the simulation model.

- **Water Resources: Supply and Demand for GW Scenarios**

In this section, three scenarios for water supply and treatment are outlined (scenario 1), a description of the residential building(s) is provided (scenario 2) and the respective water demands and potential for GW production determined (scenario 3). Throughout, it is assumed that GW is substituted only for water closet (WC) flushing. Whilst GW can be used for other purposes (e.g., gardening, car washing), these are beyond the scope of this current reseach.

In terms of water utility infrastructure requirements, all scenarios are consistent with the 2013 Palestinian Building Regulations, which specify metering for all new properties, eight liters/flush for standard toilet. The treatment performances of MBR and VFCW are well-reported within the literature (e.g.,) and, therefore, will not be repeated here.

- **Defining GW Recycling Scenarios**

The three scenarios analyzed in this reseach are listed below in addition to main entering of municipality water and shown in Figure 5. A short description of each follows.

Main water: from municipality which entering the system will arrive to elevated tank.

Scenario 1: consumption of sanitary device from water (with grey water) in flat no 1.

Scenario 2: consumption of sanitary device from water for flats 2, 3 and 4 but without using for grey water.

Scenario 3: consumption of sanitary device from water (with grey water) in the flat no 5, the same scenario 1 but using collecting consumption of sanitary devices process in a single process.

In Scenario 1 and 2 in figure (5), distinction is made between the system with gray water and without gray water. Within the residential building, it is assumed that GW is collected from showers only and used for flushing standard toilets. Initial estimations (Table 1) show that this supply source more than meets demands; therefore, GW from basin and baths is not required.

Table 5.9. Assumed residential descriptions.

Variables	Residential block
Number of floors	5 Floors
Total floor area (m2)	1000 m2
(Per floor)	200 m2
Occupants	35
(Per floor)	7
Total number of toilets	15
Number of toilets in each floor	3

- **Water Demands and GW Production**

In order to estimate likely grey water volumes produced and consumed in domestic residencies, we need to consider the breakdown of total water demands by end-use. As the focus of this study is on Palestine residential building, internal demands only are included. The associated impact of changes to these input parameters on supply demand requirements is beyond the focus of this reseach. For further information. Total daily water consumption due to garden watering is excluded.

- **Water Demands in Domestic Dwellings**

The water demands for a typical domestic resident can be seen in Figure 3 and Table 2. The data for predicted frequency of uses and volume of water per use are based on past monitoring studies. The calculated water demand value of 148 liters/person/day reflects the average per capita water use in the Palestine domestic sector (Table 5.10).

Table 5.10 Water usage breakdown in residential dwellings.

Water use	Water consumption (units)	Duration of use (minutes/ usage)	Frequency of use (per day & person)	Total water use (Liters/day/person)	Fate of streams
WC flushing	8 (L/usage)		4.8	38.8	to sewer
Hand basin	8 (L/minute)	0.33	3.5	9.24	To GW recycling
Washing machine	80 (L/load)		0.21	16.8	to sewer
Shower	8 (L/minute)	8	0.6	38.4	to GW recycling
Kitchen sink	8 (L/minute)	0.33	3.5	9.24	to sewer
Other	4 (L/day/person)			4	to sewer
Total daily water consumption (L/person/day)				116.48	

Water demands (and grey water generation) within the residential buildings are calculated by multiplying frequency of appliance(s) use by volume of water consumption (per use) by the number of occupants (Table 1). This assumes a linear relationship between frequency of water use and occupancy. Such an approach has been successfully adopted by many authors, including. It is assumed that each flat has three toilet, four hand basin and one shower connected to the GW system. Occupancy rates are based on Palestine average values. Operation is assumed to be for 365 days per year.

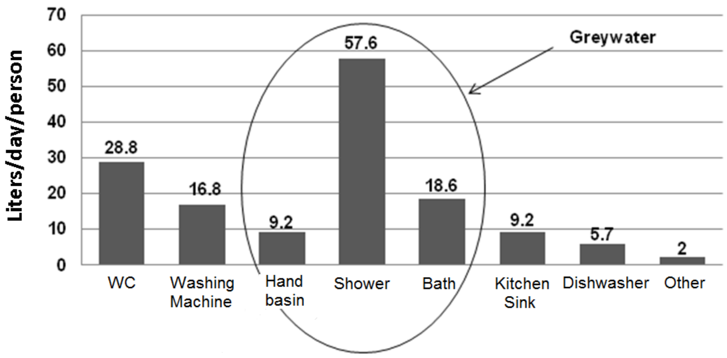


Figure 5.3 Water usage breakdown by end-use in Palestine residential dwellings, GW production highlighted. WC, water closet.

- **Savings: Main Water and Wastewater**

Models that include a financial factor typically use the cost savings in main water supply (*i.e.*, due to replacement with recycled GW) and wastewater disposal (*i.e.*, due to reduced outflow requirements) as the main indicator of financial performance. These are commonly referred to as avoided costs and are the primary ways in which GW recycling systems offer the potential to save money on a private basis. The simulation results from the following water flow module are used to provide quantification of the water saving potential for the mixed-use GW recycling system. The module has two components: annual GW supply (GWS) and annual GW deman*d* (GWD). Equations 1 and 2 are used to calculate the volume of GW supply in residential (*GWSR)* and office block (*GWSO*). The GW supply component is contributed to from showering within the residential block and from hand basin(s) within the office block. (Other sub components, e.g., bathing, or washing machines, could be added by the user if so desired, but are not considered here.)

The input data for these equations is shown in Tables 2 and 3.

$$GWSR = Vs \times Fs \times R \times T$$

Where:
V_S = total shower volume (l/use),
F_S = frequency of shower (uses/person/day),
R = number of residents, and
T = number of days used per year.

$$GWSO = VB \times FB \times E \times T$$

The second component of the water flow module is for grey water demand. It is assumed that grey water is only used for toilet flushing. The total grey water demand for toilet flushing in residential (*GWDR*) and toilet and urinal flushing in offices (*GWDO*) is calculated by using Equation 3 and Equation 4:

Table 5.9. Water usage breakdown in residential dwellings

	Apartment 1																			
	Main Bath						Bath 2						Guest Bath				Kitchen			
	Sink		toilet		Shower		Sink		toilet		Shower		Sink		toilet		Basin		Washing machine	
Hour	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)	Liter	Time (S)
12.00	6	600	12	300	0	3600	0	3600	6	600	0	3600	0	3600	0	3600	7	514	0	3600
1.00	6	600	6	600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	3	1200	0	3600
2.00	3	1200	6	600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600
3.00	3	1200	6	600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600
4.00	50	72	42	85	32	112	6	600	0	3600	0	3600	0	3600	0	3600	7	514	0	3600
5.00	10	360	12	300	0	3600	0	3600	6	600	0	3600	0	3600	0	3600	0	3600	0	3600
6.00	50	72	30	120	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	24	150	0	3600
7.00	30	120	24	150	42	86	5	720	0	3600	0	3600	0	3600	0	3600	26	138	0	3600
8.00	30	120	6	600	0	3600	0	3600	6	600	70	5	0	3600	0	3600	40	90	0	3600
9.00	6	600	6	600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	32	112.5	80	45
10.00	10	360	6	600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	10	360	0	3600
11.00	5	720	6	600	0	3600	5	720	0	3600	0	3600	0	3600	0	3600	6	600	0	3600
12.00	30	120	30	120	80	45	0	3600	6	600	0	3600	0	3600	0	3600	8	450	0	3600
1.00	24	150	24	150	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	16	225	0	3600
2.00	30	120	12	300	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	20	180	0	3600
3.00	20	180	6	600	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	40	90	0	3600
4.00	20	180	12	300	40	90	0	3600	0	3600	0	3600	0	3600	0	3600	3	1200	0	3600
5.00	30	120	6	600	0	3600	4	900	0	3600	0	3600	0	3600	0	3600	16	225	0	3600
6.00	18	200	18	200	0	3600	0	3600	0	3600	0	3600	6	600	6	600	20	180	0	3600
7.00	30	120	12	300	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	8	450	0	3600
8.00	20	180	6	600	40	90	4	900	6	600	0	3600	0	3600	0	3600	4	900	0	3600
9.00	30	120	24	150	0	3600	0	3600	0	3600	0	3600	0	3600	0	3600	30	120	40	90
10.00	10	360	12	300	40	90	8	450	0	3600	0	3600	0	3600	0	3600	8	450	0	3600
11.00	12	300	18	200	0	3600	0	3600	6	600	0	3600	0	3600	0	3600	16	225	0	3600
Sum	483		342		274		32		36		70		6		6		344		120	

5.2.6.1 Conceptual Model:

The following flow chart describes the process for the water management in existing residential building in Palestine throughout the simulation.

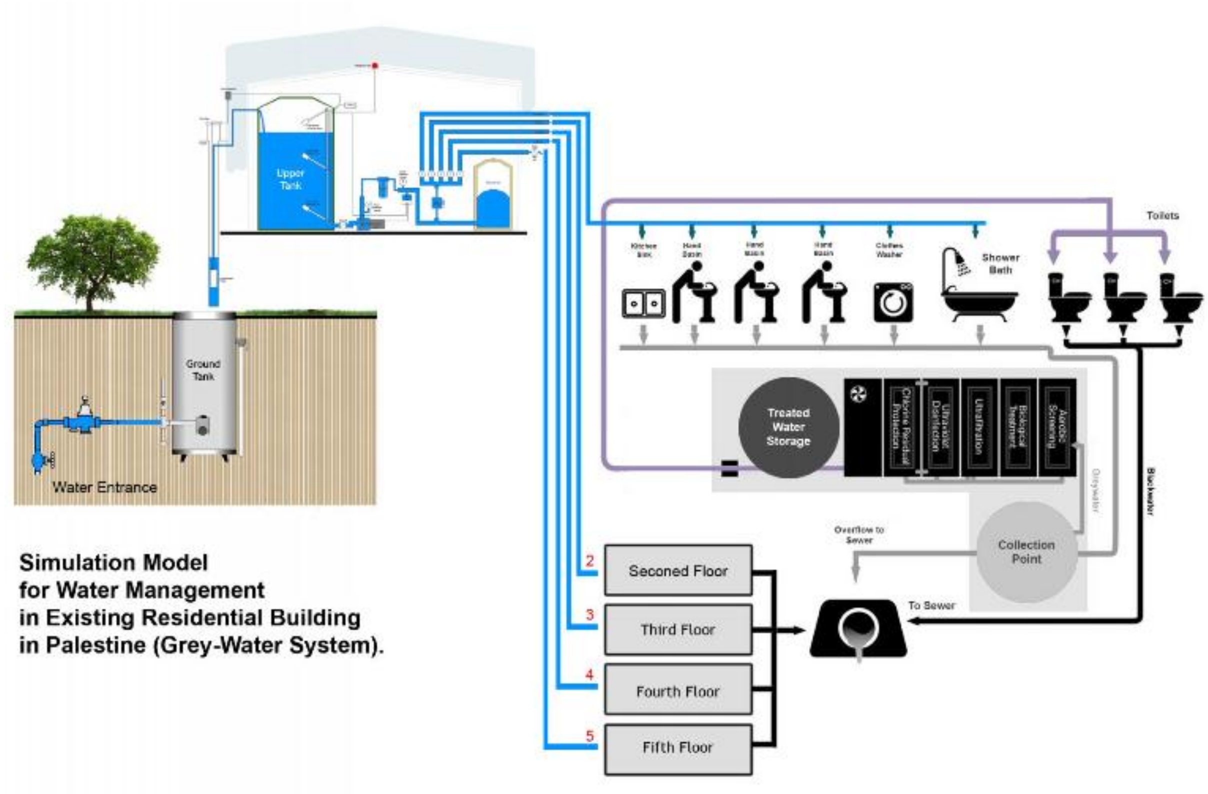


Figure 5.4 The process for the water in existing residential building

5.2.6.2 Collected Data:

Data were collected by monitoring the average consumption of five floor residential building in Gaza strip for one week. As tabled:

Table 5.11: Resources needed and time distribution for process of system *

Part (1) .Main water entrance				
No.	**Process**	**Resource needed /available**	**Time**	**Remarks on Process**
1	Ground tank	1 pump1,1	TRIA(0.19,0.22,0.26)	
2	Elevated tank	1 R elevated tank ,1	Constant Value (2)	just technique to assist in Reservation water to wait

Scenario no (1) .Flat 1 – used back wash system			
No.	**Process**	**Resource needed /available**	**Time**
1	Sink main bath 1	1 Resource,r11	72+EXPO(150)
2	Shower main bath 1	1 Resource,r13	120+3.56e+002*BETA(0.212,0.139)
3	Sink bath 2	1 Resource,r14	450+3.15e+003*BETA (0.049,0.0202)
4	shower bath 2	1 Resource,r16	1000+3.55e+002*BETA(0.526,0.182)
5	Sink guest bath	1 Resource,r17	Constant Value (0.1666)
6	basin kitchen	1 Resource,r19	90+EXPO(309)
7	Washing machine kitchen	1 Resource,r10	Constant Value (0.008)
8	reuse tank	1 reuse water,1	Constant Value (5)
9	toilet main bath 1	1 Resource,r12	UNIF(85, 600)
10	toilet bath 2	1 Resource,r15	600+3e+003*BETA(0.112,0.112)
11	toilet guest bath	1 Resource,r18	Value (0.1666)

*All resource used in device sanitary in this system just technique to assist in Reservation water to wait in water line for sanitary device except the resource pump1 in ground tank process.

Scenario no (2). Flat 2,3,4			
No.	**Process**	**Resource needed /available**	**Time**
1	Flat 2	1 Flat2,1	27+32*WEIB (58.4,0.554)
2	Flat 33	1 Flat 3,1	23+0.37*WEIB (58.9,0.702)
3	Flat 44	1 Flat 4,1	32+0.35*WEIB (76.4,0.625)

Scenario no (3). Flat 5, used back wash system			
No.	**Process**	**Resource needed /available**	**Time**
1	reuse tank 2	1 reuse water 2,1	Constant Value (5)
2	toilet main bath Flat 2	1 Toilet 2,1	UNIF(60, 380)
3	Flat 55	1 Flat5,1	25+0.22*WEIB (116,0.621)

5.2.6.3 Model formation

Main water entering the system

1. Crete module firstly used to represent the creation of municipality water as the entities of module where the municipality water pumped with average 8 hr./day (12 :00 pm – 8: am) shown in schedule model that attached in table no. 3) with the possibility of amending the number of hours pumping from municipality at any time as shown in arena model at figure (5).

2. Assign module used to have many attributes assignments but here mainly entity picture.

3. Decision module used to decide the capacity of water allowed to arrival to ground water tank (to be less than 16 m3) based on the conditions related to the capacity of ground water tank used to consumption of flat , followed by record module to account water municipality consumption .

4. After that , process module used to start raise the water from ground water tank to elevated tank above roof by using pump1 as resource in time as trial(0.19,0.22,0.26) , where we assumed that the pump1 was working continually for 4 hours when municipality water reach to ground tank from 12:00 pm to 4:00 am)

5. Again decision module used to limit the capacity of elevated water tank to be less than 10 m3, by assuming that we need to 5 tanks with capacity equal to 2m3 for each.

6. Separate module used to convert the unit of water from m3 to litter where is the sanitary equipment (hand washing basin, toilet, sink) deal with litter unit.

7. Process module used to provide the flats (1, 2, 3, 4 and 5) with water from elevated tank according to decide module 3 conditions.

8. Decide module will be used to distribute the water in flats 1, 2, 3 based on the conditions related to the quantity of water which must be equal to 10 m3.

9. We assuming that there are 4m3 of water previously in the system to assist in the continuity of water flow inside system when running the system by using create water saved in tank module.

Scenario no 1

This scenario is describe the consumption of device sanitary from water municipality and the using of back wash system in flat 1 by the following steps :

1. Seven process modules preceded by seven records modules will be used to calculate the average daily consumption of water for sanitary device (sink main bath 1, Shower main bath 1, Sink bath 2, shower bath 2, Sink guest bath, basin kitchen and Washing machine kitchen), where we have got the average daily consumption rate of sanitary device by monitoring the average consumption of five residential building in Gaza strip (attached table no 5.9) and the model system in figure (5.5).

2. Decide module used to eliminate the quantity of water tank for the backwash water from the seven sanitary device to be 1 m3.

3. Process module used to collect the quantity of water arrival from backwash water sanitary device in reuse tank preceded by record module to account quantity of back wash water

4. We suppose that there is 1 m3 of water in the water line previously to continuity of flow of water in water net by using create module (create 2).

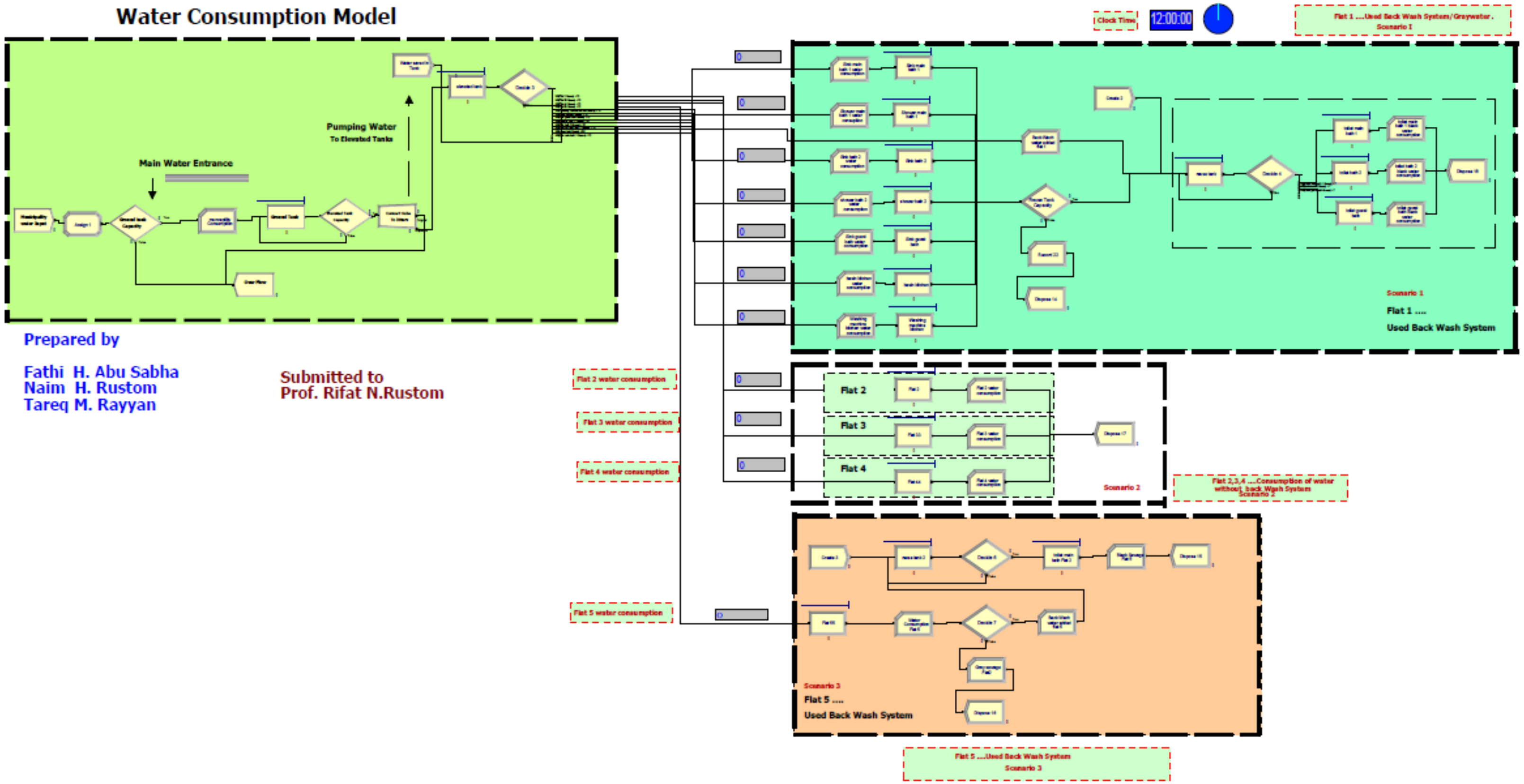
5. Decide module used to limit the consumption of sanitary device from backwash (toilet main bath 1, toilet bath 2 and toilet guest bath) to be seven litter for each of them.

6. Three process modules (toilet main bath 1, toilet bath 2 and toilet guest bath) preceded by three records modules, were used to calculate the average daily consumption of water for sanitary device from back wash water.

7. The resources used in device sanitary in this system just technique to assist in Reservation water to wait in water line for sanitary device.

figure no .5 : Simulation Model using Arena program for Water Management in Existing Residential Building in Palestine(Grey-Water System).

06-06-2014



Scenario no 2

In this scenario , three process module (Flat 2, Flat 33 and Flat 44) followed by three record modules(Flat 2 water consumption, Flat 3 water consumption and Flat 4 water consumption) used to expose the normal average daily consumption of water for each one of flats without using to backwash system.

Scenario no 3

This scenario explain the average daily consumption for device sanitary in flat 5 (toilet main bath flat, the same scenario no 1) but in the following steps:

1. Process module (flat 5) followed by record (Water Consumption Flat 5) module will be used to calculate the total consumption of water for the seven sanitary device in scenario no 1 but in a single process Called flat 5.

2. Deicide module 7 used to eliminate the quantity of backwash water from the seven sanitary device as in part scenario no 1.

3. Process module (toilet main bath flat 2) followed by record module (Black Sewage Flat 5) will be used to calculate the total consumption of water from back wash water for the three device (toilet main bath 1, toilet bath 2 and toilet guest bath) as discuss in scenario no 1.

5.2.6.4 Simulation model importance

1. Model can run for 24 hours and programming the pump, according to the capabilities of the peak and the calculation of the required ground tank capacity and the required capacity of elevated tank.

2. Model shows full scenarios of municipal pumping and pumping the ground tank to the elevated tank and consumption of a flats in a residential building and can be controlled in these scenarios to improve the design of future in the Gaza Strip.

3. Model shows that the value engineering where reality appear from the use of water resulting from hand washing basin (backwash) to clean the toilet unit.

4. This is Model nucleus to build an integrated model shows the pressure and consumption and therefore can be improved hydraulic design accordingly.

5. Could be the nucleus of the adoption of simulation science in the work of the municipalities of the Gaza Strip.

6. This model represents a model residential building of 5 flats truly representative of the building where verification fact that the percentage was 95%.

4.2.6.5 Model constraints:

Many constraints considered to control the system these constrains are:

1. The period where the electricity is available in Gaza strip (around 16 hrs. /day) which control the period of operation to the system.
2. Period of pumping water municipality to residential building in area which control the operation of system pumps in building. (Around 8 hr. /day).
3. The maximum capacity of ground tank (10 m3),elevated thank (7 m3) and backwash tank (1m3) which will calculate through knowing to the daily consumption of water by using simulation in this system .

5.2.6.7 Results and analysis:

The results in table (5.13) show the consumption of the five flats from municipality water , the consumption of sanitary devices from municipality water and the consumption of toilets unit from backwash water which summarized in the following :

- The model show the results from above table of the consumption of water from municipality for flat no 1 , flat no 2, flat no 3 , flat no 4 and flat no 5 which were respectively , 1713,1485,1722,1192 and 1432 litters .
- The model show the results from above table of the consumption of water municipality for sink main bath 1, Shower main bath 1, Sink bath 2, shower bath 2, Sink guest bath, basin kitchen and Washing machine kitchen)in flat no 1 which were respectively 391,281,49,79,16,232 and 135 litters.
- The model show the results from above table of the consumption of water from backwash for toilet main bath 1, toilet bath 2 and toilet guest bath in flat no 1 which were respectively, 253,40 and 5 litters .

Table 5.13: recorded consumption of the five flats from municipality water, the consumption of sanitary devices and the consumption of toilets unit from backwash water.

Counter

Count	Value
Back Wach water added flat 1	0.00
Back Wach water added flat 5	365.00
basin kitchen water consumption	232.00
Black Sewage Flat 5	391.00
Flat 2 water consumption	1485.00
Flat 3 water consumption	1722.00
Flat 4 water consumption	1192.00
Gray sewage Flat2	1067.00
muncapility Consumption	25.0000
Record 22	783.00
shower bath 2 water consumption	79.0000
Shower main bath 1 water consuption	281.00
Sink bath 2 water consumption	49.0000
Sink guest bath water consumption	16.0000
Sink main bath 1 water consumption	391.00
toilet bath 2 black water consumption	40.0000
toilet guest bath black water consumption	5.0000
toilet main bath 1 black water consumption	253.00
Washing machine kitchen water consumption	135.00
Water Consumption Flat 5	1432.00

Table 5.14: the volume of water in ground water tank and elevated tank.

Queue

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
basin kitchen.Queue	9.9812	(Correlated)	0.00	10.0000
elevated tank.Queue	7064.59	(Correlated)	0.00	9953.00
Flat 2.Queue	9.9812	(Correlated)	0.00	10.0000
Flat 33.Queue	9.9748	(Correlated)	0.00	10.0000
Flat 44.Queue	9.9768	(Correlated)	0.00	10.0000
Flat 55.Queue	9.9694	(Correlated)	0.00	10.0000
Ground tank.Queue	17.0520	(Insufficient)	0.00	18.0000
Process 1.Queue	0.00	(Insufficient)	0.00	0.00
reuse tank 2.Queue	992.87	(Correlated)	0.00	1012.00
reuse tank.Queue	999.22	(Correlated)	0.00	1000.00
shower bath 2.Queue	9.9779	(Insufficient)	0.00	10.0000
Shower main bath 1.Queue	9.9695	(Correlated)	0.00	10.0000
Sink bath 2.Queue	9.9757	(Insufficient)	0.00	10.0000
Sink guest bath.Queue	9.9817	(Insufficient)	0.00	10.0000
Sink main bath 1.Queue	9.9650	(Correlated)	0.00	10.0000
toilet bath 2.Queue	6.9936	(Insufficient)	0.00	7.0000
toilet guest bath.Queue	6.9914	(Insufficient)	0.00	7.0000
toilet main bath 1.Queue	6.9906	(Correlated)	0.00	7.0000
toilet main bath Flat 2.Queue	9.9844	(Correlated)	0.00	10.0000
Washing machine kitchen.Queue	9.9856	(Insufficient)	0.00	10.0000

As shown in table no 6: the minimum average capacity of ground water was 17.05 m3 while the maximum was 18m3, also the minimum average of elevated tank was 7.06m3 while the maximum was 9.95 m3.

Table 5.15: the saving in water consumption.

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.04480145	0.004050969	0.00	3.9998

NVA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	0.000000000	0.00	0.00

Wait Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	11.2905	(Correlated)	0.00	23.9559

Transfer Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	0.000000000	0.00	0.00

Other Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	0.000000000	0.00	0.00

Total Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	11.3353	(Correlated)	0.00	23.9819

Other

Number In	Value
Entity 1	13080.00

Number Out	Value
Entity 1	7000.00

WIP	Average	Half Width	Minimum Value	Maximum Value
Entity 1	9232.59	(Correlated)	0.00	12134.00

As shown in table no 5.16 we can calculated the saving in consumption of water municipality, where The amount of water entering in the system was 13080 liters while the outflows of water was 7000 liters , so , the saving was the difference between two values equal to = 6080 liters which we got it from water gray, also as discuss before , All resource used in device sanitary in this system just technique to assist in Reservation water to wait in water line for sanitary device except the resource pump1 in ground tank process. As shown in table no 8 the utilization of resource pump 1 was 17.47 %

Table 5.16: the utilization of resource

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
Flat 3	0.9997	(Correlated)	0.00	1.0000
flat 4	0.9994	(Correlated)	0.00	1.0000
flat 5	0.9991	(Correlated)	0.00	1.0000
FLAT2	1.0000	(Correlated)	0.00	1.0000
pump1	0.1747	(Insufficient)	0.00	1.0000
r 1 1	0.9972	(Correlated)	0.00	1.0000
r 1 10	0.9989	(Insufficient)	0.00	1.0000
r 1 2	0.9999	(Insufficient)	0.00	1.0000
r 1 3	0.9975	(Insufficient)	0.00	1.0000
r 1 4	0.9978	(Insufficient)	0.00	1.0000
r 1 5	0.9995	(Insufficient)	0.00	1.0000
r 1 6	0.9980	(Insufficient)	0.00	1.0000
r 1 7	0.9983	(Insufficient)	0.00	1.0000
r 1 8	0.9990	(Insufficient)	0.00	1.0000
r 1 9	0.9986	(Insufficient)	0.00	1.0000
R elevated tank	1.0000	0.000000000	0.00	1.0000
reuse water	1.0000	0.000000000	0.00	1.0000
reuse water 2	1.0000	0.000000000	0.00	1.0000
Toliet 2	0.9999	(Correlated)	0.00	1.0000

5.2.6.8 Model verification

As shown the data in table 8 which referring to model verification the results from the arena records very close to the results from actual for example: the quantity of water consumption for Sanitary device (Sink main bath 1) was 483 liter in real situation while from arena record was 391 liter so the percentage of accurate close to 80 %, the same way for the others device as shown in table (5.17).the average total consumption of water municipality in flat consist of six people in flat 2 was in actual 1468.20 while from arena record was 1485 , so the percentage of accurate close to 100 % . Also, the average total consumption of water municipality in flat consist of eight people in flat 3 was in actual 1713 while from arena record was 1722. , so the percentage of accurate close to 100 % .The same way for the other flats as shown in table 9.

Table 5.17: model verification

Model verification				
No.	**Sanitary device**	**Real**	**Arena recode**	**Rate**
1	Sink main bath 1	483	391	0.80
2	Shower main bath 1	274	281	1.02
3	Sink bath 2	32	49	1.5
4	shower bath 2	70	79	1.12
5	Sink guest bath	6	16	2.6
6	basin kitchen	344	232	0.67
7	Washing machine kitchen	120	135	1.125
8	toilet main bath 1	342	253	0.74
9	toilet bath 2	36	40	1.11
10	toilet guest bath	6	5	0.83
11	Flat 2 water consumption	1468.20	1485	1.011
12	Flat 3 water consumption	1713	1722	1
13	Flat 4 water consumption	1223.5	1192	0.974
14	Flat 5 gray consumption	1329	1067	0.80
15	Flats toilet	384	391	1.01

5.2.7 Summary

Encouraging the use of gray water system resulting from laundries, washing machines and kitchen sink and hand washing basin to re-use in toilet as it provides saving in the water quantities amount of 30% of total consumption of water per day.

Chapter 6: Developed Mobile Application Used in Construction for promoting Green Building Practices in Palestine.

6.1 Introduction

Construction projects of today are dependent on reliable and updated information through a number of ICT based business systems, communication tools and shared storage servers. (Löfgren, 2006).The continuing development of affordable mobile technologies such as handheld devices Smart Phones and Tablet PCs alongside the latest generation communications infrastructure (3G, WLAN and GPRS) could provide the 'last mile', connection to the point-of activity and hence provide the missing link to help address the ongoing drive for process improvement and re-valuing construction (Bowden et al. 2006).

Mobile apps have become very useful tools in our everyday lives with a variety of purposes, some specifically tailored for construction. This report will outline the benefits of developing a project specific mobile app that incorporates some of the construction tools already available in the smart phone markets along with other functions. The proposed app that must be developed will streamline communication and documentation of progress in a construction project, as well as provide useful tools for project managers and trades people. (Clancy et al, 2012)

Mobile applications can be utilized to benefit many of the undertakings required for a successful project and they have become more common because of the development of three partnering technologies; software, devices, and networks. Mobile application software allows powerful applications to run on devices as big as a laptop and as small as a phone. Some applications are outfitted with specific handheld devices, often times in construction they are built with a rugged exterior suitable to the built environment. Tablets are commonly found in many work places including construction. These devices have become more readily available as costs decrease due to competition and technological advancements. (Clancy et al, 2012)

Achieving green building, however, requires an integrated team; combining a wide range of different specialists through in-depth collaboration so that the complexity of trade-offs between architectural features, building services and other factors can be reached. Matipa (2010), in his research has highlight the availability and use of software systems in the

Irish construction cost consultancy; and to gather views from practicing professionals on how the available systems could ease the implementation of total cost management of green buildings.

There are about 90.6% of the Palestinians, at the age of 18 years and older, carry already cell-phones, and 22% among them own smart-phones of different brands and the results undoubtedly show that the Palestinians, notwithstanding the very hard conditions imposed on them by the Israeli authority, are keeping pace with the modern technology of telecommunications and social media devices and adapt these to their benefit. This is shown, for example, by the relatively long time Palestinians spend in average on the Internet educating themselves and promoting their vocational abilities, as well as interacting and communicating with others on the different social media sites inside and outside Palestine (Kukalil, 2012).

Although the cost factor and a lack of awareness are the most important factors influencing the decision to build green home also noted that studies have indicated previously, as well as the importance of information technology through mobile application of speed in the dissemination and exchange of information between people and the research about applications for cost estimating for green buildings is very little so in this section we focus on the previous studies about using mobile IT construction and the role of IT to promote green building to help us develop mobile application prototype for promoting green in Palestine and its function will be:

a. Cost estimation for greening and traditional construction for residential buildings projects.
b. Guide line and help tool for Palestinian to make the concept of green construction understandable.

6.1.1 ICT and mobile application in green construction.

6.1.1.1 Mobile IT Used in Construction

Researching the use of mobile IT in construction began in earnest in the mid-nineties, spurred on by the introduction of the Apple Newton Message Pad in 1993. The first Personal Digital Assistant (PDA) (Bowden et al. 2005a). Kimoto and Endo reported a development of mobile computing system with personal digital assistants (PDA) for construction managers on construction sites. Experts researched the mobile IT application in the construction industry (Kim et al. 2011; Sutton 2010).

Garrett and Sunkpho pay close attention to issues in delivering IT systems in the field, including understanding of field worker's context, functionality, mobile computing hardware, interface, and software and field evaluation of system with users (Garett and Sunkpho 2000). By case study, Bowden, Dorr, Thorpe e.g. found the utilization of mobile technologies by point-of-activity workers in construction increases the efficiency of the process resulting in improved data collection and hence a rapid return on investment (Bowden et al. 2005b).

Yuan Chen and John M. Kamara introduced a framework for the implementation of mobile computing on construction sites (Chen and Kamara 2008). They admit that the developed framework has its own limitations since it is only concerned with the limited factors that impact on the implementation of mobile computing (Chen and Kamara 2011). Nourbakhsh presents the results of usability testing of a mobile application prototype for improving information management in construction projects (Nourbakhsh et al. 2012).

Phones and mobile apps have a multitude of functions that simplify life. By putting forth the investment in developing a project specific mobile app a contractor stands to make more money and making it easier. The most important and primary benefit to the company will be the time savings that are realized once the whole mobile-based process is implemented, learned, and accepted by the employees. Secondary benefits that will follow may appear in the form of, employee productivity increases due to the fact that they were able to take controls in job progress. Another may be improved quality; the expectation is that the mobile apps will operate more efficiently as well as more effectively (Clancy et al, 2012).

6.1.1.2 Mobile application Used in Green Construction

Sørensen et al. (2009) in their study presented that a number of users needs for future ICT systems. The needs are captured during the prototype development process and include that future ICT systems must be more user-friendly, enable object oriented quality assurance procedures, capture data to be used in process optimization (lean construction), support a wide range of user environments ranging from mobile phones to large displays for presentation and editing data shared in virtual model resources, enable real-time tracking and location of machines and materials, and integrate traditional document/drawing based working practice with the use of virtual models to enable an easier adaptable change process for the construction industry.

Nourbakhsh et al. (2012) in their study aimed to investigate the information requirements for broad use mobile applications for construction projects and presented the results of usability testing of a mobile application prototype for improving information management in construction projects. After presenting an overview of green building construction and we provide an extensive review of literature, case studies, and research to prove that cost is the most significant constraint when building green and analyze how modifying traditional project management practices can contain the risk of inflated costs associated with green building. In this chapter the results were collected it will summarize in mobile application prototype for promoting green building which work as a help tool to Palestinian people to make the concept of green building understandable and help to give them initial cost estimation for whom small buildings projects.

Achieving green building, however, requires an integrated team; combining a wide range of different specialists through in-depth collaboration so that the complexity of trade-offs between architectural features, building services and other factors can be reached. Matipa (2010), in his research has highlight the availability and use of software systems in the Irish construction cost consultancy; and to gather views from practicing professionals on how the available systems could ease the implementation of total cost management of green buildings. His research concluded that the industry is well poised to move into the next generation of surveyors that would fully participate in the envisaged green construction industry; and that development in the ICT complement the traditional competencies of Quantity Surveying.

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Nourbakhsh et al. (2012) in their study aimed to investigate the information requirements for broad use mobile applications for construction projects and presented the results of usability testing of a mobile application prototype for improving information management in construction projects.

6.2 Developed mobile application to promote green building practices in Palestine

Design Manager App.

To Manage Your Green Design Home

6.2.1 about the application:

- **Project Name:** Design Manager App.
- **Establishment Year:** 2014
- **The target group:** The Decision Support tool is focusing on decision makers (for example housing association managers, homeowners association, etc.). In addition, the tool also contains practical and in-depth information of relevance to architects, energy experts, building contractors, and building users.

6.2.2 App. Definition:

Design Manager App. aims to promoting green building practices in Palestine and its main functions are:

1. Supported Cost estimation for residential green buildings
2. Promoting tool for Palestinian to make the concept of green construction understandable.
3. Main decisions in relation to ambitions in energy-efficiency, sustainability, economic feasibility and occupants' participation take place in the first, or the initiative phase.

6.2.2.1 The role of application to Supported Cost Estimation for Green Buildings.

The concept of cost is defined in various ways. In the most general sense, cost means the monetary value of the all goods and services used in order to perform an operation. In terms of building construction participants of the projects, the owner, the designer, the contractor, the user and the society are concerned with the building cost in various ways, due to the diverse expectations and the objectives of the participants.

In building construction projects, the direct cost is often emphasized and it is underlined in the cost estimation and cost control studies as the direct cost generally is very high compared with indirect cost within the building cost.

Besides, decisions on investment of building projects, owner's evaluation of bids prepared by contractors, calculation of the tender price of the contractors, cost control during the decisions on design are all bound to the correct or almost correct cost estimation.

Cost is a measurement of the function and the performance of a building. Therefore, in order to appraise the design of a building it is necessary to use a convenient cost model (Yaman and Tas, 2007).

The first step in using a cost model is collecting the data required. Then, these data must be analyzed and updated. In the meantime, the quality and the level of data and thus the convenience of the chosen model must be evaluated. As soon as new data are acquired during the implementation of the model, they must be appended to the previous data.

6.2.2.2 The role of application to Supported Cost Estimation for Green Buildings:

Integrated design necessitates an associated integrated costing methodology to overcome the perceived first cost barriers of green building design.

- Integrated design and costing shifts the levels of effort to earlier design phases and increases effort by, and cooperation amongst, design team members. It is a methodology that can succeed over repeated collaborations as design teams build trust and familiarity with such a systemic approach of design and costing.

- In the green design industry, whole building, or integrated, design is regarded as a way of achieving high performance without significantly raising the first cost of the building beyond a standard performance building. However, this process is also seen as the most difficult aspect of green building design.

- One of the main barriers to an integrated design process is Owners' expectations: Owners and users have an "as usual" expectation about the outcome in terms of aesthetics and functionality of the building or system. An integrated design process necessitates that all the stakeholders, including the owner, have an open mind towards new technologies.

6.2.2.3 User Awareness and Decision Support

- Design Manager Application can play an important role in making users aware of how much energy they are using. The main concepts of user awareness and decision support performance management, visualization of energy use and behavioral change by real-time pricing.

- Design Manager Application **for 'User awareness and decision support'** can visualize energy use and provide real-time pricing.
- Design Manager Application **for 'Energy management and trading'** are applications for the smart grid that make it possible for the building to act as a node in the grid, its user/manager thus participating in the energy market as a 'presume', both providing and using energy.

- **'Integration Technologies'** are used to enable different stakeholders to collaborate and share knowledge through ubiquitous and multi-platform ICT tools across geographical boundaries. Integration Technologies are also used to enable different systems and tools to communicate with each other. Another important aspect of Integration Technologies is that they make it easy for the user of the system to install new tools and systems (easy to plug-and-play).

6.3 For whom is the "Design Manager App."?

- The Decision Support tool is focusing on decision makers (for example housing association managers, home owners association, etc.).
- The tool also contains practical and in-depth information of relevance to: architects, energy experts, building contractors, and building users.

6.4 What kind of decisions is supported with the "Design Manager App."?

- Decision making process towards facilitating energy-efficient and green construction buildings.

6.5 Mobile application aims:

• The overall goal in **"Design Manager App."** is to reduce energy consumption for heating, cooling, ventilation and domestic hot water in small residential buildings. , compared to the present standards. In addition, a decision support tool will be developed to assist project developers, housing corporations etc. with a viable implementation of the measures suggested. This includes a closer look at organizational and financial aspects of building.

6.6 The objectives in mobile application are to:

1. Develop minimum standards for green building. There is a strong need for quality demands based on performance indicators and performance requirements to improve building environment in Palestine. Several quality labels should be developed to distinguish several levels of energy saving in housing. .

2. Develop a decision-making tool to improve green building construction. To realize the desired sustainable development in Palestine there is a strong need to develop a decision-making tool for constructing green building. Each housing unit concerned in the process of green building can use the tool as an instrument for realizing optimized energy savings. Using this tool on large scale will make a real difference.

3. Develop, implement and demonstrate technological solutions to reduce energy and water consumption. The overall goal in **"Design Manager App."** Is to reduce energy consumption for heating, cooling, ventilation and domestic hot water in construction of housing. To realize this objective innovations are necessary: Available renewable energy technologies are mainly developed for application in houses and there are a lot of additional boundaries for the application of these technologies, such as physical or social constraints. This means that these technologies have to be adapted before they can be applied in the building sector. The degree of realized energy saving will be measured by defining a demonstration.

4. Develop a multidisciplinary approach of sustainable renovation to improve life quality. Sustainable renovation requires a multidisciplinary approach. Not only are the technical solutions important. Factors at organizational, social and financial level play an important role in realizing the objectives as well.

6.7 Advantages in "Design Manager App." Can be described in three ways:

6.7.1 Financial factors:

There is a strong interaction between financial consequences and the implementation of technical solutions in green homes. In order to remove the financial barriers to large-scale implementation of new renovation technologies new financing models will be developed and demonstrated.

6.7.2 Organizational factors:

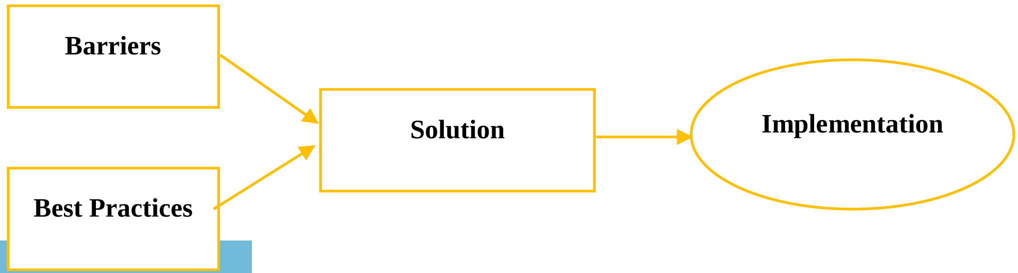
Organizational barriers include the integration of communication and activities with regard to the many organizations and stakeholders involved in the process of sustainable renovation. ***"Design Manager App."*** aims at finding solutions for these barriers by looking at new management systems to ensure effective large-scale rehabilitation of existing building stock.

6.7.3 Social factors:

Technological solutions should not only contribute to energy savings but also to the improvement of life quality including a healthy indoor climate. Technological solutions should be developed with the customer in mind.

Also:

- Energy savings, health and social factors will be taken into consideration;
- Technical barriers, organizational and financial barriers to the implementation of new technologies will be studied.



6.8 The role of social media technologies in design manager app. to support green thinking.

Social media is a new phenomenon that has emerged during the last couple of years. The main function of social networks is to find and manage contacts with whom an individual wants to communicate. Once the connection is established, there are further opportunities to build groups or communities for special interest areas. In 2010, social media technologies took a new step and became an important marketing tool. Examples include Facebook, Twitter, LinkedIn, etc. Groups can be formed around different topics, such as a local football club, family network, neighbors, etc. and with purposes such as to facilitate the booking of fixtures or gathering of pictures, maintaining e-mail conversation or chat-groups, etc. The social media community can also be used for more specific knowledge sharing and learning. Social media focusing on energy efficiency could be used both for professionals and residents. In the energy sector there are a couple of existing social media platforms that can be connected to the energy providers' services.

6.8.1 The actor perspective

Social media platforms such as Facebook, Twitter and LinkedIn are tools where many people already are connected and it is therefore very easy to start an online 30 community between for example residents in a house, the main restriction being whether they are willing to use it. There are also other forms of social media platforms, for example energy providers or a building owner's own web-portal or system.

6.8.2 Possible energy savings

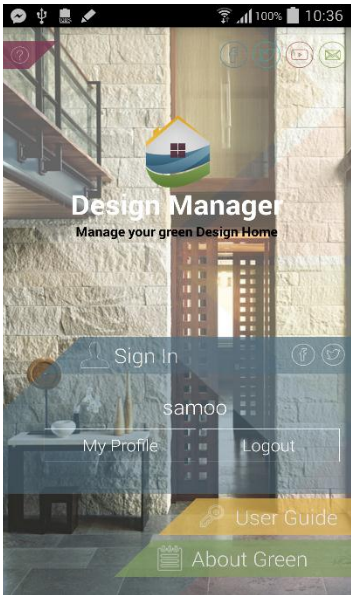
The amount of energy that can be saved thanks to social media is very difficult to predict, but they provide opportunities for spreading ideas on energy-efficient ways of using and managing buildings.

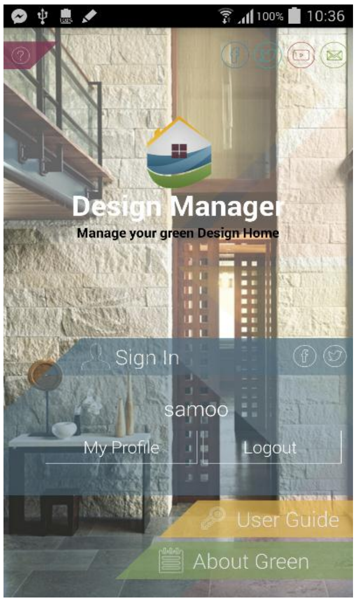
6.8.3 Personal integrity

Social media platforms store all information about their members, which can be a threat to personal integrity. Sharing information about private energy use with anyone in a social network would probably require a restricted part of the social media network to be set up.

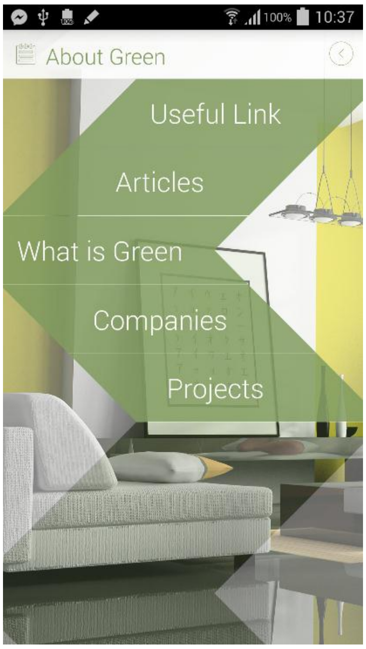
2.8 The basic stages to use the Application:

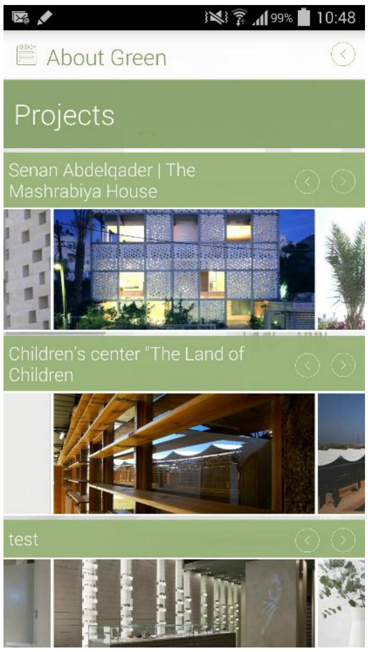
1. Firstly, the application must be downloaded from mobile store.
2. In a main interface of Design Manger Application, it has three main icons, which they are: Sing in, User guide, about green. In addition, it has other icons in the top like about app. (?), Facebook, Twitter, YouTube, and Mailbox.



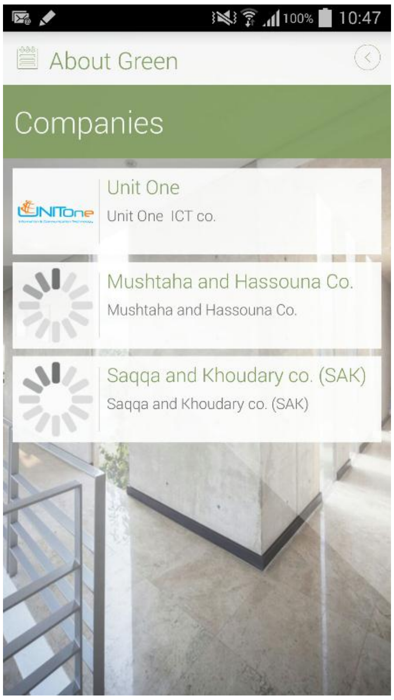


3. The user must make an account in the application by click in the first icon (sing in).
4. The user can have help by click in the second icon (User Guide), which present a guide for any new customer.

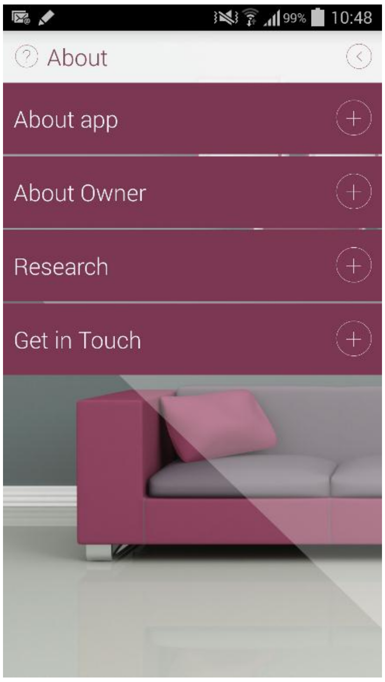


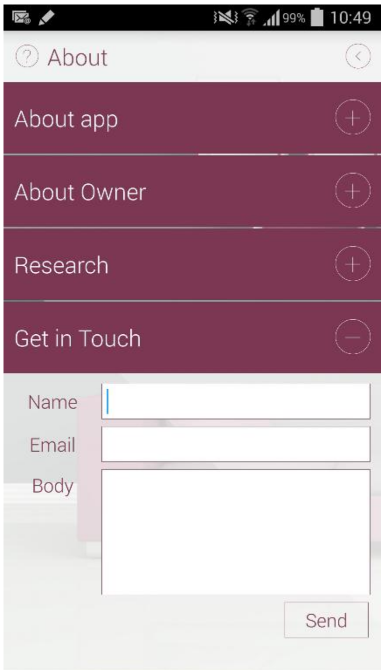


5. The application provide the user information about green. Through click in the last icon (About Green) the application open new page, contain of Useful Link, Articles related to green, what is Green, Companies, and Projects. Every icon is leaded to new page as show in pic 4, 5, and 6.

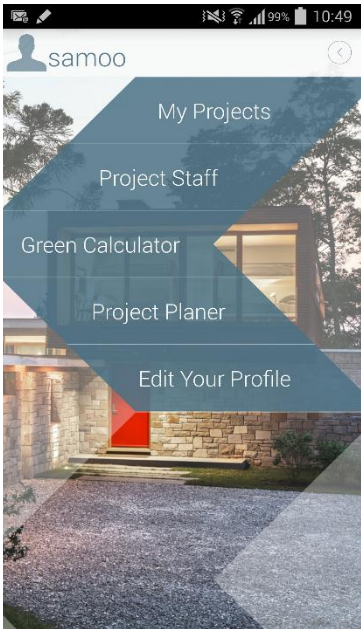


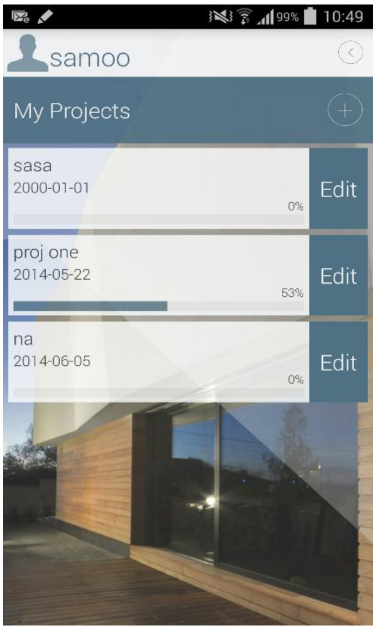
6. The user can knew more about application by click in (?) icon in the main interface. It will lead him to other page comprise: About app, about owner, research, Get in touch.



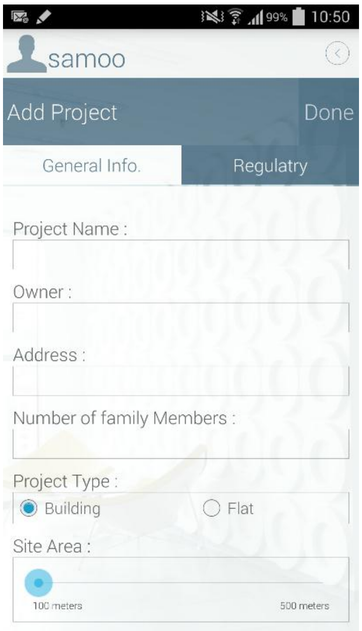


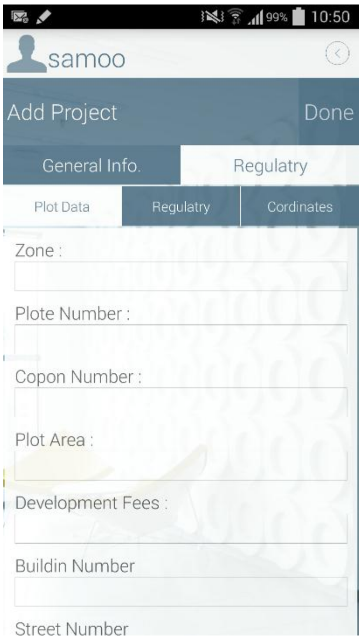
7. After make account in Design Manger Application, the user starts his own project by click on (My project) and add new one.





8. In Project page there are two types of data the user must be inserted. First type its general information which its project name, owner, address, number of family, project type, site area, building area, number of floors economic statue and quality of finishing. The second type of information its regulatory information which it's Plot Data, regulatory and coordinates as shown in pic 14. The third type of information is the stages.in this type the user selects the finished category.



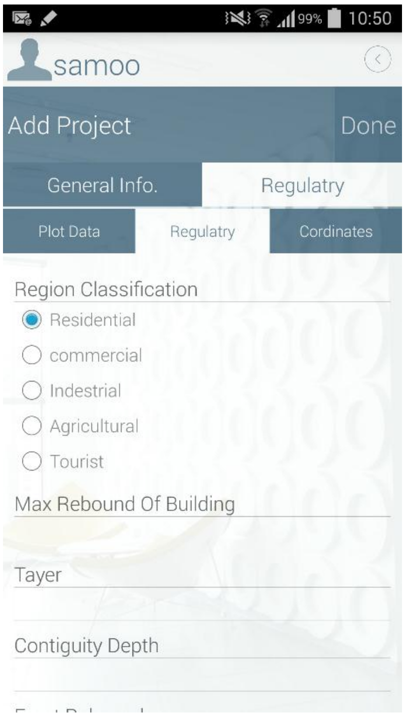


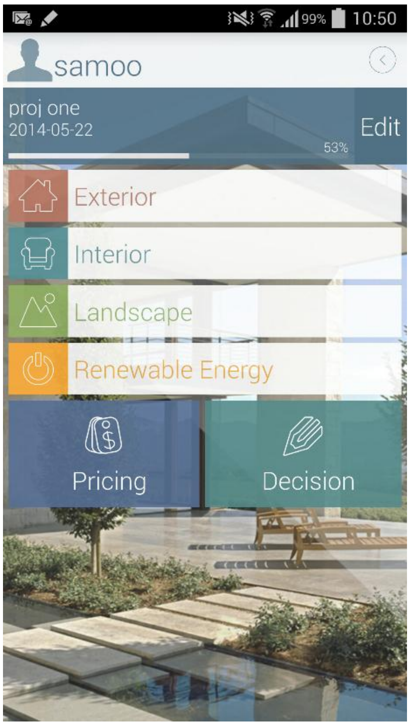
Regulatory information contain of:

Plot Data: In this part the user, insert plot properties like a zone, plot number, coupon number, plot area, development fees, building number, street number, plot type, street type, type of property title and case of plot.

Regulatory: In this part the user, insert regulatory properties like a region classification, max rebound of building, tayer, contiguity depth, front rebound, right side rebound, left side rebound and number of floors.

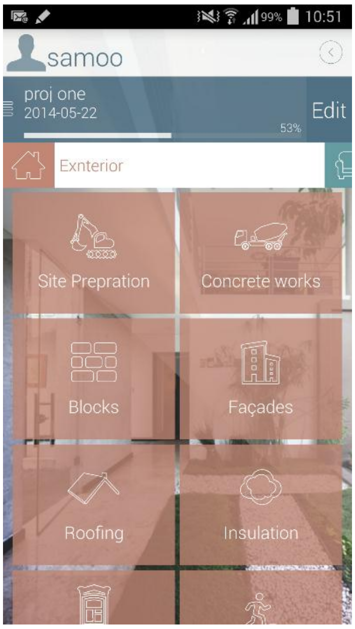
Coordinates: In this part the user, insert coordinates properties.

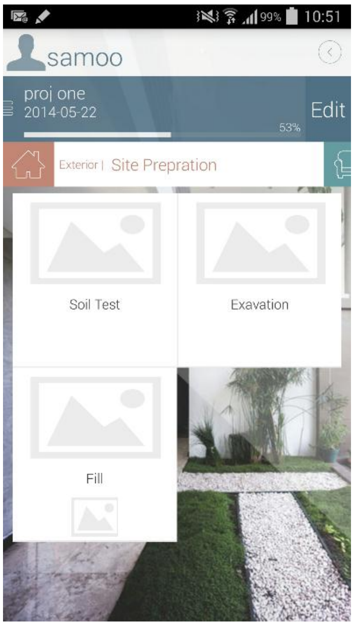


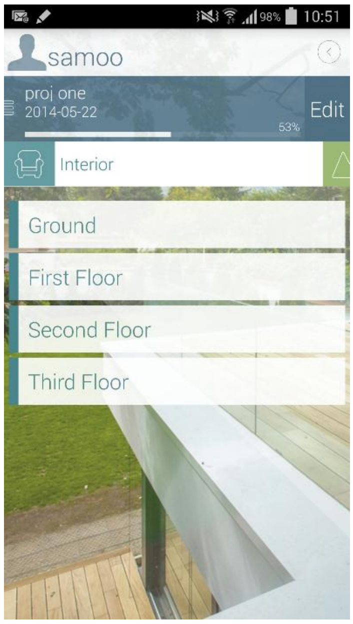


10. In external work, application have all stages and related stuffs to establish building which are: Site Preparation, Concrete works, Blocks, Facades, Roofing. The user can click in any stage he want, and then sage page will opened. For example if he click on site preparation, he will found the information about soil test and he can insert the requested information.

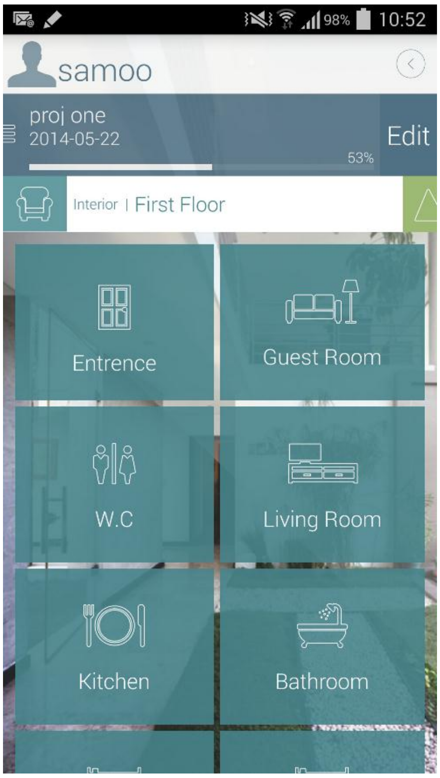
11. In interior work, application let to the user chose the floor he want to work in. It is give the user four option (Ground, First floor, Second floor, Third floor).

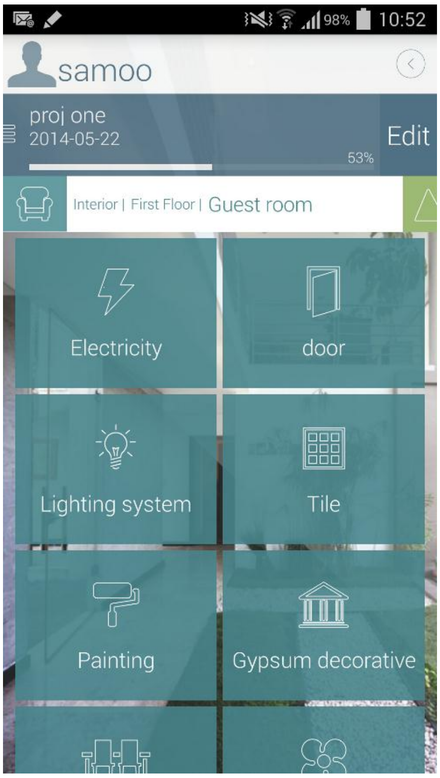




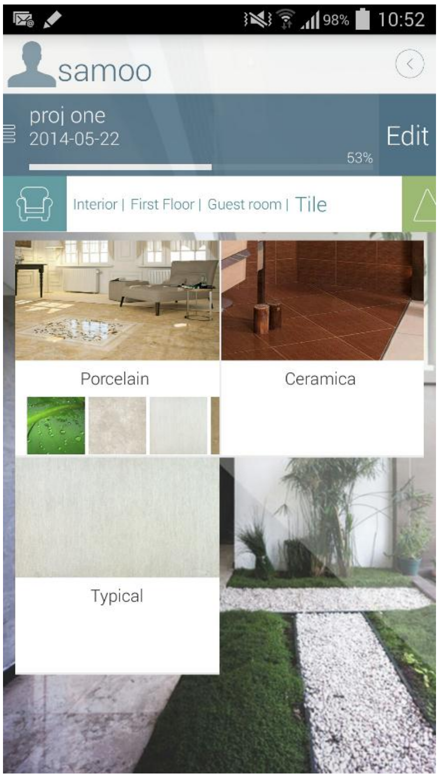


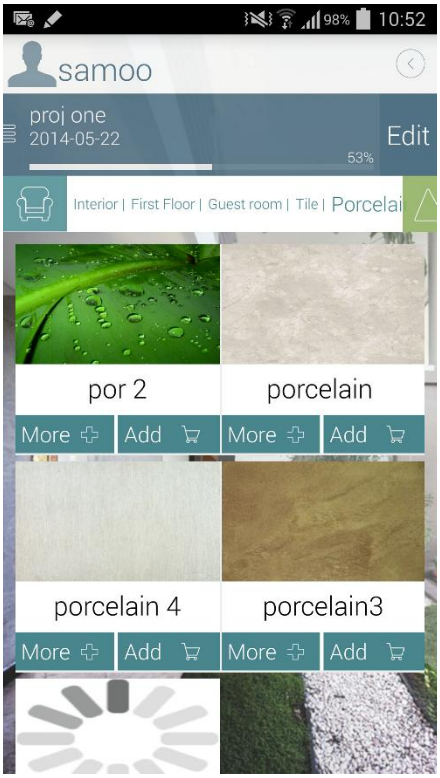
After click in any floor icon, the user will enter in floor partition such as entrance, Gust room, W.C, Living room, kitchen etc... Subsequently he will enter to room design parts which its electricity, door, lighting system, tile, painting, gypsum decoration etc.…





Also in if user click in any icon like (electricity, door, lighting system…) the App will lead him to <u>another</u> page that is types of it and when customer choose one, user will turns to page have specific details and more kind for every type .



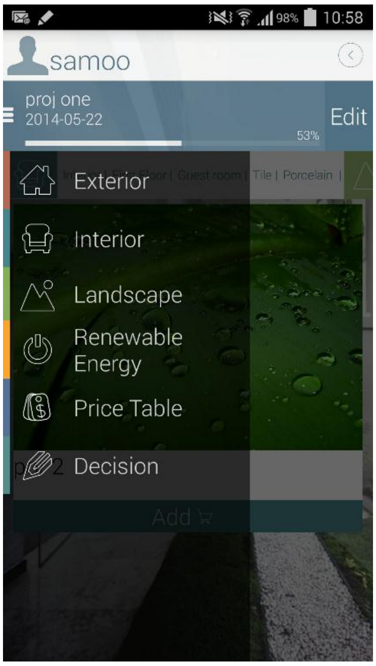


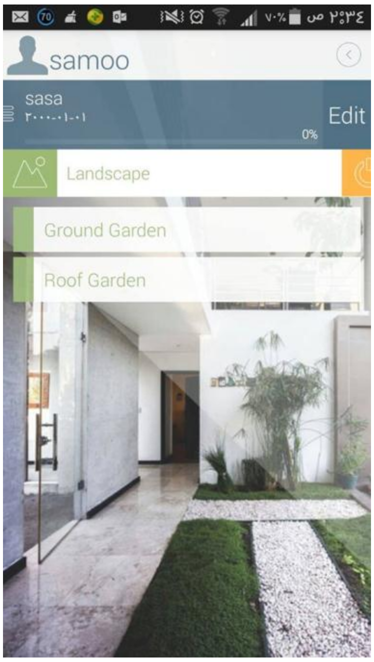
On this page, the user can click on more to see, more color for material or more details. Also, one click on (Add) to add it to his requirement for the home. Then the Design Manager App will add the cost of the type for the total cost estimation of the house.

12. From side slide, the user can switch between the designs for exterior, interior, landscape, renewable energy price table, decision as show in pic 22.
13. In landscape work, application left to the user selected the type garden that is suitable to him whether it's ground garden or roof garden.

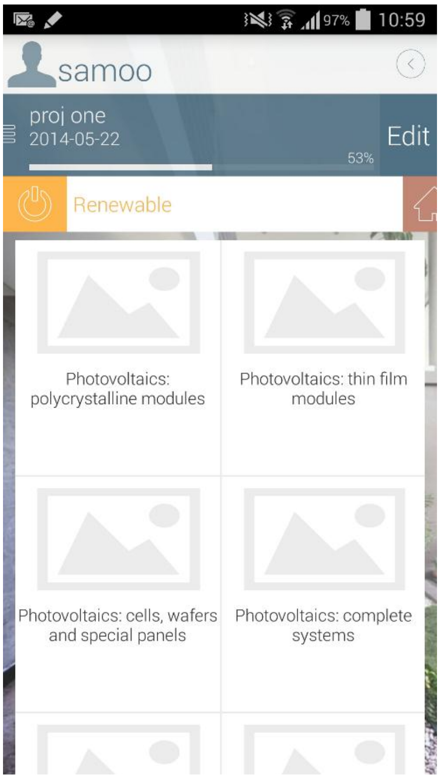
After choosing a type of ground, the user switches to another design details like lighting, grill, furniture, deck, pergolas, canopies, carports, patio umbrellas, planters, garden spot, garden edginess, garden fountains, period lighting and water treatments, garden fireplaces, stepping and deck boards.

Moreover, when user click on any icon on them it will lead him to more details. Then he will choose the type he needs and add it to cost of home.

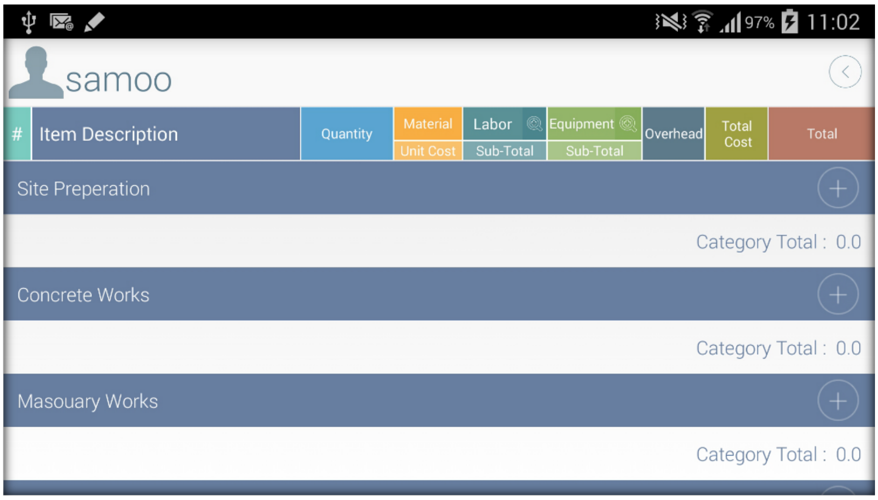




14. In addition, the same previous steps will happen, when user click on renewable energy.

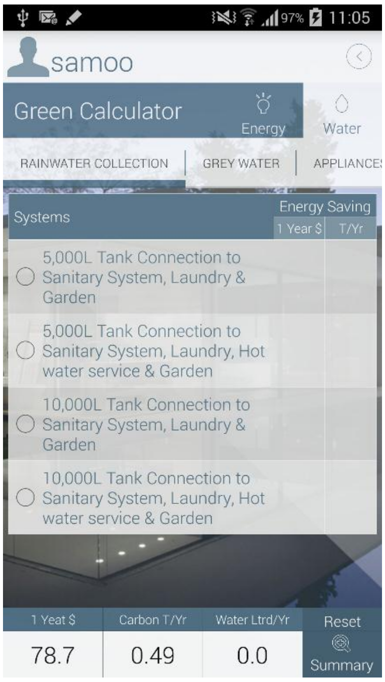


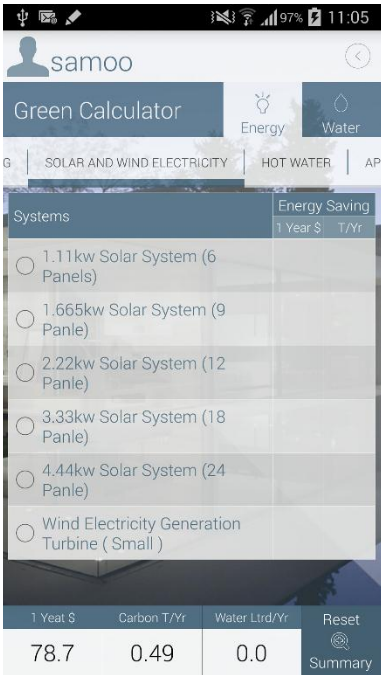
15. Finally, the app will calculate all cost and prize for every part of work, and gives customer material price details with unit price and all material price.



After app makes calculation, it will give the user the cost estimation for the project, and tell him if it over budget or on budget. And give him the discount percent if he have.

In addition, of all service app present a unique service for user that is green calculator.





Chapter 7: Conclusions and recommendations

7.1 Introduction

This research aimed to promoting green building practices in Palestine through identified the challenges, barriers, applications and benefits which affect the implementation of greening construction in Palestine this achieved by studying green building practices in developed and developing countries and through conducting practical case studies, Also suggested specific modifications to conventional building practices to optimize the delivery of cost-efficient green building projects through conducting two simulation model using linear programming method to allocate best method to converse energy and water. Mobile application prototype was developed for promoting green building practices to use by owners and consultants and its main function was supported cost estimation tool for greening residential building. This chapter included the conclusions and several recommendations suggested to promote green building practices through the previous objectives which are studied in this research.

7.2 Conclusions

Based on the analyses, findings and discussions in the previous chapter, the methods of promoting green building practices in Palestine. As the triangulation method emphasizes seeking corroboration from both quantitative and qualitative data, only hypotheses supported and cross-validated by both quantitative (i.e., supported by main survey) and qualitative (i.e., supported by personal interviews) data analyses were included in the final mobile application of the current study. From the current study the outcomes indicated the following:

7.2.1 Outcomes related to Barriers for green building practices in Palestine:

There are numerous barriers preventing green construction in Palestine; most of the experts from engineers, contractors, developers and researchers attribute these barriers to the political situation while others think that although instability and insecurity play a major role in preventing sustainable growth but they believe that there are many other causes such as:

1. Operational factors: failure to effectively manage markets, finance, employees, prices and customer satisfaction.

2. Management skills, technical ability and leadership, decision making ability, motivation and aspiration values of managers.

3. Accepting change.

4. Financial constraints; lack of financial resources.

5. Limited marketing and human resource management expertise; lack of understanding marketing concept and lack of employees training and development.

6. Limited strategic planning; market segmentation, pricing strategies and environment analysis.

7. Limited incentives for innovation.

8. Ineffective information technology, lack of system knowledge.

9. Ignorance of life cycle cost, lack of education and knowledge in sustainable design, and client worries in profitability and pay-back period.

7.2.2 Outcomes related to cases studies for green projects in Gaza Strip:

7.2.2.1 Case Study (1): construction of Kuwait city school at khanyounis city

It can be concluded from the collected and analyzed data Gaza Strip suffers from many problems. One of the most important problems is population density and limited sources and not applying the conceptions of sustainability in a way that achieves balance. But, in this project we've created a school environment-friendly, matching to LEED (Leadership in energy and environmental design) criteria in assessment of achieving sustainability for building from several side, where this project include sustainable solutions were achieved through the following:

- Reduced heating and cooling demands covered by energy produced on site with renewable.
- Reduced water demand for cleaning, WC, irrigation and personal hygiene through applying to rain harvesting system.
- Using raw earth materials as building material in construction green school.
- Reduce of CO_2 emissions.
- In summer classrooms' temperature is cooled down through thermal mass and natural ventilation while In winter classrooms are heated by solar powered air conditioning
- Better learning environment (classrooms with lower temperatures in summer and warmer in winter).

7.2.3 Outcomes related to simulation models:

7.2.3.1 Model (1): Linear Programming for optimizing efficient allocation of budget for household energy conservation in Palestinian houses

In this study, linear programming method was used to maximize energy savings subject to budget for a hypothetical household in Gaza city in Palestine. The subject house was selected to be a five-floor, detached building. The methods involved to decrease the building's energy consumption were installing photovoltaic solar panels on the roof, replacing incandescent light bulbs with compact fluorescent light bulbs, installing double-glazed windows, installing double wall and installing solar heating water. The physical constraints of the house in regards to the above-mentioned methods were as follows:

- A total window area 122 m2
- Total roof area allocated for solar panel installation: 84 m2
- Total number of light bulbs to be replaced: 84
- A total wall area 400 m2
- Total roof area allocated for solar panel installation: 84 m2

The energy savings were calculated in power units (Watts). Energy savings induced by each individual method were either obtained from manufacturer or distributor companies' websites, or calculated where applicable. The purchase and installation costs of each of the energy saving methods were obtained by taking the averages of various values gathered from the manufacturer or distributor companies' websites. Lindo 6.0 software was used to for linear optimization. The energy savings were calculated as a function of total allowable budget, and budgets ranging between \$3,500 and \$91,000 were used as inputs for the model.

The results indicated that installing photovoltaic solar panels is the optimum choice throughout the entire budget range, as a result of the high energy saving opportunity. Renewing household appliances did not emerge as very profitable options, due to the low energy savings when compared to other techniques. Double glazed window installation, double wall installation and purchasing compact fluorescent light bulbs was the optimum combination because of the relatively low cost.

For the given constraints the maximum amount of energy savings was found to be 274051.8 W, at a budget of \$77,000 as the researchers, we believe that the most significant contribution of this particular work to building energy research is the methodology developed rather than the results themselves. The model we presented can be modified as desired for different households, climate conditions, or countries so that the final results would be completely different. The reason we decided to implement the model by using data obtained from local sources was to ensure consistency, yet we believe the model can be applied globally as long as the required data can be provided.

7.2.3.2 Model (2): Simulation Model using Arena program for Water Management in Existing Residential Building in Palestine (Grey-Water System).

A. Simulation model importance

- Model can run for 24 hours and programming the pump, according to the capabilities of the peak and the calculation of the required ground tank capacity and the required capacity of elevated tank.
- Model shows full scenarios of municipal pumping and pumping the ground tank to the elevated tank and consumption of a flats in a residential building and can be controlled in these scenarios to improve the design of future in the Gaza Strip.
- Model shows that the value engineering where reality appear from the use of water resulting from hand washing basin (backwash) to clean the toilet unit.
- This is Model nucleus to build an integrated model shows the pressure and consumption and therefore can be improved hydraulic design accordingly.
- Could be the nucleus of the adoption of simulation science in the work of the municipalities of the Gaza Strip.
- This model represents a model residential building of 5 flats truly representative of the building where verification fact that the percentage was 95%.

A. Model constraints:

Many constraints considered to control the system these constrains are:

- The period where the electricity is available in Gaza strip (around 16 hrs. /day) which control the period of operation to the system.
- Period of pumping water municipality to residential building in area which control the operation of system pumps in building. (Around 8 hr. /day).

- The maximum capacity of ground tank (10 m3),elevated thank (7 m3) and backwash tank (1m3) which will calculate through knowing to the daily consumption of water by using simulation in this system .

7.3 Recommendation:

1. Adopting the principles of green concepts in buildings design as a solution for the problems from which Gaza Strip suffers.

7 As a result of the adverse impacts of fossil fuels in the environmental used in diesel generators where produces air pollution and the need to buy oil from Israel with high cost , it is recommended to use solar energy system to mitigate these cost and avoid to use generator diesel.

8 Gaza strip suffering from lack of potable water and irrigation water due to increasing in population, also increasing in untreated waste water that is dumped, it is recommended to implement the techniques of water management and water conservation such as rain water harvesting, treatment and reuse of sewage and gray water for irrigation, toilet.

9 Due to change in the temperatures degree during seasons, it is recommended to use shading elements, panels and skylight.

10 Encouraging the use of gray water system resulting from laundries, washing machines and kitchen sink and hand washing basin to re-use in toilet as it provides saving in the water quantities amount of 30% of total consumption of water per day.

11 To encourage designers to use the Arena program in the internal water network design inside residential buildings, and to increase the value engineering through increase the efficiency and effectiveness of water tanks

12 We recommend to add of the rain water system as another source of sustainability in projects

13 The study of developmental work so as to re-use the water from the sewage output in other operations, such as agriculture and injected in the ground.

14 It is recommended that, every decision maker must learn simulation methods according to simulation ability to solve complex problems.

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