CHAPTER 5

INTERNATIONAL AND LOCAL EXPERIENCES TOWARDS ECO HOUSING
After reviewing the main principles of the Eco House, this chapter will present examples of best practices in Eco-Houses both at the international and local levels in order to study how these principles were applied and how were their outcomes. On the International level, experiences from India, Israil and Tunisia were chosen because they applied lots of eco design concepts from using low embodied materials, low cost construction techniques and climatic design tools.

On the local level, experiences of pioneer architects such as Hassan Fathy and Ramses Wissa Wassef, together with the house constructed in Toshka and the Ecolodge of Siwa, were chosen for the local case studies. Along with these examples, efforts like: producing Egypt's map of available raw building material and its industries, enhancing building bricks to come with new types of bricks with insulation materials and bricks from industrial wastes- construction and demolition wastes- agricultural wastes, producing Egyptian residential energy code, had to be mentioned as a serious step towards accomplishing the Eco-Eco house.
5.1. INTERNATIONAL EXPERIENCE TOWARDS ECO HOUSING

5.1.1 MONAMA

LOCATION: Hyderabad, India
CLIMATE: Inland composite

This house relies on energy efficient design to reduce loads and, where possible, reverts to renewable energy to meet them. The house was completed in 2001.

5.1.1. A Low environmental impact:

The underlying ideology behind the building design was to generate as low an environmental impact as possible, within the limits of site and budget. Environmental impact resulting from both embodied (from materials) and operational (in use) considerations were assessed.

5.1.1. B Construction materials:

Although the original idea was to use compressed earth blocks, on further investigation the soil quality in the area was found to be unsuitable. It was realized that soil would have to be transported from approximately 400 km away and country bricks that were made within a couple of kilometers of the site would be a better alternative. Country bricks tend to require plaster on the external side as they are not of a quality that can withstand the extreme climate. The solution was to make cavity walls with country bricks on the inside and first class, wire cut bricks on the external façade. As a result, the need to use plaster was eliminated. This strategy also provides high thermal mass, which suits the prevailing climatic conditions. The upper floor and roof structure is made with reinforced concrete, which has low environmental impact. Natural materials have been chosen for most internal finishes (Fig. 93).

5.1.1. C Wall orientation and form:

West oriented openings are associated with external conditions of high solar radiation and ambient temperature during the summer. Thus the windows in this orientation were minimized or replaced with other solutions. Depending on the time of the day, high or low pressure zones form in either east or west directions. This induces air movement from the zone of high pressure to that of low pressure. The windows of the house have been
specially oriented such that these pressure differences, in combination with the prevailing wind direction, may be utilized for continuous ventilation. There is also a ventilation shaft to exhaust hot air located in the central part of the house, which is based on the principles of buoyancy and venturi's effect. The open plan design supports this process by eliminating any internal resistance to the full movement of air (Fig. 95).

5.1.1. D Buried pipes and evaporative cooling:
The system used is a water pond along with an air fan. The system provides cooling by consuming just the amount of electricity necessary for the operation of the fans. Since the fans consume less energy than air conditioners this proves an energy efficient design for maintaining human comfort. During the humid months evaporative coolers are rendered inefficient owing to the high humidity levels. The system allows for the ponds to be drained during these months (July through October) and window fans used to forcefully ventilate the house (Fig. 96, Fig. 97).

5.1.1. E Renewable energy:
In Hyderabad there are four hours of power cut each day. The client specifications were to design a system that works as a photovoltaic stand alone system during power cuts, and as a regular grid connected system when the grid is working. The battery chosen for this design allows for four days of autonomy, making unlikely that the client has to use the utility power to charge the battery.

5.1.1. F Solar hot water collector:
The system chosen in this house was the free flow system known as a thermosiphon system. The system has no pump or controls and is fully automatic in operation. In the thermosiphon system the tank is positioned above the collector. As the water in the collector is heated by the sun, it rises into the tank mounted above the collector. This causes the cold water in the tank to flow into the collector, where it is heated. In this way, flow is created and the tank is filled with hot water\textsuperscript{125} (Fig. 98).

\textsuperscript{125} Roaf, \textit{op cit}, pp.304-309
Figure 91
Ground floor plan
(Ref.: Roaf, op cit)

Figure 92
Elevation for Monama house
(Ref.: Ibid)

Figure 93
Wall construction, using stabilized mud blocks
(country bricks).
(Ref.: Ibid)

Figure 94
South and West windows, designed to avoid direct solar gain.
(Ref.: Ibid)
Figure 95
Ventilation paths through the house
(Ref.: Ibid)

Figure 96
Evaporative cooling
(Ref.: Ibid)

Figure 97
Buried pipes.
A: Inlet to circulate air 2m underground
B: Outlet for living area, with adjustable "trunk" (Ref.: Ibid)

Figure 98
The solar water collector works by thermosiphon.
(Ref.: Ibid)
5.1.2 REDEVELOPED PROPERTY AT CIVIL LINES

LOCATION: Civil lines, New Delhi, India.

CLIMATE: Composite

This project explores the challenges of designing and building a house in a dense urban setting. This eco-project includes four courtyard houses built on a street. The houses on the north face of the street are courtyard houses leading towards gardens on the south side; whereas the houses on the south side of the street have their gardens on the north side and are linear. These are all large single family houses, two to three storey high.

5.1.2. A Orientation:
The general orientation of the buildings is aligned east-west, with most window openings in the north and south faces. The courtyard houses, because of their square proportions in plan, also face towards the east and west. The windows on these faces look into narrow protected alleys or the small courtyard between the houses. The alley space on the west side is shaded by retaining the wall of the original double-storey building that had previously lined the side street. For the linear houses on the north side, the width of the driveway that separates the two row of houses is just sufficient to enable winter sunshine to enter the first floor windows. Terraces on the second floor have skylights that again admit winter sun into the first floor rooms on the north side of the house.

5.1.2. B Wind driven evaporative cooling:
The west house takes advantage of the prevailing north westerly hot winds that blow during the hot dry seasons. A vertical screen tower is built on the west wall. This tower houses Khus evaporative pads on its outer surface, fed by a water pump. The inner side has adjustable windows opening into the adjacent rooms. The natural wind pressure will drive air through the wet Khus pads and will then flow into the adjacent rooms. This vertical arrangement would spread the Khus fragrance across the two storeys of the house (Fig. 101).
5.1.2. C Courtyard roof:
The roof courtyard of the two courtyard houses is intended to be the main climate response device. The hipped steel frame roof is cladded with a 20mm glass sandwich with a reflective film and frosted underside for the most part, with a panel of transparent glass on the south slope. This is under slung by a pair of razais (quilts), which can be pulled across to cover the underside of the roof (for insulation) or allowed to hang down vertically (to allow heat transfer). Above the roof is another frame in chicks (bamboo severs), which can similarly be opened to shade the roof or rolled up to catch the sun.

The ridge of the roof is a water channel from which water overflows on to the thin roofing membrane of stone and glass. Some water evaporates and excess water is collected at the foot of the slope and re-circulated. This makes the roof a large evaporative cooler over the central space of the house. All rooms communicate directly with this central space (Fig. 103, 104, 105).

The roof provides for:
1. Shading from outside / insulation from inside.
2. Roof evaporative cooling
3. Direct radiation

5.1.2. D Insulation / materials:
The roofs are finished with broken marble mosaic, which is reflective in nature.

The roof construction sandwich contains 30mm thick polyurethane board insulation above the concrete slab. For the courtyard houses the western wall of the upper floor, the east and west walls of the courtyard roof and the water tank walls are insulated using an innovative construction sandwich of 115mm brick + 15mm plaster + 30mm polystyrene foam + 50 mm terracotta jails, whose cavities are rendered with cement sand mortar. Initially the courtyard roof was to be designed with 20mm thick stone slab. After revisiting the idea, it was decided to replace the stone with glass sheets sandwiching a reflective film to ensure a crack free, damp proof cover for water to stream over.
Figure 99
Façade of Courtyard House
(Ref.: Ibid)

Figure 100
Ground floor plan
(Ref.: Ibid)

Figure 101
Wind driven evaporative cooling
(Ref.: Ibid)

Figure 102
Section (Ref.: Ibid)
Figure 103
Interactive courtyard roof
(Ref.: Ibid)

Figure 104
West wall "Khus" cooling tower
(Ref.: Ibid)

Figure 105
Looking up from the court
(Ref.: Ibid)
5.1.3 MEIR HOUSE
LOCATION : Desert Highlands, Israel
CLIMATE : Arid, with hot and dry summers, cold winters.

The Meir house was designed as a prototype towards creating an energy conservating urban building code. It combines external insulation and internal thermal mass with open plan.

5.1.3. A Thermal mass:
The wide diurnal temperature fluctuations characteristic of the Negev Desert climate dictate the use of thermal mass, both for internal temperature damping and for energy storage. The exterior walls are 250mm cellular concrete (YTONG) blocks, painted with a high reflectivity ochre- coloured paint. The low conductivity of the YTONG blocks eliminates the need for traditional sandwich wall sections or external insulation that demands precise construction. Floors are reinforced concrete poured in place. The roof is cast reinforced concrete, covered by extruded polystyrene, aerated sloped cement and waterproofing. Aluminium frames encase double glazing for acoustical considerations and are fitted with mosquito screens. To further reduce solar gains in the summer, external aluminium rolling shutters filled with insulation (expanded polyurethane) and interior Venetian horizontal and vertical blinds are fitted.

5.1.3.B Winter solar heating and solar water heating:
Approximately 24 m² of the south façade and 8m² of the east façade is glass, achieving a passive approach to heating the house. The addition of a collapsible greenhouse on the balcony, made of polycarbonate sheeting recovered from a dismantled agricultural greenhouse, yielded winter temperatures of 35-36 deg C during the afternoon increasing the room temperatures by 1-2 deg C with the help of a small fan that pushes the air into the living spaces.
5.1.3. C Summer cooling and stack ventilation:
Although the higher windows provide solar access to the northern parts of the plan (necessary in winter), the different height of spaces and operability enhance stack ventilation and exhaust hot air from the upper strata (during the summer). North and south facing windows enable cross ventilation during summer nights.

5.1.3. D Xeriscape
An intense post occupancy project was carried out to reduce by landscaping the amount of wind driven dust. By laying stone paving, pebble ground covering, and planting drought and salinity resistant plants, airborne dust is trapped and kept on the ground. Plants are drip irrigated by a computer, providing a relative humidity sensor by-pass to the automatic operation mode.\(^{126}\)

\(^{126}\) Roaf, *op cit*, pp.330-343
5.1.4 TUNISIA SOLAR HOUSE\PAVILION
LOCATION: Tunisia
CLIMATE: Pretty warm

The Tunisia Solar House, built by the National School for Engineers, explores the use of a passive heating element and a trombe wall, among other features, in identical and adjacent units that total 66m2 in area.

5.1.4. A Orientation / site
The aerodynamic shape decreases the wind pressure on the sides that are potentially exposed to the prevailing winds. The shape forces windows to face 45 deg south of east and west.

5.1.4. B Thermal mass
The construction materials of the west unit is made of an inner layer of 35cm stone, an insulation of 6 cm cork and an outer layer of 6.5 cavity bricks resulting in a thermal capacity of $U= 0.51$. The east unit has a double of cavity bricks separated by 6 cm of cork insulation, which provides a higher insulator but lower thermal capacity ($U=0.43$). The floor is a 10 cm concrete slab with 4 cm of cork insulation on 15 cm of stone. The cork is placed under the stone in the floor of south area, which is subject to direct solar radiation. The roof is a 20 cm thick concrete slab with 4 cm of cork on the outward side topped with a reflective coating for summer radiation reflectance. The high level of insulation is not customary in Tunisia dwellings. The trombe wall for each unit is made of 35 cm stone and protected by a single glazing but without night insulation. The assembly (Fig. 109 A and B) is indicative of the very high thermal capacity and high insulative quality in each unit's wall construction.
5.1.4. C Underground duct

A cooling chimney is integrated by way of an underground duct which pulls air from a shaded area about 30m from the pavilion. The air crosses under the garden about 80 cm below and is refreshed by the cold and humid soil above. The inlet into the pavilion on the north side and an air flow was added later to blow air near the ceiling of the sitting room, with the aid of a 30 W fan. However, operation of the underground duct when night ventilation is active has shown to be disadvantageous. This is because room air in the case of night ventilation is cooler than blown air from the underground duct.

The actual trombe wall with its thickness of 35 cm is a bit excessive. For this wall, double glazing is of little help and is not cost effective. Thermal insulation is decisive for the average level of room temperature but thermal capacity allows for the temperature to remain stable\textsuperscript{127} (Fig. 110).

\textsuperscript{127} Roaf, \textit{op cit}, pp.388-393

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{ground_floor_plan}
\caption{Ground Floor Plan (Ref.: \textit{Ibid})}
\end{figure}
Figure 109
A: East side
B: West side
(Ref.: Ibid)

Figure 110
a: Section showing underground duct and cooling chimney
b and c: Ventilation is reactive to the seasons (Ref.: Ibid)
5.1.5 OSBORN CLAASSEN HOUSE, TUSCON,

LOCATION: ARIZONA, USA  
CLIMATE: Hot arid  
An overriding aim of the scheme was to be as sit-sensitive as possible: the design was developed after careful study of the existing vegetation and the building was almost surgically inserted into the native desert so that no trees or cacti were destroyed during construction. Rainwater is diverted from the roof via a gutter that runs the full depth of the house, but it is not collected for domestic use so as not to starve plants of water.

**Construction materials**

The rammed-earth construction of the house further emphasizes the site sensitivity and the architect’s exposed intention to create a building that was rooted in the context and culture of its surroundings. The soil used to construct the house was not drawn from the site, but from three different sources in the immediate area-soils chosen for their color and structural integrity. These were slightly moistened, mixed with a small amount of iron oxide pigment and 3 percent Portland cement, and compacted into thick forms. The unreinforced exposed rammed-earth walls sit on concrete stem walls and spread footings. The north and south walls are 2 feet thick. The softly warping ‘butterfly’ roof is made of weathered steel, extended out over the rammed-earth walls to serve as weather protection and to shield the veranda from heat and sun. Interior walls, where they are not made of exposed rammed earth, are of painted drywall on steel studs, and the floors are of polished natural gray concrete and the windows are double-glazed\(^\text{128}\).

\(^{128}\) Wilhide, *op cit*, pp.52
Figure 112
View of the house with its background
(Ref.: Ibid)

Figure 113
The guest room is located on the north side of the house. (Ref.: Ibid)

Figure 114
The main living space of the house comprises an open eating, cooking, relaxing area. The rammed earth construction of the wall can clearly be seen
(Ref.: Ibid)
5.1.6 PALMETTO HOUSE, MIAMI
LOCATION: FLORIDA, USA
CLIMATE: Warm humid

The plan is in the form of a cross, with the longer sides of the building aligned north-south, and the living space aligned east-west and raised up a level to catch the cooling southeasterly breezes. On the south side, deep eaves keep the sun off exterior walls in the summer; awnings shade the windows so they can be kept open, even during storms. At either end, screened porches shield interior spaces from the sun; inside, there are few partitions or walls so that air flows freely—the main living space is an open plan kitchen/living room/dinning room. The floor of the loft space is metal grating, which allows air to circulate and permits light to filter through and the walls are lined in louvered windows. Lush subtropical undergrowth shades the house at the lower level.

5.1.6. A Natural cooling
Material use also has a role to play in natural cooling. The exterior walls and roof are clad with corrugated aluminum, which reflects the light and heat, high-mass concrete, used in construction of the first floor keeps this part of the house cool.
The upper floors are lightweight timber-frame construction. To supplement these natural cooling features, walls are also vented. Radiant barriers made of high-emissivity metal foil inside the walls and roof trap heat before it has a chance to reach the interior and expel it through high-level vents, drawing cooler air in from the shaded eaves (Fig. 115).

5.1.6. B Solar water heating
Almost all of the house’s hot water is heated by solar panels installed on the portion of the roof that faces south, and the water is circulated by a pump powered by photovoltaic cells. There is also a graywater system, with flow-control faucets to conserve water.
Unlike air conditioned homes, which must be hermetically sealed, this house is open to the elements and to the sights, sounds, and smells of the natural landscape\(^\text{129}\).

\(^{129}\) Wilhide, \textit{op cit}, pp.74
Figure 115
Detail of vented wall (Ref.: Ibid)

Figure 116
View of the house with its surrounding
(Ref.: Ibid)
Figure 117
The loft space on the top level is floored with metal grating to allow air and light through. The walls are lined with louvered windows. Plexiglas on the ceiling diffuses fluorescent light. No supplementary lighting is needed during the daytime in any part of the house.
(Ref.: Ibid)
5.2. LOCAL EXPERIENCE TOWARDS ECO HOUSING

5.2.1 NEW BARIZ BY HASSAN FATHY

The first Chairman's Award (which was established to honour special achievements) was given in 1980 to Hassan Fathy, an Egyptian architect, artist and poet in acknowledgment of his lifelong commitment to architecture. Early in career he began to study the preindustrial building systems of Egypt to understand their aesthetic qualities, to learn what they had to teach about climate control and economical construction techniques and to find ways to put them in contemporary use. In his lifetime he designed more than 30 projects including several villages for the poor and modest private residences shaped by his profound understanding of vernacular design. 

LOCATION : Kharga Oasis, Egypt
CLIMATE : Arid, with hot and dry summers, cold winters.

5.2.1. A Courtyards

One of his most distinguished projects is the village of "New Bariz" in kharga oasis. In this project, Fathy decided to employ a system of internal courtyards as a primary means of climate control in his design, along with shading. In his initial presentation, he stressed that thermal comfort in the housing design he proposed depended on the natural control of air temperature, air movement, relative humidity and radiation. Air movement was to be generated by creating a pressure differential and by convection, utilizing the basic physical principle that hot air rises and is replaced by cooler air to best advantage.

5.2.1.B Wind driven evaporative cooling:

To bring air into the series of internal courtyards planned for each house, he proposed wind towers, or "Badgirs" to catch the higher cooler breeze above the desert, and bring it into each house.

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His refinement, also used in the market, where cool temperatures were essentials to preserve agricultural perishables awaiting shipment to larger markets, consisted of two shafts. One of these has an opening facing the windward side, and the other face the leeward side with a metal-bladed funnel pointed downward, which ensures suction by Venturi effect. This second stack and funnel have been painted black to draw air from below as they are heated by the sun. To add to their cooling capacity the windward towers had straw mats hanging inside them which were damped by a hand pump at regular intervals during the day.

5.2.1.C Building materials

A shortage of viable building materials indicated a repetition of the same vault and dome system in mud brick, used at New Gourna, with paraffin and bitumen emulsions used as stabilizers, since the soil at Kharga Oasis is of poorer quality than that near the Nile.

5.2.1.D Construction System

The housing, had it been built, would undoubtedly have functioned equally well, but we only have his working drawings to show us what it would have looked like. Rather than the domes that predominate in New Gourna, he relied mostly on a "Barasti" truss system; a lighter reed and wire frame roof that was easily built and helped to promote better convection. The repetitive, triangular forms of the Barasti roof, topping off the linear, two-story housing blocks, would have been as visually distinctive as the Badgirs of the market\textsuperscript{131}.

\textsuperscript{131} Steel, \textit{op cit}, pp.79-84
Figure 118
Site plan of New Bariz
(Ref.: Steel, *op cit*)

Figure 119
Plan of neighbourhood unit for non farmers
(Ref.: *Ibid*)
Figure 120
Plan, sections and elevations of neighbourhood unit for non farmers
(Ref.: Ibid)

Figure 121
Roofscape of market at New Bariz
(Ref.: Ibid)
5.2.2 ART CENTER BY RAMSES WISSA WASSEF

Agakhan winning award

Near the pyramids of Giza, the centre was founded in the early 1950s by the late architect Ramses Wissa Wassef as a weaving school. It has since evolved to comprise workshops and showrooms, a pottery and sculpture museum, houses and farm buildings, constructed entirely of mud brick. For Wissa Wassef, vaulted and domed brick structures represented something quintessentially Egyptian as these forms had been adopted in turn by Pharaonic, Coptic and Islamic civilizations. The choice of this traditional technology also reflected his desire to transmit the values of handicraft to succeeding generations in a rapidly industrializing country. The jury commended the centre for "the beauty of its execution, the high value of its objectives, the social impact of its activities as well as the power of its influence as an example."

Scale 1:200

Figure 122
Section and plan for the art center in Haraneya (Ref.: FISA, op cit)
Figure 123
Different shots for the art center with its background
(Ref.: Ibid)
5.2.3 TOSHKA HOUSE

LOCATION : Toshka region - Egypt
CLIMATE : Hot arid

A house in Toshka was built as a prototype through which several passive systems were applied to reach an acceptable thermal performance in this region throughout the whole year using the most convenient construction method in this area and the available local building materials. The house was built on an area of 200m²

5.2.3.A Building material:
Made of light weighted concrete blocks that are thermally insulated (Lyca aggregate - cement-sand- thermal insulation). Its dimensions are 20x30x40 cm. This block is made by a manual compressor. (Fig. 124-125)
The U-value of this block reached 0.365 watt/ m² deg C which is a very low value compared to traditional building materials that reached a U-value greater than 1.5 watt/m² deg C

5.2.3.B Construction system:
The construction method used in this house is bearing walls using the previously mentioned concrete block.
Reinforced walls are simply built by interlocking those blocks together thus saving mortar, and therefore decreasing the costs. (Fig. 126-127-128)

5.2.3.C Evaporative cooling:
Wind catchers were used to enhance natural ventilation, and further, water sprinklers were used inside those ducts to cool the air before entering the house spaces.
The house is thermally comfortable throughout the months October and November and bearable in the period from July till September¹³³. (Fig. 129)

¹³³ رسالة ماجستير: رشا سليم، (2003)، "تأثير تكنولوجيا البناء المستخدم في الخلف الخارجي على ترشيد الطاقة في المباني"، قسم عماره، كلية الهندسة، جامعة القاهرة، ص 114-111.
Figure 124
The manual compressor for concrete block production.

Figure 125
Light weighted concrete block with insulation material

Figure 126
The steel reinforcement in wall construction and the way of preventing it from conducting the heat
Figure 127
Foundations and the steel reinforcement in the middle of the walls

Figure 128
Four stages of Toshka prototype construction
Figure 129

The prototype after applying the finishing
5.2.4 ECOLODGE IN SIWA

LOCATION: SIWA-EGYPT
CLIMATE: HOT ARID

The ecolodge is a hotel located in Siwa, and it was chosen to be presented in our case studies although it is not a residential case study and does not use electricity at all because it has adopted a no. of eco design principles which we can learn from.

Built on the edge of the Sahara, at the foot of a mountain and next to a mirage-like lake (that is as salty as the Dead Sea and great for the skin).134

The hotel was built using the traditional Berber techniques and architecture used in Siwa for centuries. It is completely made out of mud, wood, straw, and salt.

The locals made everything in the hotel from the doors to the furniture by hand. There is no electricity but night ventures are enjoyed by candlelight135. There is no telephone or air conditioning136. The lodge even has its own organic garden where the food for all meals is grown137.

Figure 130
Interior spaces are lit using natural day lighting in the morning and candle lights at night

134 http://greethenewblack.blogspot.com
135 http://community.iexplore.com
136 http://greethenewblack.blogspot.com
137 http://community.iexplore.com
Figure 131
Exterior views for the Ecolodge with its background
5.2.5 EGYPT'S MAP OF AVAILABLE RAW BUILDING MATERIAL AND ITS INDUSTRIES

The objective from this study made on Egypt was as follows:

- Classifying and locating raw building materials all over Egypt.
- Introducing the chemical and natural properties of raw materials in different locations.
- Listing industries of building materials depending on those raw materials.
- Offering a geo technical map of raw material locations that are qualified for use all over the republic and industries depending upon it.

This study is important for architects because it identifies the available local materials in order to use it and decrease the embodied energy.

Building materials were classified all over the Arab Republic of Egypt into:

- Clay
- Gypsum
- Aggregate (lime stones and its reciprocals such as dolmite – sand – gravel - bazalt…etc)
- Decorative stones

The Republic was divided into eight areas:

1. North of Sinai
2. South of Sinai
3. Delta – East of Delta – East of Tafreea (شرق التفرعه)
4. Suez Gulf and Red Sea
5. Nile valley
6. Toshka region – South of the valley
7. Western Northern Coast and West of Delta
8. Oasis and East of Oaynat (شرق العوينات)

The following table (20) presents the eight above mentioned areas of Egypt with its available raw materials.

Table (20) Available raw building materials in the eight areas of Egypt and its industries.

138 بحث: مركز بحوث الإسكان و البناء ،"خريطة مصر عن خامات مواد البناء المتاحة و الصناعات القائمة عليها"
<table>
<thead>
<tr>
<th>RAW BUILDING MATERIALS</th>
<th>AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North of Sinai</strong></td>
<td>Qualified for use in manufacturing clay brick and cement</td>
</tr>
<tr>
<td><strong>South of Sinai</strong></td>
<td>Qualified for use in manufacturing clay brick</td>
</tr>
<tr>
<td><strong>East of Delta – East of Tafreea</strong></td>
<td>Qualified for use in manufacturing clay brick</td>
</tr>
<tr>
<td><strong>Suez Gulf and Red Sea</strong></td>
<td>Qualified for use in manufacturing clay brick</td>
</tr>
<tr>
<td><strong>Nile valley</strong></td>
<td>Qualified for use in manufacturing clay brick and cement</td>
</tr>
<tr>
<td><strong>Toshka region – South of the valley</strong></td>
<td>Qualified for use in manufacturing clay brick and cement</td>
</tr>
<tr>
<td><strong>Western Northern Coast and West of Delta</strong></td>
<td>Qualified for use in manufacturing clay brick and cement</td>
</tr>
<tr>
<td><strong>Oasis and East of Oaynat</strong></td>
<td>Qualified for use in manufacturing clay brick and cement</td>
</tr>
</tbody>
</table>

1. **CLAY**

- Qualified for use in manufacturing clay brick
- Unqualified for use in manufacturing clay brick
- Qualified for production of brick
- Qualified for use in cement

2. **LIME STONE**

- Qualified for use as blocks
- Unqualified for use as blocks
- Qualified for production of lime stones
- Qualified for use in cement
- Qualified for use in cement
- Types of lime stones
- Aggregate of lime stones
, building stones and in manufacture of lime. In case of using aggregate in concrete, it should be taken into consideration that the increte metal present in some of the lime stones might react with the alkaline of the cement production of concrete aggregate since it deviates from the specs of Egyptian standard. Best of these stones are those located at El Toor area. It could be used in manufacture of quick and slaked lime quick lime and lime blocks. Also qualified for use in concrete works. Lime blocks could also be used in construction works but away from water sources due to its high ability of water absorption. Those stones could also be constructio n works either in production of aggregate or lime bricks. lime blocks works, also some of the produced aggregate could be used in concrete works. manufact uring clay brick and cement northern west coast could be classified as follows: 1. Dolomite lime stones 2. Silic lime stones 3. Sand lime stones 4. Clay lime stone 5. Chalk lime stone. Studies showed the following: 1. Qualification of first type to use as lime blocks. 2. Qualification of second and third not qualified for use in concrete works. Most samples are qualified for use as blocks except for those of El Farafra which could be used in manufacture of quick and slaked lime.
<table>
<thead>
<tr>
<th>Marble Type</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Third type</td>
<td>Used as aggregate in large-scale infrastructure projects.</td>
</tr>
<tr>
<td>2. Fourth type</td>
<td>Used in the production of quick and slaked lime.</td>
</tr>
<tr>
<td>3. Fourth type</td>
<td>Used in the manufacture of bricks and as raw material in the production of black cement.</td>
</tr>
<tr>
<td>4. Fifth type</td>
<td>Used in the production of quick and slaked lime.</td>
</tr>
</tbody>
</table>

3. MARBLE

<table>
<thead>
<tr>
<th>Marble Type</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Third type</td>
<td>There are two types of good-quality marble.</td>
</tr>
<tr>
<td>4. Fourth type</td>
<td>Used in the manufacture of bricks and as raw material in the production of black cement.</td>
</tr>
<tr>
<td>5. Fifth type</td>
<td>Used in the production of quick and slaked lime.</td>
</tr>
</tbody>
</table>
228
different types of marble such as : El Feleto - El selsela – El shabah and they are all qualified for use in cladding and decorative works and in production of blocks.

| 4. GRANITE | Of good mechanical and natural qualities. | Abundantly found in Aswan and Quina , it is red in color and of very Qualified for cladding works and facades. | Qualified for cladding works and facades. Aggregate produced from natural |
### 5. SAND

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
<th>Use</th>
<th>Place of origin</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>High resistivity to pressure, it is not easily affected by chemical factors.</td>
<td>Standard specs deviates from specs of aggregate used in concrete works, but it is suitable for mortar and plaster works, or as an additive</td>
<td>Used in manufacture of clay, concrete and sand bricks.</td>
<td>Found in areas of west and east banks of Cairo – Alexandria desert road and it is qualified for use in construction works such as: concrete works-mortar and plaster-as an additive</td>
<td>Unqualified for use in concrete works, but it could be used in plaster and mortar works or as additives in manufacture of other construction materials such as: concrete works-mortar and plaster-as an additive</td>
</tr>
</tbody>
</table>
230

| 6. GRAVEL AND GRAVEL SOIL | Qualified for use in concrete works, except that in gr. 3 | Un qualified for use in concrete works due to its deviation | Qualified for use in concrete works, except that in gr. 3 | Needs to redo its particle gradation since it | Qualified for use in concrete works, except that in gr. 3 | Salisilic gravel is qualified for use in concrete works, but the carbonic... | manufacture of clay, concrete and sand bricks. | as clay, concrete and sand bricks. |

- White sand is abundantly found and is known for its high purity which qualifies it for use in glass manufacture.
- General it could be used in mortar and plaster works or as additives in manufacture of concrete, sand and clay bricks.
- Containing high percentages of mud and soft substances which may reach 11%.

230
| 7. BAZALT | Aggregate is produced from bazalt | Bazalt of Abu zabal is qualified for use as aggregate in concrete | Qualified for use as aggregate in concrete works and in plane and reinforced concrete works and in road paving works | gravel is not, but it could be used in paving works. |

- From standard Egyptian specs, except for those samples in El Toor of granite origin, those samples are qualified for use in concrete aggregate.
- In general, it needs improving its particle gradation.
- Deviates from standard Egyptian specs of concrete aggregate. Rest of properties are qualified for use in construction works.
<p>| 8. GYPSUM | Qualified for use in wall cladding with plaster or paris and in manufacture of gypsum boards, paints and used as additives in manufacture of cement. | Qualified for use in manufacturing gypsum boards and gypsum walls. | Qualified for use in manufacturing gypsum boards and plaster of paris. | or it could be cut down to natural stones in order to be used in construction works. |</p>
<table>
<thead>
<tr>
<th>9. STEEL</th>
<th></th>
<th></th>
<th>Percentage of iron oxide in raw steel exceeds 80%</th>
<th></th>
<th>Percentage of iron oxide in raw steel reaches 74% by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. SAND STONE</td>
<td></td>
<td></td>
<td>Contains an acceptable percentage of minerals. Its rocks are of high resistivity to decaying and of good mechanical and natural properties.</td>
<td></td>
<td>Could be used in production of stone blocks and in construction works.</td>
</tr>
</tbody>
</table>
Figure 133
Raw building material sites in Egypt
مركز بحوث الإسكان و البناء، مرجع سابق
Figure 134
Building material manufacture sites in Egypt
مركز بحوث الإسكان و البناء، مرجع سابق
5.2.6 ENHANCING BUILDING BRICKS

Efforts were made to enhance building bricks from different angles. First: to decrease the U-value and thermal capacity in order to fit in arid conditions. Second: to produce a recyclable building bricks with low environmental impact. Both will be discussed respectively.

5.2.6.A Studies and experiments have been held in order to find a way to combine building materials with thermal insulation material, and the results of those studies confirmed the importance of using thermal insulation materials with building materials. Those special bricks have passed through laboratory experiments using five different walls with five different types of bricks and hot box to show the heat flow and U-value of each type of brick and results came as follows (Fig. 135):

First wall:
Was built from hollow clay brick with thickness of 25 cm. Results showed that heat flow reached 60 watt / m2 which confirm the ability of the brick to prevent heat flow and creating thermal accumulation in outer crust of the brick which causes reduction of heat flow and consequently reduces the U-value and increase the thermal resistance of the brick. Also the thermal accumulation resulted in increasing temperature difference between layer of brick facing the hot room and middle of the brick which shows capability of this brick, with addition of thermal insulation material, to reduce heat flow.

Second wall:
Was built from hollow concrete blocks with thickness of 25 cm. The brick contains two consecutive voids. Results showed that heat flow reached 120 watt / m2 which indicate that it is not suitable for use in hot climates due to the increase of U-value and its low thermal resistance which makes it incapable of creating thermal accumulation thermal accumulation on the outer crust of the brick.
**Third wall:**
Was built from concrete bricks insulated with extruded polystyrene with thickness of 7.5cm and at 4cm away from the outer surface of the brick, it is also has two separate voids. Results showed that this brick is suitable for use in hot dry regions since it has low U-value due to presence of insulating material.

**Fourth wall:**
Was built from hollow concrete blocks with thickness of 12.5cm. The brick contains three consecutive voids, but it was taken into consideration, when building a wall of 25cm thickness, to alternate the void locations in order to create two separate alternating voids of 4cm apart. Results showed that heat flow reached 29 watt/m², which clarifies the effect of the two voids in comparison to hollow concrete blocks in second wall. And so therefore one can say that using two voids in a brick has good effect on decreasing the U-value, it also decreases the thermal storage capacity of the brick.

**Fifth wall:**
Was built from concrete bricks made from light weighted Lyca as a substitute of aggregate with thickness of 30cm. This brick has three defensive lines of thermal insulating material from extruded polystyrene, it was taken into consideration in this brick to distribute the insulating material in a way to prevent the heat transfer through thermal bridges in the brick. This type of bricks is constructed b interlocking without using any mortar. The wall was reinforced by steel horizontally and vertically through leaving voids without thermal insulation every 80cm to place the steel bars. Results showed that heat flow reached 18 watt/m². This type of bricks is considered very suitable since its manufacture depends on clay Lyca, also it does not contain high percentages of cement. The outer layer of Lyca facing exterior climatic conditions store heat during day and expel it during night, this is due to the role of the thermal insulating material in creating thermal accumulation.
Conclusion

From previous study, the following findings can be concluded:

1. Usage of building materials available in the hot dry region alone is not enough and does not fulfill the thermal needs of the building, and therefore thermal insulation materials should be used with those building materials in order to increase its thermal resistivity and decrease its thermal capacity. Thermal insulation layer must be placed in the outer surface of the wall in order to create a layer capable of storing heat during day and expelling it during night.

2. Usage of several consecutive air voids in walls give positive results in decreasing the U-value, it also decreases the thermal capacity of the structure and therefore the building structure becomes convenient during night. Reflective thermal insulation materials could be placed on the outer layer.\(^{139}\)

\(^{139}\)بحث: مركز بحوث الإسكان والبناء,” المواد العازلة للحرارة في الأغواء الحارة الجافة”، ص. 303-2002.
Figure 135
Different types of bricks and its corresponding walls
5.2.6.B Other bricks were created by HBRC in order to make good use of solid wastes in its different forms because solid wastes are considered one of the most important environmental problems and according to statistics of environmental ministry, the total amount of solid wastes in Egypt reached 60 million tons annually and that included: Industrial wastes- construction and demolition wastes- agricultural wastes…etc. Examples of industrial wastes are:

- Wastes of ceramic tiles during manufacture.
- Wastes of clay brick industry
- Wastes of by-pass cement dust

Figure 136

Different types of bricks made from industrial and construction-demolition wastes: First one from left is cement block that contains 25% of cement dust Middle one is clay brick made of clay brick manufacture wastes Last one is clay brick that contains ceramic wastes
Figure 137
Various types of bricks made from demolition wastes and ceramic wastes…etc
One of the most important examples of agricultural waste in Egypt which caused a lot of troubles is “rice straw”, where the amount of rice straw reaches 2 million tons per year. The peasants have tried to get rid of it by burning it but this caused what is called “the black cloud” which caused lots of illnesses besides, the burning process raises the soil temperature and emits the ammonia present in the soil and so the soil loses a great amount of one of its most important elements.

So studies were made and the results came out as follows:

- Production of low density construction units using rice straw
- Production of thermally insulated construction units which contain rice straw
- Production of gypsum boards that contain rice straw

Figure 138

Thermally insulating clay bricks that contain different percentages of rice straw

Figure 139

Thermally insulating cement bricks that contain different percentages of rice straw
5.2.7 Egyptian Residential Energy Code

The Housing and Building National Research Center (HBRC) and the Organization for Energy Planning (OEP) were engaged in an effort to produce an Egyptian Code for the residential buildings. The project intended to improve the efficient use of electrical energy. The Egyptian Residential building code gives minimum performance standards for building envelope, windows and openings, natural ventilation and thermal comfort, natural and artificial lighting. A great effort has been made to ensure its applicability in our buildings here in Egypt specifically to the general climate conditions of the two cities, Cairo and Alexandria. For example, the exterior building envelope must comply with the following requirements:

5.2.7.A Non air conditioned buildings in Cairo

Table (21) Requirements of building envelope for non air conditioned buildings in Cairo and Delta region

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Electrical Surface Absorptivity</th>
<th>Required Min R values of Insulation</th>
<th>Max SHGC Values for Fenestration or Min. SGR Values For Shading Devices</th>
<th>WWF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Roof</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>0.70</td>
<td>2.70</td>
<td>2.30</td>
</tr>
<tr>
<td>NE, NW</td>
<td></td>
<td>0.50</td>
<td>0.59</td>
<td>0.19</td>
</tr>
<tr>
<td>E, W</td>
<td></td>
<td>0.70</td>
<td>1.03</td>
<td>20.63</td>
</tr>
<tr>
<td>SE, SW</td>
<td></td>
<td>0.70</td>
<td>0.70</td>
<td>0.67</td>
</tr>
<tr>
<td>S</td>
<td></td>
<td>0.70</td>
<td>0.67</td>
<td>0.67</td>
</tr>
</tbody>
</table>

(a) R Values for typical Roof construction are equivalent to:

 مركز بحوث الإسكان و البناء، "الكود المصري لتحسين كفاءة استخدام الطاقة في المباني" الجزء الأول: المباني السكنية" 2000

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R value 0.3: equivalent to 12cm Concrete, 6cm of sand, 2 cm of mortar, 2cm of tiles
R value 0.4: equivalent to 12cm Concrete, 8 cm of sloped concrete, 6 cm of sand,
2 cm of mortar, 2 cm of tiles
R value 0.6: equivalent to 20 cm Hollow Blocks 8cm of sloped concrete, 6 cm of sand,
2 cm of mortar, 2 cm of tiles
R value 0.8: equivalent to 30 cm Hollow Blocks 8cm of sloped concrete, 6 cm of sand,
2 cm of mortar, 2 cm of tiles

(b) R Values for typical Wall construction are equivalent to:
R value 0.4: equivalent to 12 cm clay brick 2cm of Plaster on both sides
R value 0.6: equivalent to 25 cm clay brick 2cm of Plaster on both sides
R value 0.8: equivalent to 38 cm clay brick 2cm of Plaster on both sides

(c) R value for typical insulation material without R_st & R_so, are equivalent to:
R value 0.59 = 2 cm expanded polystyrene insulation
R value 1.18 = 3 cm expanded polystyrene insulation
R value 1.75 = 6 cm expanded polystyrene insulation
R value 2.35 = 8 cm expanded polystyrene insulation
If insulation is placed to the inside of the wall the R value is reduced by 30%
R value of 100 mm non vented cavities in the wall is considered 0.16 m² °C/W
Outdoor surface thermal resistance = 0.04 m² °CW
Indoor surface thermal resistance = 0.123 m² °CW

Fenestration Requirements: Compliance is achieved if one of the following are met for all applicable orientation:
(a) Maximum SHGC (In columns 8-11), or
(b) Minimum SGR (in columns 12-15), or
(c) An adjusted SHGC reduced by applying the SGR factor as indicated in part (B) to the SHGC of the glassing to achieve an SHGC less than the required maximum

Windows with shutters have no requirement for either SHGC or SGR
* If WWR exceeds 30% SGR must be not less than 0.9
* For exposed glass windows should meet the min SHGF
* Shaded Windows should meet the min SGR in 21 Sept., if not; the glazing should
meet the SHGC requirement.
These SHGC values are calculated including window frames

0.27 = reflective single glazing CLR 20%
0.75 = clear single glazing

**SGR = percentage of glazing surface shaded from 9 am to 5 pm on 21 September.**

### 5.2.7.B Non air conditioned buildings in North Coast

Table (22) Requirements of building envelope for non air conditioned buildings in North Coast region

(a) **R Values for typical Roof construction are equivalent to:**

- **R value 0.3:** equivalent to: 12 cm Concrete, 6 cm of sand, 2 cm of mortar, 2 cm of tiles
- **R value 0.4:** equivalent to: 12 cm Concrete, 8 cm of sloped concrete, 6 cm of sand, 2 cm of mortar, 2 cm of tiles
- **R value 0.6:** equivalent to: 20 cm Hollow Blocks 8 cm of sloped concrete, 6 cm of sand, 2 cm of mortar, 2 cm of tiles
- **R value 0.8:** equivalent to: 30 cm Hollow Blocks 8 cm of sloped concrete, 6 cm of sand, 2 cm of mortar, 2 cm of tiles

(b) **R Values for typical Wall construction are equivalent to:**
R value 0.4: equivalent to: 12 cm clay brick 2cm of Plaster on both sides
R value 0.6: equivalent to: 25 cm clay brick 2cm of Plaster on both sides
R value 0.8: equivalent to: 38 cm clay brick 2cm of Plaster on both sides

(c) R value for typical insulation material without $R_{si}$ & $R_{so}$, are equivalent to:
R value 0.59 = 2 cm expanded polystyrene insulation with $k = 0.032$ W/m°C
R value 1.18 = 3 cm expanded polystyrene insulation with $k = 0.032$ W/m°C
R value 1.75 = 6 cm expanded polystyrene insulation with $k = 0.032$ W/m°C
R value 2.35 = 8 cm expanded polystyrene insulation with $k = 0.032$ W/m°C
If insulation is placed to the inside of the wall the R value is reduced by 30%
R value of 100 mm non vented cavities in the wall is considered 0.16 m² °C/W
Outdoor surface thermal resistance = 0.04 m² °CW
Indoor surface thermal resistance = 0.123 m² °CW

Fenestration Requirements: Compliance is achieved if one of the following are met for all applicable orientation:
(a) Maximum SHGC (In columns 8-11), or
(b) Minimum SGR (in columns 12-15), or
(c) An adjusted SHGC reduced by applying the SGR factor as indicated in part (B) to the SHGC of the glassing to achieve an SHGC less than the required maximum.

Windows with shutters have no requirement for either SHGC or SGR.
* If WWR exceeds 30% SGR must be not less than 0.9
* For exposed glass windows should meet the min SHGF
* Shaded windows should meet the min SGR in 21 Sept.
If not, the glazing shall meet the SHGC requirement.
These SHGC values are calculated including window frames
0.27 = Reflective single glazing CLR 20%
0.75 = Clear single glazing
Conclusion

This chapter reviews international and local case studies of eco houses. It is also concerned with the local efforts made as an approach for achieving an eco house. Those efforts were as follows:

- Map of Egypt for available raw material and its industries. This part divided the republic into eight areas and discussed the raw materials found in each area and its industries and the conclusion is as follows:
  1. Clay:
     Present abundantly in all different eight areas that were previously mentioned, and it is qualified for use in manufacture of clay bricks.
  2. Lime stone:
     Present in most of the eight areas, and is qualified for use in lime blocks and lime bricks.
  3. Marble:
     Located abundantly and with various types in North of Sinai - South of Sinai - Suez Gulf and Red Sea - Nile Valley, and it is qualified for use in cladding and decorative works.
  4. Granite:
     Located in South of Sinai – Nile Valley – Toshka region and South of the valley – Oasis and East of Oaynat, but it is abundantly found in Aswan and Quina where it is red in color and of very high resistivity, it is qualified for use in cladding and manufacture of concrete bricks and tiles.
  5. Sand:
     White sand is abundantly found in North of Sinai and it is known for its high purity which qualifies it for use in glass manufacture.
     Sand located in: South of Sinai - Suez gulf and Red sea – Oasis and East of Oaynat areas is unqualified for use in construction works such as: concrete works, mortar and plaster. Sand located in other areas is qualified for use in construction works and in manufacture of clay, sand and concrete bricks.
6. Gravel and gravel soil:
Located in all areas except in Toshka region, South of the valley, Western Northern coast and West of Delta. It is qualified for use in concrete works in all areas except in South of Sinai.

7. Bazalt:
Located in all areas except in: North of Sinai, Delta - East of Delta - East of Tafreea, Western Northern Coast and West of Delta.
It is qualified for use as aggregate in concrete works and in manufacture of concrete bricks and in road paving.

8. Gypsum:
Located in South of Sinai – Suez Gulf and Red sea – Western Northern Coast and West of Delta. It is qualified for use in wall cladding with plaster of paris and in manufacture of gypsum boards.

9. Steel:
Located in the Nile Valley, Oasis and East of Oaynat.

10. Sand Stone:
Located in the Nile Valley, Oasis and East of Oaynat. It is qualified for use in construction works.

- Enhancing building bricks
A study has been held in HBRC on different types of construction bricks and comparisons were made between them, conclusion of this study was as follows:

1. Usage of building materials available in the hot dry region alone is not enough and does not fulfill the thermal needs of a building, and therefore thermal insulation materials should be used with those building materials in order to increase its thermal resistivity and decrease its thermal capacity. Thermal insulation layer must be placed in the outer surface of the wall in order to create a layer capable of storing heat during day and expelling it during night.
2. Usage of several consecutive air voids in walls give positive results in decreasing the U-value, it also decreases the thermal capacity of the structure and therefore the building structure becomes convenient during night. Reflective thermal insulation materials could be placed on the outer layer.

New types of bricks were created in HBRC in order to make use of solid wastes, such as:

- Wastes of ceramic tiles
- Wastes of clay brick
- Wastes of by pass cement dust

Also other bricks were made from agricultural waste such as rice straw.

- Egyptian residential Energy code
The Egyptian residential energy code gives minimum performance standards for windows and openings, natural ventilation and thermal comfort, natural and artificial lighting, where the exterior building envelope must comply with the requirements mentioned in the code.

After reviewing all the principles concerning the Eco Eco house, a cost analysis system is established to help designers throughout the design process and decision making.
CHAPTER 6

ESTABLISHMENT OF COST ANALYSIS SYSTEM FOR ECO-HOUSE DESIGN
Studies have shown an urgent need for establishing a cost analysis system in order to help designers reach a trade off between cost and ecological aspects during the different phases of housing development. This earned a top priority because of all what has been stated before in addition to the coming two factors:

1. In Egypt, buildings in general are responsible for 60.18% of the total electricity consumption in all sectors. Energy demand has reached about 69.2 Billion kWh with an annual increase of 7%, where the industry takes about 43%, Residential and commercial buildings share is 42.6%, Governmental buildings and services consume about 16.7% while Agriculture use only 4%. The two major consumers of electricity are households and industry, followed by Government and public utilities. In order to reduce the energy consumption in buildings, the Housing and Building Research Centre in collaboration with UNDP&JEF. Has produced a building code to provide designers with know how but we need to provide them also with cost effectiveness evaluation tool to help them making decisions related to the market, the client affordability and the developments plans drawn by the government.

2. Modernization trends in building designs in Egypt imported a new technology which has led to an increase in energy consumption in buildings and at the urban scale for many reasons:
   - Exaggeration in use of metal and glass
   - Not using thermal insulation in general practice
   - Relying totally on mechanical air conditioning
   - No effort done in design to adapt foreign technology to local conditions

Studies of the building industry in Egypt and technological innovations in the building industry (intelligent building elements and systems, component for renewable energy) Show that the cost of these ecological components is still too high to encourage its use on a large scale. Therefore, feasibility studies and methods to balance costs with benefits are urgently needed. 

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The thesis recommends a thorough cost analysis system for ecological houses helping designers to decide according to checklists and choices available in each design phase. The following is a proposal for a total approach followed by examples of detailed modules supporting the total system that needs further development and completion in future studies.

6.1 An integrated approach to achieve trade off between the ecological and economical aspects of housing design

The designer is constantly making decisions as he goes through the design process. Each decision has a cost impact that should be analysed and in order to achieve eco-cities, eco-districts and eco-houses, additional costs might be required, therefore, a comparison should be done between eco-design cost and the regular or traditional design solutions in terms of costs taking into consideration all the advantages listed previously from eco-design and the pay back that may not be instantly felt but on the long run. The following chart proposes an approach of cost analysis following the design phases to help defining the costs of eco-house. This system is composed of steps following design process:
Checking land for contamination

- Using neutralizing chemicals
- Replacement with clean soil
- Sealing the base of site with barriers

Checking site for air pollution (dust-sand)

- Protection from storms
- Exposure to desirable winds
- Site location on slopes

SITE SELECTION

COST

If contaminated

COST

If found

SITE DESIGN

- Grouping patterns for cooling effect and minimizing infrastructure cost
- Road pattern and orientation
- Landscaping and vegetation
- Land subdivision
- Distribution of public spaces-wind breaks -sound barriers-pavements
- Outdoor shading devices

COST

A

N

P

COST
Implementing ecological economical design factors:
- Outer shape
- Size, no. of rooms and their areas
- No. of storey
- Clear storey height
- Horizontal grouping
- Openings

Building envelope
- Roof insulation (loose fill-semi rigid-rigid-foamed-reflective)
- Roof shape (horizontal-vertical- inclined)
- Wall insulation
- Opening design:
- Size and distribution of windows
- Type of glazing (single-double-triple)
- Shading devices

Building materials
- Locality of materials
- Embodied energy of materials
- Recycling and renewability of materials

GARDENING AND LANDSCAPE

Choice of species
- Choice of irrigation system
- Avoid using insecticides
- Compost organic waste matter

CONSTRUCTION

Choosing an ecological economical construction system from:
- Traditional system
- Developing system
- Developed system

GARDENING AND LANDSCAPE

Choice of species
- Choice of irrigation system

ADDITIONAL COSTS TO ACHIEVE ECO DESIGN

COST

END OF DESIGN PROCESS
6.2 Cost Effectiveness Modules for ecological measures

As explained in the above mentioned system, cost analysis modules integrated with the proposed system are needed to help designers decide about cost effectiveness of specific design measures aiming at ecological and environmental improvement and preservation. These modules varies from environmental impact assessment (EIA) to evaluation of Energy performance in residential buildings, as well as evaluation of appropriateness of different construction systems and different building materials used in residential buildings regarding their availability and suitability to local natural conditions. Following are some examples of cost effectiveness modules of ecological measures.

6.2.1. Evaluation of energy performance in residential buildings taking into consideration life cycle cost

As part of developing the building energy code, the energy performance of new prototypes of residential buildings and urban planning in Egypt was investigated theoretically and experimentally taking into consideration the climatic conditions in Cairo and Alexandria aiming to:

- reduce the energy consumption in buildings
- improve the comfort of the inhabitants in outdoor urban areas as well as in indoor spaces.
- enhance the building energy efficiency leading to the quality of architectural and urban environment.

The research used the following methodology in two stages:

First:
A field survey was conducted in both Cairo and Alexandria regions where construction activities are very high. The survey aim was to evaluate design, construction, and energy use in typical new residential buildings with a view to improving current building practices and introducing new energy - efficient features through comprehensive building code.
In order to have a sample representative of new construction, building selection was carried out according to predefined sampling scheme based on primary and secondary variables. The sample was designed to cover:

- Different zones in Cairo (Maadi, Nasr City, New Cairo …) and Alex (Agami, borg El Arab City...).

Types of building heights (high rise: higher than 6 floors, middle: 5-6 floors, low rise: villas of 2 floors).

- Income level (high income, middle income and low income level).

- A number of 140 buildings were surveyed, analyzed and classified into two main patterns:

  A) Introvert looking onto internal courts attached and semi detached as shown in table 23.

  B) Extrovert with different shapes totally detached with low density arrangements in sites as shown in table 24.

Table (23) Attached and semi detached introvert units

<table>
<thead>
<tr>
<th>Pattern A</th>
<th>-Semi attached) attached from one side)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Square shape</td>
</tr>
<tr>
<td></td>
<td>- Rectangular</td>
</tr>
<tr>
<td></td>
<td>- Two units per floor</td>
</tr>
<tr>
<td></td>
<td>- One closed light-well</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>- Rectangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 4 units per floor</td>
</tr>
<tr>
<td>- 2 closed light-wells</td>
</tr>
<tr>
<td>- Buildings are attached from the sides</td>
</tr>
</tbody>
</table>

The Base Case Plan

\[143\] Ibid
Table (24) Detached extrovert units\textsuperscript{144}

| Pattern B | - Detached and surrounded by a garden  
- Irregular shape  
- Buildings are detached.  
- T shape.  
- Units have 3 : 4 external facades  
- buildings are detached  
-Swastika shape  
- units have 4 external facades |

To study the impact of the different factors of buildings, a simulation analysis was conducted using:

- DOE2 program: a standard program for energy simulation in the USA. It was developed by Lawrence Berkeley National Laboratory (LBL).
- Visual Doe program: a window application that enables architects, engineers, to quickly evaluate the energy savings of building design options.
- LCC analysis: The life cycle cost analysis is the most commonly used rigorous method to determine the economic feasibility of energy efficiency projects, several parameters are needed to perform LCC analysis such as investment costs (including initial costs, replacement costs, and residual costs), annual energy costs (including electricity costs and fuel costs), non – annual operating costs (such as maintenance costs) and interest rates.

\textsuperscript{144} Ibid
The base case is a housing unit in an apartment building at the top floor. The total area of the unit is 125 m² and the floor has 4 units (see Base Case in table 20, pattern A). Each unit has two 0.25 m thick external walls on different orientation built in cement bricks. Windows are of single glazing, transparent and 3mm thick.

The results of the simulation can be summarized in table (25) and are shown in figures 140 to 149.

Table (25): Results of the simulation\textsuperscript{145}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Complied</th>
<th>Improvement%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cairo</td>
<td>Alex.</td>
</tr>
<tr>
<td>Roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td>50 mm poly.</td>
<td>39.5</td>
</tr>
<tr>
<td></td>
<td>150 siliton</td>
<td>37.3</td>
</tr>
<tr>
<td>Absorbance</td>
<td>Light color &amp; solar absorbance= 0.3</td>
<td>31.64</td>
</tr>
<tr>
<td>Insulation</td>
<td>25 mm Poly.+ Absorbance 0.3</td>
<td>48.9</td>
</tr>
<tr>
<td>Shading</td>
<td>Optional</td>
<td>20.67</td>
</tr>
<tr>
<td>Insulation+Shading</td>
<td>25 mm Poly.+ Shade</td>
<td>42.9</td>
</tr>
<tr>
<td>Wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>Hclay_25 mm</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>Silt_brick_25mm</td>
<td>8.1</td>
</tr>
<tr>
<td>Insulation</td>
<td>poly 25 mm _Mid</td>
<td>10.5</td>
</tr>
<tr>
<td>Absorbance</td>
<td>Light color 0.3</td>
<td>13.3</td>
</tr>
<tr>
<td>Absorbance+Insulation</td>
<td>Light color 0.3 + poly 25 mm _Mid</td>
<td>14.31</td>
</tr>
<tr>
<td>Window</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Window type</td>
<td>SHGF_29</td>
<td>9.94</td>
</tr>
<tr>
<td>WWR</td>
<td>WWR_15</td>
<td>3.16</td>
</tr>
<tr>
<td>PF+ WWR</td>
<td>WWR_15+PF0.75</td>
<td>5.31</td>
</tr>
<tr>
<td>WWR +Wind. Type</td>
<td>WWR_15+SHGC0.29</td>
<td>6.75</td>
</tr>
</tbody>
</table>

\textsuperscript{145} Ibid
Energy simulation for performance analysis was conducted using DOE2, Visual Doe and Life cycle cost (LCC)\textsuperscript{146}.

![Graph showing Total Electricity (KWh) vs. Roof Insulation Thickness]

**Figure 140**

Impact of roof insulation on energy consumption

![Graph showing LCC (LE) vs. Roof Insulation Thickness]

**Figure 141**

Impact of roof insulation on life cycle cost (LCC)

Studying LCC and the impact of roof insulation on energy consumption shows that the optimum roof insulation is 50 mm polystyrene or 150 mm siliton

\textsuperscript{146} Ibid
Studying LCC and the impact of wall insulation on energy consumption shows that the optimum wall insulation is 25 mm polystyrene mid.
Studying LCC and the impact of projection factor and SHGC on energy consumption in Cairo shows that the optimum PF is 0.5m with 1P_ref B-clr H or 1P_ref C-Tint M.
The best orientation for Cairo and Alex is N but the worst orientation for Cairo is SW and for Alex is SE.

The simulation shows that using 25 cm of wall construction is better than 12 cm and using silt or hollow brick better than cement brick.
The simulation shows the optimum WWR is 0.15 with 1P_ref B-clr H in Cairo.

Figure 148
Impact of Glass type (SHGC) and WWR on energy consumption in Cairo

The simulation shows the optimum WWR is 0.15 with 1P_ref B-clr H in Alex.

Figure 149
Impact of Glass type (SHGC) and WWR on energy consumption in Alex
In conclusion, one can state that building energy performance is a trade off between different design factors to achieve a target level of energy consumption that varies according to the climatic conditions of the city. The impact of the different design elements and measures evaluated for both Cairo and Alexandria climates show variation giving relative importance to the different passive solutions.

6.2.2 Payback analysis for design improvements

Payback analysis help designers decide about accepting or rejecting improvement measures since it relates initial costs needed to improve building performance to savings achieved due to it in the following years by users. Examples of payback analysis are:

6.2.2.1 Payback analysis for adding thermal insulation layer to the roof

Assuming an exposed ceiling of 500m2 area composed of a layer of reinforced concrete 12 cm thick (U= 3.45 watt/m2.C). Adding a layer of thermal insulation 7 cm thick will decrease thermal transmittance (U= 0.45 watt/m2.C). Cooling loads will decrease leading to electricity savings.

\[ \Delta E = H \times A \times (U_b - U_p) \times \text{CDD} \]

Where
- \( \Delta E \) energy savings in watts
- \( H \) occupancy period where AC function in hours
- \( A \) area of exposed roof in m2
- \( U_b \) roof thermal transmittance before adding insulation
- \( U_p \) roof thermal transmittance after adding insulation
- \( \text{CDD} \) cooling degree-day for a base of 25°C = \( \sum_i \sum_j (T_o - 25) \)
- \( T_o \) outdoor air temperature
- \( i \) month
- \( j \) hours

\[ \Delta E = 15 \times 500 \times (3.45 - 0.45) \times 2500 = 56250 \text{ Kwh/year} \]
Payback period = cost of insulation / energy savings
= (500*0.06*300) / (56250*0.1) = 1.6 years

Previous studies have calculated payback periods for adding a 7cm insulation layer to a 500 m² roof in different climatic regions to assess the impact of each climate. It was found that payback period is 1.6 years in Alexandria, decreases to 1.2 years in Cairo and 0.9 year in Aswan\(^{147}\). According to theories, a payback is tolerable until a period of 7 years. It is obvious that the harsher the climate, the shorter the payback period.

6.2.2.2 Payback analysis for increasing glazing thermal resistance by using double glazed panels

Calculation are made for a building envelope with 200 m² glazing. Single glazing have a U value of 5.6 watt/m²°C while double glazing U value decreases to 2 watt/m²°C. Assuming the cost of 1 m² in double glazing exceeds the cost of 1 m² of single pane by 200 LE, and the cost of electricity is 0.1 LE/ Kwh.

For Alexandria:
ΔE = 15 *200 * (5.6-2)*2500 = 27000 kwh/year
Payback = (200*150)/(27000*0.1)= 14.8 years
The payback is high and is rejected for Alexandria and Cairo (11.6 years). It is acceptable in Aswan (8.8 years).

6.3 Specific technical conclusion and recommendations

The thesis has reached a set of technical and strategical conclusion and recommendations based on the literature review and the analysis of the best local and international practices. These are summarised as follows:
CONCLUSION:

An eco eco house should provide:
• Healthy living conditions through selecting eco materials and avoiding materials that cause sick building syndrome and allergies and cancer, and selecting a site that is clear of any contamination or radiation.
• Thermal comfort through following passive cooling strategies that are classified according to Givoni chart.
• Energy efficiency through a set of design principles for shelter, house layout and building envelope.

An eco house should select:
Low embodied energy materials with minimal environmental impact.
Recyclable and renewable materials to avoid harming the landscape resources of the earth which may not be able to recover.
Eco gardening by adopting Xeriscaping that fits with our hot arid climate.

An eco house should be economical through:
Applying economical but ecological design factors and through selecting economical ecological construction systems that uses local and natural building materials that provide thermal insulation and could be recycled and consumes low energy during construction.

In order to achieve an eco eco house, cost analysis chart should be applied through out all the design phases.
RECOMMENDATIONS:

- Necessity of applying cost analysis for ecological design framework through all the design phases.

- Directing future studies towards designing cost effectiveness modules for cost analysis studies to help out the planners and designers evaluate the economic feasibility and take the decisions needed.

- Establishment of labs for measuring the efficiency of different building elements.

- Providing eco materials in the market to be available and in reach for consumers, architects and contractors to use.

- Providing the eco tech needed such as the double and triple glazing with reasonable and affordable prices.

- Enforcement of Egyptian energy residential code through the building permits process and training designers on using and applying the code.
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APPENDIX

Table (5) Thermal specs for thermal insulation materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Density kg/m³</th>
<th>Thermal Conductivity Watt/m.deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Polysterene products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Molystyrene boards</td>
<td>28-40</td>
<td>0.033-0.027</td>
</tr>
<tr>
<td>2 Expanded polystyrene boards</td>
<td>15-40</td>
<td>0.03-0.037</td>
</tr>
<tr>
<td>3 Polystyrene granules</td>
<td>15</td>
<td>0.045</td>
</tr>
<tr>
<td><strong>2. Glass wool products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Molystyrene</td>
<td>Less than 32</td>
<td>0.045</td>
</tr>
<tr>
<td>2 Semi rigid boards</td>
<td>More than 72</td>
<td>0.045-0.050</td>
</tr>
<tr>
<td>3 Loose fibres</td>
<td>130</td>
<td>0.043</td>
</tr>
<tr>
<td><strong>3. Rock wool products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Covers</td>
<td>130</td>
<td>0.043</td>
</tr>
<tr>
<td>2 Fibre (Molystyrene)</td>
<td>70</td>
<td>0.049</td>
</tr>
<tr>
<td>3 Boards</td>
<td>100-350</td>
<td>0.043-0.055</td>
</tr>
<tr>
<td>4 Loose fibres</td>
<td>150</td>
<td>0.044</td>
</tr>
<tr>
<td><strong>4. Polyurethane products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Boards</td>
<td>30-40</td>
<td>0.02-0.027</td>
</tr>
<tr>
<td>2 Polyurethane</td>
<td>30</td>
<td>0.026</td>
</tr>
<tr>
<td><strong>5. Mortar and insulative concrete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Loose perlite</td>
<td>32-176</td>
<td>0.039-0.06</td>
</tr>
<tr>
<td>2 Perlite mortar</td>
<td>400-610</td>
<td>0.079-0.11</td>
</tr>
<tr>
<td>3 Foamed cement mortar</td>
<td>400-880</td>
<td>0.1-0.25</td>
</tr>
<tr>
<td>4 Foam granules mortar</td>
<td>60-1000</td>
<td>0.11-0.19</td>
</tr>
<tr>
<td>5 Silton</td>
<td>480</td>
<td>0.17</td>
</tr>
<tr>
<td>6 Loose vermiculite</td>
<td>100</td>
<td>0.065</td>
</tr>
<tr>
<td>7 Vermiculite mortar</td>
<td>480-960</td>
<td>0.135-0.303</td>
</tr>
<tr>
<td>6. Cork products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>1 Boards</td>
<td>110-130</td>
<td>0.033-0.039</td>
</tr>
<tr>
<td>2 Cork granules</td>
<td>100-115</td>
<td>0.039-0.052</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Various materials</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rigid rubber</td>
<td>1190</td>
<td>0.016</td>
</tr>
<tr>
<td>2 Cotton</td>
<td>1500</td>
<td>0.042</td>
</tr>
<tr>
<td>3 Textile wool</td>
<td>110-330</td>
<td>0.036-0.063</td>
</tr>
<tr>
<td>4 Hand saw</td>
<td>145</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Table (7) Thermal specs for construction and finishing materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Density kg/m³</th>
<th>Thermal Conductivity Watt/m.deg C</th>
<th>Specific Heat Joule.kg deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First : Construction bricks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Hollow foam</td>
<td>530</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>2 Solid foam</td>
<td>800</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>3 Hollow gypsum</td>
<td>750</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>4 Solid gypsum</td>
<td>950</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>5 Hollow lycra</td>
<td>1200</td>
<td>0.39</td>
<td>1000</td>
</tr>
<tr>
<td>6 Hollow clay</td>
<td>1790</td>
<td>0.60</td>
<td>840</td>
</tr>
<tr>
<td>7 Solid clay</td>
<td>1950</td>
<td>1.00</td>
<td>829</td>
</tr>
<tr>
<td>8 Solid concrete</td>
<td>1800</td>
<td>1.25</td>
<td>880</td>
</tr>
<tr>
<td>9 Hollow concrete</td>
<td>1140</td>
<td>1.60</td>
<td>880</td>
</tr>
<tr>
<td>10 خرساني مصمم</td>
<td>2000</td>
<td>1.40</td>
<td>840</td>
</tr>
<tr>
<td>11 خفاف ابيض</td>
<td>985</td>
<td>0.33</td>
<td>850</td>
</tr>
<tr>
<td>12 رملي وردي مصمم</td>
<td>1800</td>
<td>1.59</td>
<td>835</td>
</tr>
<tr>
<td>13 Hollow sand</td>
<td>1500</td>
<td>1.39</td>
<td>811</td>
</tr>
<tr>
<td><strong>Second : Tiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 PVC tiles (Canaltex)</td>
<td>1350</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Elastic tiles</td>
<td>1700</td>
<td>0.40</td>
</tr>
<tr>
<td>3</td>
<td>Ceramic tiles</td>
<td>2000</td>
<td>1.20</td>
</tr>
<tr>
<td>4</td>
<td>Concrete tiles</td>
<td>2100</td>
<td>1.10</td>
</tr>
<tr>
<td>5</td>
<td>Mosaic tiles</td>
<td>2450</td>
<td>1.60</td>
</tr>
</tbody>
</table>

**Third : Wood**

1. Natural wood

| 1 | Beech | 700 | 0.17 |
| 2 | Spruce | 415 | 0.105 |
| 3 | Oak | 770 | 0.16 |
| 4 | Mahogany | 700 | 0.155 |
| 5 | Pitch pine | 660 | 0.14 |

2. Artificial wood

| 1 | Plywood | 530 | 0.14 |
| 2 | Chip board | 400 | 0.17 |
| 3 | Conter | | 0.212 |

**Fourth : Metals**

| 1 | Lead | 11300 | 34.8 | 129 |
| 2 | Stainless steel | 7830 | 45.3 | 500 |
| 3 | Zinc | 7130 | 110 | 390 |
| 4 | Aluminium sheets | 2740 | 221 | 896 |
| 5 | Red copper | 8780 | 150 | 400 |
| 6 | Yellow copper | 8310 | 120 | 400 |

**Fifth : Gypsum and cement materials**

| 1 | Gypsum | 320 | 0.15 |
| 2 | Gypsum boards | 950 | 0.39 |
| 3 | Portland cement | 1335 | 0.12 |
| 4 | Thermal cement | 1406 | 0.175 |

**Sixth : Aggregate and stones**

| 1 | Sand | 1520 | 0.33 | 800 |
### Table (13) represents selected list of useful plant material located in northern Egypt including Cairo and Suez area.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Name</th>
<th>Type</th>
<th>D/E (Deciduous or Evergreen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought resistant plants (R)</td>
<td>Acacia spp.</td>
<td>Shrubs</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Agaves</td>
<td>Succulents</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Aloes</td>
<td>Succulents</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Eucalyptus citriodora</td>
<td>Large trees</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Euphoria schimperi</td>
<td>Succulents</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Lantana camara</td>
<td>Shrubs</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Nerium oleander</td>
<td>Shrubs</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Opuntia dillenii</td>
<td>Succulents</td>
<td>E</td>
</tr>
</tbody>
</table>

Numbers shown in this table are guidance and not obligatory, they are the most frequently used in local market.
<table>
<thead>
<tr>
<th>Salinity tolerant plants (S)</th>
<th>Shade trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parkinsonia aculeate</td>
<td>Azadirachta indica</td>
</tr>
<tr>
<td>Pithecellobium dulce</td>
<td>Bauhinia variegate</td>
</tr>
<tr>
<td>Prosopis juliflora</td>
<td>Bombax malaburicum</td>
</tr>
<tr>
<td>Tamarix articulate</td>
<td>Cassia spp.</td>
</tr>
<tr>
<td>Yucca gloriosa</td>
<td>Delonix regia</td>
</tr>
<tr>
<td>Zizyphus spini-Christi</td>
<td>Jacaranda acutifolia</td>
</tr>
<tr>
<td></td>
<td>Mangifera indica</td>
</tr>
<tr>
<td></td>
<td>Peltophorum africanum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Salinity tolerant plants (S)</th>
<th>Shade trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia spp.</td>
<td>Azadirachta indica</td>
</tr>
<tr>
<td>Atriplex halimus</td>
<td>Bauhinia variegate</td>
</tr>
<tr>
<td>Dodonea viscosa</td>
<td>Bombax malaburicum</td>
</tr>
<tr>
<td>Eucalyptus citriodora</td>
<td>Cassia spp.</td>
</tr>
<tr>
<td>Eucalyptus rostrata</td>
<td>Delonix regia</td>
</tr>
<tr>
<td>Hyphaene thebaica</td>
<td>Jacaranda acutifolia</td>
</tr>
<tr>
<td>Parkinsonia aculeate</td>
<td>Mangifera indica</td>
</tr>
<tr>
<td>Pithecellobium dulce</td>
<td>Peltophorum africanum</td>
</tr>
<tr>
<td>Prosopis juliflora</td>
<td></td>
</tr>
<tr>
<td>Ricinus communis</td>
<td></td>
</tr>
<tr>
<td>Schinus terebinthefolius</td>
<td></td>
</tr>
<tr>
<td>Tamarix articulate</td>
<td></td>
</tr>
<tr>
<td>Taxodium distichum</td>
<td></td>
</tr>
<tr>
<td>Zizyphus spini-Christi</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shade trees</th>
<th>Salinity tolerant plants (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azadirachta indica</td>
<td>Parkinsonia aculeate</td>
</tr>
<tr>
<td>Bauhinia variegate</td>
<td>Pithecellobium dulce</td>
</tr>
<tr>
<td>Bombax malaburicum</td>
<td>Prosopis juliflora</td>
</tr>
<tr>
<td>Cassia spp.</td>
<td>Tamarix articulate</td>
</tr>
<tr>
<td>Delonix regia</td>
<td>Yucca gloriosa</td>
</tr>
<tr>
<td>Jacaranda acutifolia</td>
<td>Zizyphus spini-Christi</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td></td>
</tr>
<tr>
<td>Peltophorum africanum</td>
<td></td>
</tr>
<tr>
<td>Plant Name</td>
<td>Type</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Terminalia arjuna</td>
<td>Large trees</td>
</tr>
<tr>
<td>Acacia spp.</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Cupressus sempervirens</td>
<td>Large trees</td>
</tr>
<tr>
<td>Ficus retusa</td>
<td>Small trees</td>
</tr>
<tr>
<td>Lawsonia inermis</td>
<td>Small trees</td>
</tr>
<tr>
<td>Pithecellobium dulce</td>
<td>Small trees</td>
</tr>
<tr>
<td>Acacia spp.</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Acalypha wilkesiana</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Bougainvillea spp.</td>
<td>Ground cover</td>
</tr>
<tr>
<td>Casuarina equisetifolia</td>
<td>Large trees</td>
</tr>
<tr>
<td>Dodonea viscosa</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Duranta repens</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Ficus retusa</td>
<td>Small trees</td>
</tr>
<tr>
<td>Hibiscus spp.</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Lantana camara</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Lawsonia inermis</td>
<td>Small trees</td>
</tr>
<tr>
<td>Nerium oleander</td>
<td>Shrubs</td>
</tr>
<tr>
<td>Pithecellobium dulce</td>
<td>Small trees</td>
</tr>
</tbody>
</table>
الملخص

خلال الثلاث العقود الأخيرة، أصبح العالم على دراية أكثر بالتغيرات المناخية و غيرها من التي تحدث بالعالم، بدأ يهيمن أكثر تأثير التكنولوجيا والتعرض الصناعي على الإيكولوجيا و صحة الإنسان مما نتج عنه توجه الكثير من الأبحاث إلى إيجاد طاقة نظيفة ومتجددة. و هو يمكن اعادة تدويرها باختصار تم توجيه المعماريين إلى البدء في استخدام مواد بناء و طرق بناء صديقة للبيئة و تهوية و اضاءة طبيعية... إلخ، و بدأ نجذب مسميات للمباني تظهر مثل مباني موفرة للطاقة و مستدامة و ايكولوجية، هذه الأنواع من المباني موجودة بالفعل الآن في أوروبا وأمريكا، اليابان و غيرهم من الدول المتقدمة لأن العالم بدأ يستوعب أن هناك خطورة إذا لم نتوقف عن اتخاذ كوكب الأرض و أن المباني الإيكولوجيا هي إحدى الطرق للحفاظ عليه للأجيال القادمة.

و لمعظم الناس، ساكننا يمثل الاستثمار الأكبر في حياتنا، وبالتالي ستكون صدمه كبيرة إذا كانت هذه البيوت غير مهتمة بمساكنه أو بالبيئة المحيطة. بيوتنا يمكن أن تدور صحتنا والهواء الذي نستنشقه والماء الذي نشربه بدون أن تكون على علم بذلك.

البيت لا يفيق عند الباب الأمامي و لكنه يؤثر في و يتأثر بما يحيطه.

و إذا نظرا ما امرس سنجد أننا دائما ما كانت تبنى مباني إيكولوجيا حتى بدأنا نستورد التكنولوجيا الغريبة بدء إجراء أي تغيير فيها تناسب أجوانا أو مواد البناء المتاحة لدينا. وبالتالي فنحن الآن متأخرين عن باقي دول العالم في طرق بناننا لندنا و بيوتنا.

هذ الرسالة اهتمت بالإسكان الإيكولوجي لما هو من أهمية كبيرة كما أنها اهتمت بالإسكان الاقتصادي لشدة الطلب عليه، فهي تناقش مبادئ التصميم الإيكولوجي المطبق حاليا وتجارب مصر في الإسكان الاقتصادي وتقييمه من خلال مبادئ التصميم الإيكولوجي.

و في النهاية يتبقي للعمارة خطوة ارشادية لمساعدته خلال خطوات المشروع المختلفة بدءاً باختيار الموقع وحتى نظام الإنشاء ذلك للحصول على مسكن اقتصادي إيكولوجي ليكون مثالية مساهمة العمارية في الحفاظ على الأرض و الإقلاع من الضرر بها و مواردها و خلق مسكن صحي مريح و اقتصادي للناس.
اسكان اقتصادي ايكولوجي

إعداد
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في
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التخطيط والتصميم البيئي

يعتمد من لجنة الممتنعين
عضو

أ.د.سيد مدبولي علي حسن

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