Design a Computer Program for Sustainable Materials to Apply in Egyptian Housing

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Abstract

Public buildings are not without the use of energy and resources to operate and adapt them to their users' needs. The close link between environment and development has led to the emergence of a concept of sustainable development to increase better opportunities for people in a society without a shortage to meet their basic needs for a long period. To achieve prosperity and happiness for society the leading role of conscious architects is to be aware of the importance of the application of energy conservation systems, rational consumption, and the use of renewable energy alternatives to preserve the environment and reduce pollution resulting from using traditional systems of power generation. Many policies have been developed to address these growing problems associated with the nature of social and economic changes in Arab societies. The housing crisis is one of the most pressing crises the country has faced for decades. The high rate of population growth and the increase in migration from rural to urban areas have made it difficult to cope with the urban population and its demands for services and facilities. Since the mid-1970s, the state began to search for land for the housing projects and began to provide subsidized housing, especially low-income but did not provide the success these projects' problems and did not meet the needs of users. The problem is the lack of availability of computer programs in the Ministry of Housing, government bodies, and special housing agencies that help designers make the right decisions in choosing the right materials in each region that tolerate. climatic conditions and adapt to nature. So, the data was collected like materials, specifications, and prices from those Institutions. Then some programs and tools were used to enter all information and data of materials, specifications, and prices by designing a computer program to apply them in economic housing. The research **aims to** reach modern methods to reach construction sustainability and to devise ways to measure the application of methods and determine the degree of sustainability and how to apply technology and organize management, sustainability, and environmental conservation through the work of designing a computer program for sustainable materials for appropriate solutions in buildings in Egypt. The research presents using of new techniques like designing a computer program that considers the introduction of using local and sustainable materials to guide designers and companies in selecting appropriate materials from the results and graphs in each region to reduce costs and achieve sustainable development.

Keywords

Housing • Local materials • Construction • Computer program. Cost

1 Introduction

Throughout the ages, humans have developed tools and techniques that helped provide their needs and improve production to live in well-being and comfort (Afifi, 2011). They began to learn and innovate to find the best solutions, especially in the construction of the house or shelter, where the age was characterized by the continuous development and acceleration and the rapid change of images and materials quick social and economic data. Technology has begun to emerge through ideas and creativity to solve the environmental problems that have emerged in recent

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periods, which led to reconsidering the rebalancing of man and his environment and calling for the development of technology to serve the human and improve the surrounding environment (Osman, 2013).

They had begun to deal with natural materials before the emergence of industry and technology, where he began to form the stones pharaonic civilization in the temples and tombs, also formed wood materials to get different shapes and sectors, and then emerged porcelain and bricks in the Assyrian civilization, while Greece used marble and stones and added Roman Mosaic and gypsum engraved and decree They used natural concrete, then iron was used in the eighteenth century, then steel appeared and was widely used in the 18th. Industrial cement emerged as it expanded significantly in the concrete industry and became the most prevalent material. Also, the plastics and aluminum industry developed and the timber industry developed. Technol- ogy entered the material industry and innovated in modern materials and covers, which became modern styles in architecture, which made it difficult for the designer to choose the suitable building materials for each project by location (Osman, 2013) as shown in Fig. 1.

The research is based on the following questions:

i. Are there other procedures and solutions to improve housing projects during design and operation?
ii. What are the benefits when applying the idea of design, a computer program for materials that can be selected?
iii. What is the way to control the project costs and provide the needs of users as much as possible?

2 Compare the Development of Computer Programs with the Current Program Designed

The computer has become one of the foundations of contemporary life, which has been reflected in architectural creativity in its various stages. Many computer programs appeared to reduce and solve complex problems and facilitate your approach to the architectural designer. In the sixties, the beginning was the drawing of design elements, and they still represent the basis of the two-dimensional programs used today. At the beginning of the seventies, programs began to develop in three dimensions, and at the end of the seventies and the beginning of the eighties.

The modeling process reached levels of development, then with the development of technology and the development of human thought in the nineties and twentieth century. Programs began development through companies and individuals programmed to design easier and reduce problems. These programs have evolved and gone through various stages until they have concluded that a set of programs with each other design or assistance in the design of the building, not only architectural but also in more than one major, as well as calculating the quantities of materials used in the project and estimating its cost and others of operations (Mahmoud, 2012).

Table 1 reviews some of the programs used, their types and their different uses, as it explains the history and development of the various programs that have emerged to assist architects in the building.

3 Research Objective

The research aims to reach appropriate methods of construction sustainability through designing a computer program for sustainable materials to choose appropriate solutions in buildings in Egypt. Research takes the following.
proceeding to achieve the goal.

Design a computer program by name (sustainable materials in economic housing) that assists in the introduction of local and sustainable materials to assist designers and companies in selecting appropriate materials from the results and graphs that are appropriate in each region to minimize costs and achieve sustainable development.

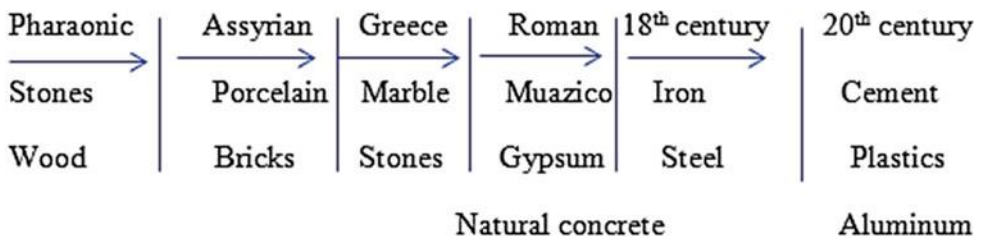


Fig. 1 Locations and availability of local building materials in different civilizations. *Source* Al Saeed & Jamal Abdul Ghani (2017)

Table 1 Some of the programs used, their types and their different uses, as it explains the history and development

	Problem analysis models (DP)		Building inference models for previous cases (CBR)		Productive design systems (GDS)		A number of different directions
	YASMIN	RBSaace	CADRE	MONEO	GAT	FWT	SEED
The producer of the program	Faculty of Engineering, Shubra, 1 University	Texas A&M	Swiss Federal Institute of Technology	A subscription between the University of Alexandria and the University of Kaiserslautern, German	Washington University'	. Alexandria University Faculty 'of Engineering	Carnegie Aiellon
Program designer	Ashraf Abdel Moneim Jaafar	Scott Anthony Artin	Joint work between architects And computer scientists	Dina Alohamed Samel, Talia	HudaHuna-ouiu	Hosni. Ahmed. Al-	Robert 'Ulrich Si James Snyder' Coyne
Time period	1996	2004	1990	2006	2007	2010	1994
The goal of the program	A proposal to assist architects in the early design stages	A proposal to assist architects in the early design stages	It helps to reuse models Previous design in producing innovative designs	A tool used in assisting the designer in the initial design stages of the process Design offers only similar solutions	A tool used m the production of designs Assist in the initial design stages for the design process	A tool used in the production of designs Assist in the initial design stages for the design process	Supports and benefits the designer in the first stage to design the building
Cases in the program	It is not limited to a specific type. Architectural projects	It is not limited to a specific type Architectural projects	Various cases divided into complex cases and simple cases according to its histoid sign	Low and medium housing units Costs	It is not limited to a specific type of Architectural projects	Tool for producing prototypes of waterfalls villa	Architectural projects of a recurring nature, as well as hospitals, housing units, and others
Design production	It depends on a mathematical model	It depends on a mathematical model	Creates designs by changing dimensions for previous models	The program displays cases like the functional relationship diagram, solving the horizontal projection of the residential unit 1	It produces a number of alternatives based on Genetic algorithms	It does not retrieve cases but rather produces alternatives emanating from Allla Waterfalls	Design cases are automatically retrieved after Conformities and requirements with the current state to be designed depending Object-Oriented on object
Output design processing	Design processing is primarily dependent on Designed Engineer	It allows the designer to interact with him to modify and sole the design problem	The user participates in the program in setting innovative design settings and the program develops a solution or a combination of	It does not treat design cases but show it only	Design processing is primarily dependent on Designed Engineer	It does not handle cases, but only produces them according toasetofiules, then evaluated by the design engineer	Supports interactive correction of the problem

Source Mahmoud, A. R. M. (2012). *Evaluation of Selected Programs for Computer-Aided Architectural Design.* Faculty of Engineering in Shubra, Banha University, Egypt

4 Methodology

4.1 Theoretical Approach

Includes a comprehensive theoretical study of the relationship between building materials and architecture, defining building materials, types, and conditions.

4.2 Applied Approach

- It deals with the extraction of indicators and elements of modern methods that achieve sustainability that benefit the designer and the community to minimize the negative effects through designing a computer program by name (sustainable Materials in Economic Housing) to evaluate the appropriate materials through the work of matrices to choose the best materials suitably, Specifications and prices for application in residential buildings.
- Also calculating the total price of the required quantity of each raw material per meter to choose appropriate specific materials to reach the objectives of the research and finally, the research finds a set of conclusions and recommendations.

They are some programs and tools used in design a computer program in the research:

(a) Programs:
   1. Visual Studio 2013.
   2. SQL server 2012
   3. Team Foundation Server (TFS)

(b) Libraries:
   1. Bootstrap
   2. Kendo
   3. Jquery
   4. Entity framework
   5. Microsoft Office

(c) Tools:
   1. c#
   2. OOP
   3. MVC
   4. Linq
   5. HTML
   6. Javascript
   7. Jquery
   8. CSS

5 The Relationship Between Building Materials and Architecture

The relationship between building materials and architecture remained simple until the industrial revolution, where construction materials were chosen either because of them availability or because of their external shape and comfortable (Hilal & Mahdi, 2014). Over the nineteenth century, architects adopted the choice of building materials on the form and function together and the availability of such materials in the local environment, where the role of building materials changed dramatically as the industrial revolution progressed (Wdeh et al., 2019).

Therefore, the concepts of sustainability and environmental architecture have emerged to reflect on the use of local building materials from renewable sources and low emissions and pollutants, characterized by durability, high resistance and recyclability which are the most important characteristics of sustainable materials (AbdulQawi & Walid, 2018).

6 Building Materials

Building materials are elements of architectural output in an era of previous eras with the development of possibilities, traditional building materials and increased knowledge of the possibilities and architectural and structural properties helped to develop architecture throughout the ages (Gamal Eldin, 2018).

Building materials include a huge boom in the construction industry and all stages from construction to internal and external finishing, including natural materials such as stone, clay, wood and sand, natural materials made of natural raw materials such as bricks, materials manufactured on natural materials such as concrete and steel and then industrial materials such as plastics, glass and paints. Construction materials are classified by the designer in the selection of type, specifications and price in the implementation and formation of buildings and output to achieve the sustainability of the building and longevity (Al Saeed & Jamal Abdul Ghani, 2017).

(a) Natural materials
(b) Manufactured materials
(c) Blended materials.

These materials and their properties are studied and the impact on the climate, environmental or social and economic aspects. It is the responsibility of the designer to choose the right materials to achieve environmental balance and user satisfaction. The materials were classified into three categories as shown in the Fig. 2.

Therefore, building materials must meet two basic conditions:

The materials should not affect high energy consumption whether in manufacturing, installation or even maintenance.

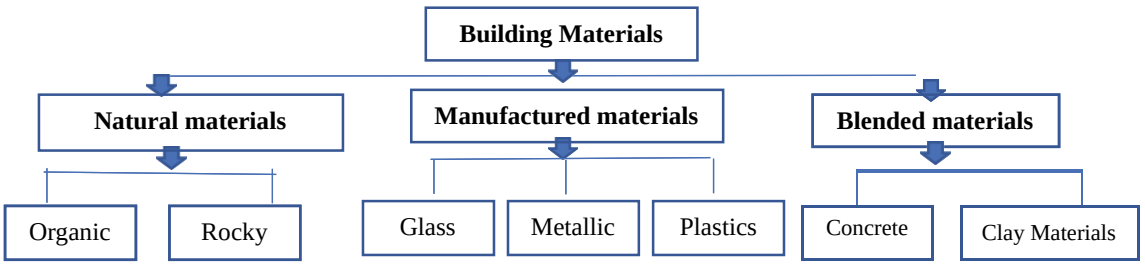


Fig. 2 General classification of the most important construction materials. *Source* Al Saeed and Jamal Abdul Ghani (2017)

It should not cause an increase in the internal or external pollution of the building. Therefore, it is preferable to use natural building materials that bear the external environment factors and adapt to the environment (Arafa, 2019) as shown Fig. 3.

6.1 Conditions of Building Materials

First: Manufacturing Processes are carried out in manufacturing or operation on the raw materials in the site, condition of the soil and its characteristics include: specifications, chronological life, and composite materials consisting of the manufacturing material. For example, timber is a natural environmentally friendly manufactured materials and needs little energy to manufacture and is the most lightweight and environmentally friendly materials and this is what made developed countries use in Europe and America diffuse.

Fig. 3 Production and use of bricks from local materials at sites. *Source* Al Saeed and Jamal Abdul Ghani (2017)

Second: Insulation Materials must be characterized by good insulation properties of increased temperature and noise or any other environmental factors, which leads to saving energy consumption and reduce pollutants.

Third: longevity life of the material in buildings that led the relationship is direct, the age of the material gives additional points for buildings to the criteria for sustainability. For example, stone is one of the most longevity materials used by the pharaohs in building the pyramids for thousands of years.

Fourth: Recycling: It is preferable to recycle demolition waste and constructions that reduce costs and continuous consumption whenever the material is recyclable, it is considered environmentally friendly as shown Fig. 4.

6.2 Construction Waste

Construction waste is defined as solid waste that is not hazardous and harmful to the environment except when collected, sorted and recycled from construction activities such as demolition, construction, development and restoration, and materials resulting from the work on-site include: asphalt, brick blocks, wood, glass, iron … etc. (Al Saeed, 2017).

The principle of recycling considers the reduction in the use of energy-consuming materials and the increase of pollutants so that buildings are designed and constructed in a way that makes buildings sustainable and longevity, so there are some materials and the proportion of waste as shown Table 2.

6.3 Recycling Building Materials

Recycling of materials contributes to the preservation of the environment and the reduction of pollutants through its role in achieving the following:

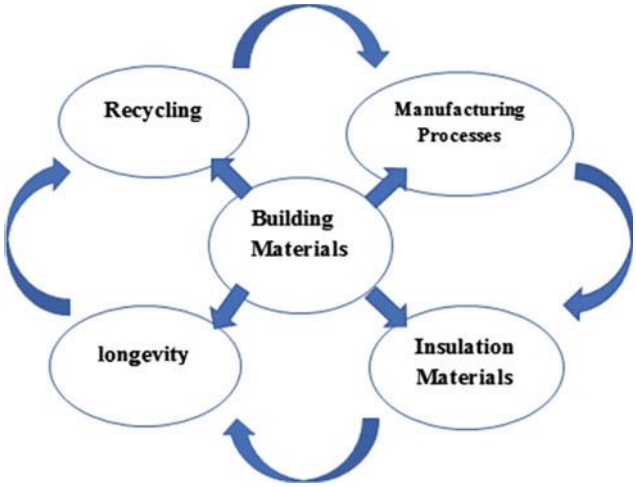


Fig. 4 Conditions that must be met in environmentally friendly building materials.

1. Conservation of energy resources and renewable materials.
2. Reduce consumption by prolonging product life.
3. Reduce consumption through recycling.
4. Energy-saving by reducing production processes.
5. Produces high economic returns from the sale of recyclable products and manufacturing as shown Fig. 5.

6.4 The Life Cycle of Sustainable Building Materials

There are criteria for analyzing building materials during the three basic stages of the building life cycle:

(a) Pre-construction phase such as extraction of raw materials manufacturing of materials—packaging materials—transport to the construction site.
(b) Construction phases such as implementation, operation, and maintenance.
(c) Post-construction phase such as recycling–reuse as shown Fig. 6.

6.5 Plan to Apply Sustainability Standards and Use Environmentally Friendly Materials to Solve Building Problems in Egypt

Figure 7 reviews plan to apply sustainability standards and use environmentally friendly materials to solve building problems in Egypt.

7 Design a Computer Program

Significant advances in computer technology and information systems contributed effectively to the construction industry, architectural design in general and sustainable architecture in particular, which helped and solved problems on the emergence of forms. It became an interactive architecture that helped the architect consider the human and environmental requirements to choose the right materials and decisions (Shukr & Aboud, 2016).

7.1 Designing a Simulation Program for Building Materials and Choosing the Most Suitable for Application in Housing (Inputs of the Program)

The simulation program for building materials is designed to enter data and specifications of building materials, where general information about the regions, climate, temperature, and humidity, the average income of individuals and prices of building materials are entered.

Table 2 Some materials and the proportion of waste:

Material	Percentage of waste (%)
Concrete and stone mixture breaking	40–50
Wood	20–30
Cutters	5–15
Asphalt	1–10
Metals	1–5
Block Horde	1–5
Plastic	1–5

Source Al Saeed and Jamal Abdul Ghani (2017)

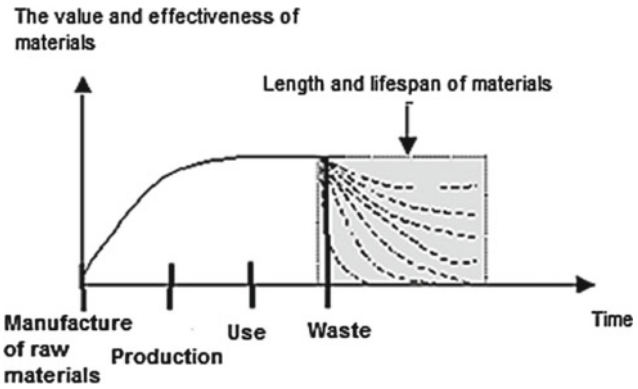
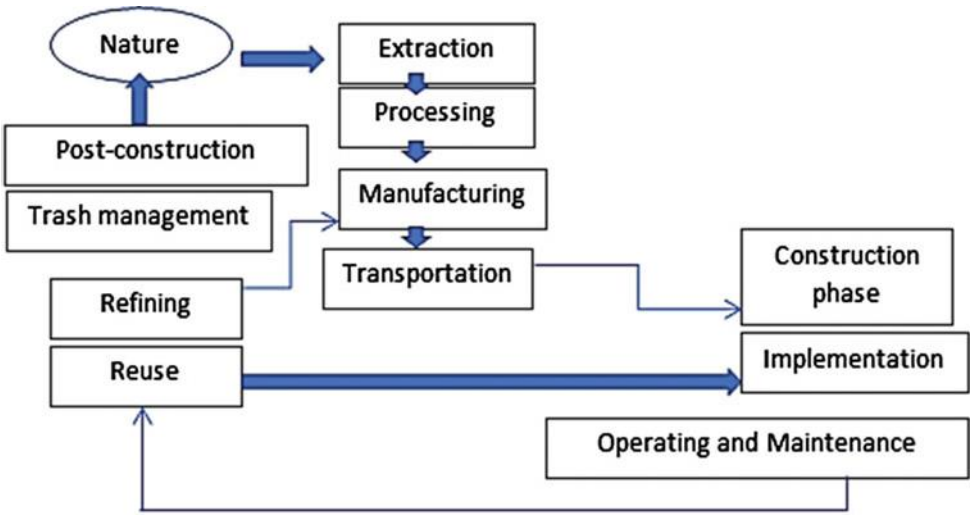


Fig. 5 Recycled building materials. *Source* Al Saeed and Jamal Abdul Ghani (2017)

Fig. 6 The life cycle of sustainable building materials



Through this, the regions were determined and thus determine the climate of temperature, humidity, materials to choose the appropriate materials, thus reducing the costs of transportation and utilization of local materials.

7.2 The Contents of the Program

1. Region's data in Egypt.
2. Data of climatic regions and their governorates through the Egyptian code and the annual statistical book of the General Authority for Mobilization and Statistics.
3. Data of local building materials available in each region, specifications and prices.

7.3 Characteristics of the Program

1. View the regions and provinces in Egypt.
2. View climate data in each region for possible identification.
3. View local materials were available in each region to be selected for application in housing projects, which reduces transportation costs and materials imported from abroad.

7.4 The Program Structure

See Fig. 8.

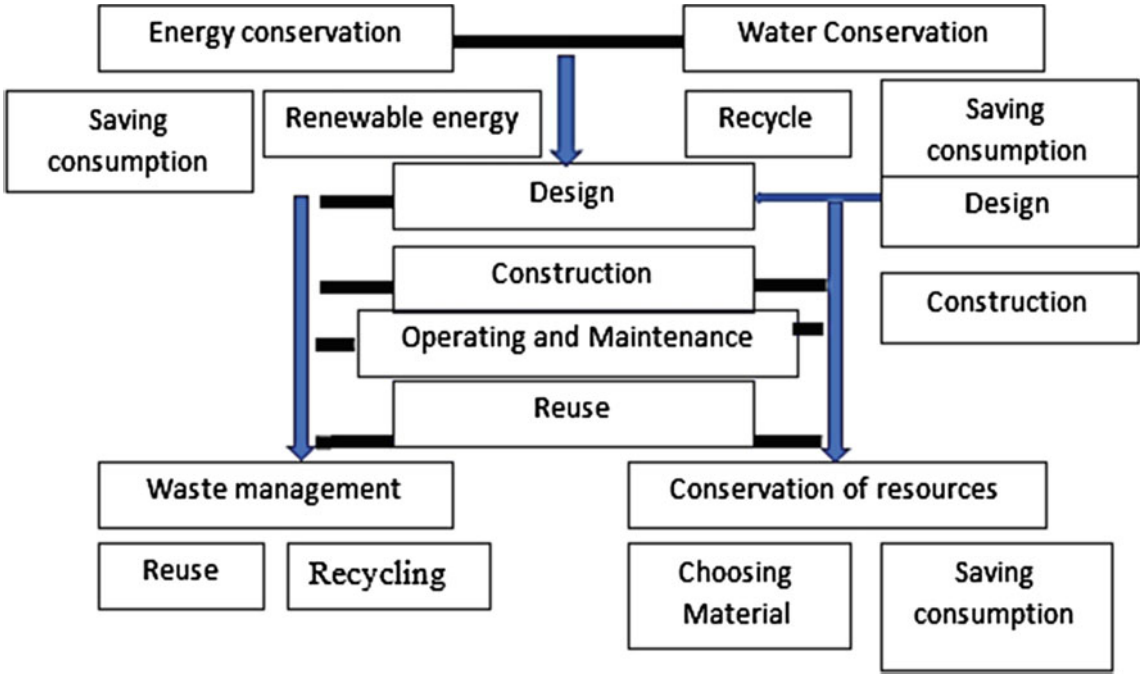


Fig. 7 Plan to apply sustainability standards and use environmental materials.

8 Results and Discussion: The Computer Program Interface (Phases of Using Program)

The research results to work and develop an evaluation method for local materials through databases through the design of computer program by collecting data for materials, specifications and prices to reach the appropriate materials and achieve sustainability to reach the objectives of research through:

- Review of data and review of climate tables, regions, population, locally available materials, and the average income of purchasing power of materials for housing construction at appropriate costs and identify them.
- Identify local building materials available in each region.
- Review and apply the Egyptian code to improve energy efficiency in residential buildings through climate schedules for each region and building materials to choose appropriate materials.
- Evaluate the appropriate materials through the work of matrices of those materials to choose the best materials, specifications, and prices in housing.
- Calculate the total price of the required quantity of each raw material per meter to choose appropriate specific materials from graphs to make analysis and housing report as shown Table 3.

9 Conclusions

The results were obtained through the study to examine this program that had reached building materials to apply in housing by using local building materials that adapt and withstand environmental conditions to take advantage of natural ventilation and lighting resulting in reduced use of cooling and heating devices. Materials should be recycled and used for building waste materials that meet the criteria of sustainability throughout their life cycle and do not adversely affect the environment in the stages of manufacturing and operation.

The selection of materials is carried out in the feasibility stages of the new buildings, especially in the new cities, where the architect must collect information and data for the specifications of the materials and choose them as available in the local market, which suits the cost and environmental sustainability. After that follow-up and continuous evaluation of new cities and communities to record experiences and take the views of the people and the government to follow-up and resolve defects and problems to work to correct the course in future projects.

This paper finds design a computer program that assists in the introduction of local and sustainable materials to assist designers and companies in selecting appropriate materials from the results and graphs that are appropriate in each region to minimize costs and achieve sustainable development.

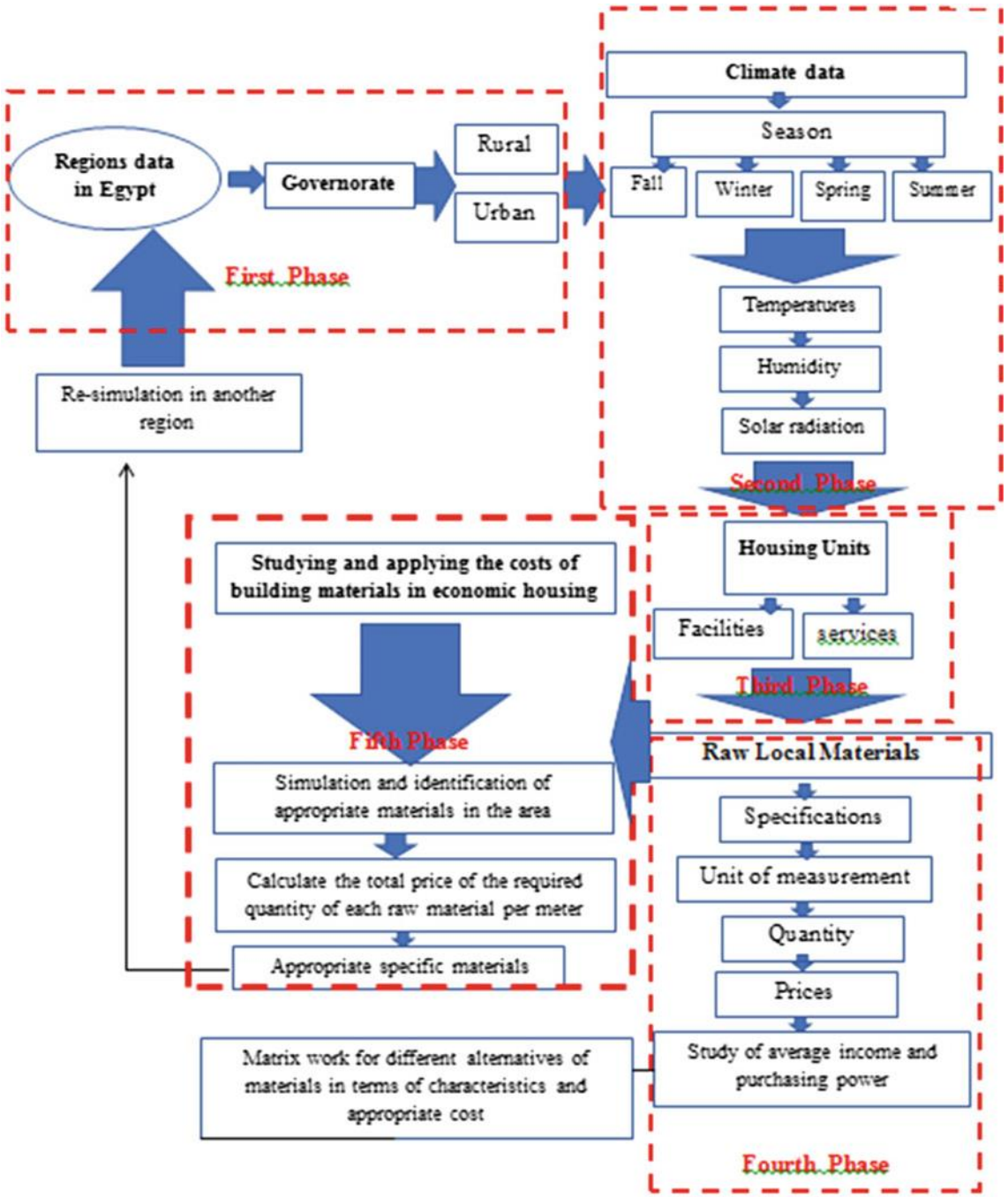
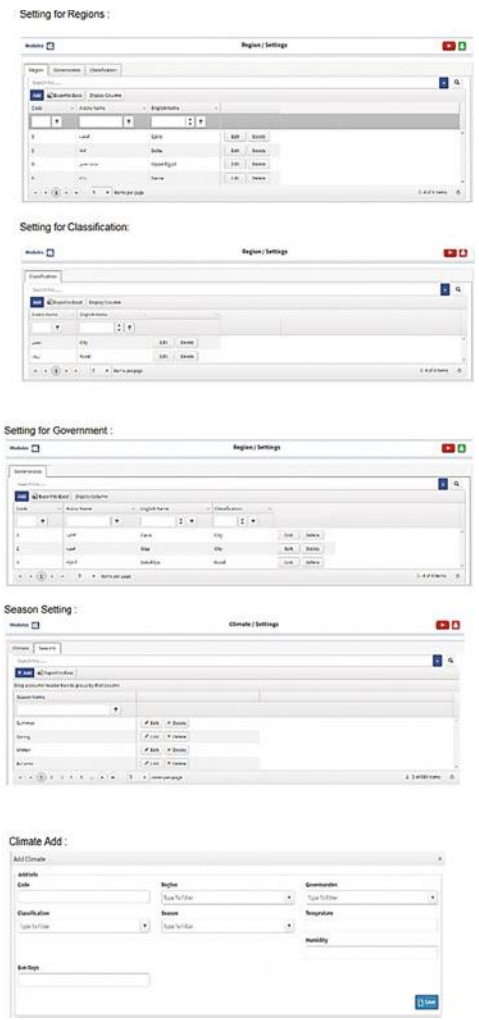
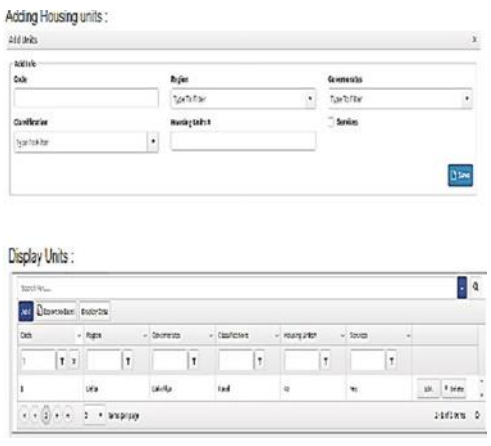


Fig. 8 The program structure. *Source* The Author

10 Recommendations

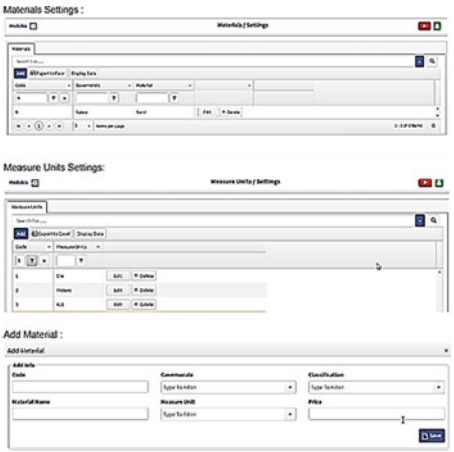
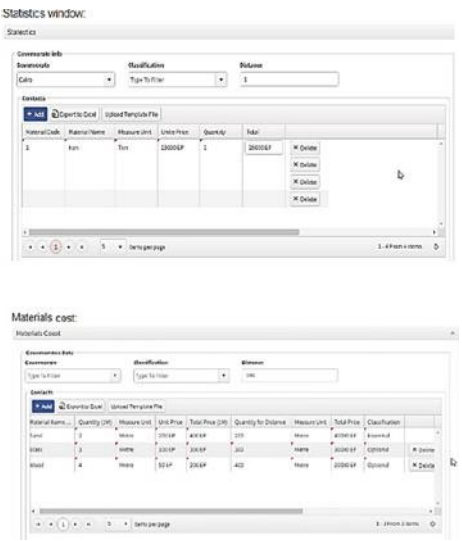
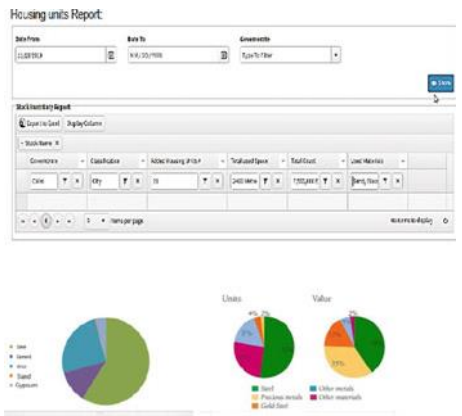
1. Encouraging companies and factories to utilize natural and local raw materials to produce sustainable materials, thus reducing the operation, consumption, and energy costs of the state.
2. Sustainability criteria must be adhered to periodically according to the environmental situation and development level.
3. The choice of the construction system must be compatible with the local capabilities of labor and equipment available besides attention and develop considerations of environmental problems to solve.

Table 3 The computer program interface (phases of using program)

Phases	Inputs	The computer program interface (Screen shot and outputs)
First phase: screen to add climate characteristics for each governorate:	– Code: governorate code appears automatic with the choice of the name of the governorate – Region: the region is selected from the list already prepared – Governorate: the name of the province is chosen from the list – Classification: select the governorate classification (rural/urban) – Season: season is selected (fall–winter–spring–summer) – Temperature: entering the degrees of great and minimum temperature – Relative humidity: the state of humidity is entered. – Sunlight: enter the state of sunlight (weak–moderate–high)	
Second phase: screen to add residential units	– Classification: select the governorate classification (rural/urban) – Housing unit: enter the name or number of the housing unit to be added. – Services: a tick will be checked if the housing unit is connected to facilities and services	

(continued)

Table 3 (continued)

Phases	Inputs	The computer program interface (Screen shot and outputs)
Third phase: screen to add raw materials that are shown and extracted from each governorate	The name of the material: write the raw material to be added and existing in the Governorate. – Unit of measurement: the unit of measurement for the raw material is selected from the list. – Price: enter the unit price of the raw material to be added	
Fourth phase: screen to make a statistical raw material used to build every 1 m in each governorate	– Area: enter an initial value of 1 square meter – Raw material code: all raw materials previously entered for each governorate are shown in the raw materials screen. – Name of the material: show the raw material to be found in the province. – Unit of measurement: the unit of measurement of the raw material is shown from the list. – Quantity: the required quantity is written in raw materials – Price: enter the unit price of the raw material to be added	
Fifth phase: screen to display the cost of the raw material used for construction according to the area of the building entered	– Total: shows the total price of the required quantity of each raw material, graphs to analysis make housing report	

Source The Author

4. Work and develop training programs for engineers and workers and how to communicate to make decisions and choose materials with considerations of costs and risks associated with some production processes in the construction sector.
5. Work on the production and development of simulation programs for the performance of buildings so that they correspond to the regions of the climate in Egypt to facilitate communication with designers and decision makers to reach positive results.
6. The state of government should be communicating with international and local companies to produce design programs and the need to participate in the proposal of innovative evaluation systems to reach sustainable architectural design.

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References

AbdulQawi, & Walid. A. (2018). *Policies of allocation and management of land and its impact on the sustainability of new cities*. Cairo University.

Afifi, A. M. (2011). *Towards the activation of an integrated strategy for the development of policies to provide and facilitate housing in the Arab World, an analytical study of the Egyptian experience*, Egypt.

Al Saeed, & Jamal Abdul Ghani. (2017). Building materials and their impact on green buildings. In *Third Arab development & investment conference in real estate and industry*, Fujairah, UAE.

Arafa, Z. M. (2019). *The environmental design of social housing buildings as a way to solve the problem of urbanization in the new cities*. Mansoura University.

Gamal Eldin, M. (2018). *Auditing standards and regulations for the selection of sustainable building and finishing materials for internal spaces of residential buildings*. Cairo University.

Hilal, M. M., & Mahdi, H. (2014). Sustainability in architecture: A study on the role of sustainable design strategies in reducing impacts on the urban environment. In *Paper published at the 13th Al-Azhar international conference*, Egypt.

Mahmoud, A. R. M. (2012). *Evaluation of selected programs for computer-aided architectural design*. Faculty of Engineering in Shubra, Banha University, Egypt.

Osman, F. O. (2013). *Selection of building materials for sustainability in architecture in developing countries (standards and mechanisms)*. Sohag University.

Shukr, A. A., & Aboud, B. A. (2016). Sustainable materials & construction techniques in Iraq. *Journal of Planned and Development, No. 33*, Iraq.

Wdeh, H. N., Roula, & Tanjour, K. (2019). The role of building materials in achieving sustainability of buildings according to global sustainability systems (Case study administrative buildings). *Tishreen University Journal for Research and Scientific Studies—Engineering Sciences Series, 41*(3), Syria.