“Honeycomb Cottonwood Eco-Friendly house”

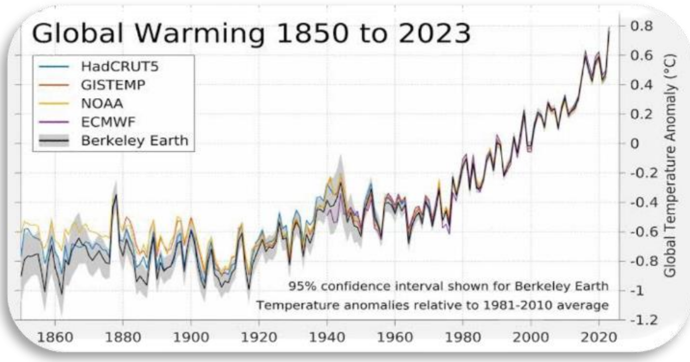
Dakahlia stem school

2024-2-212

Table of Contents

Introduction:

Egypt faces major challenges that lead to the deterioration of its development. The project for this semester seeks to address important issues in order to positively impact Egypt's eleven major grand challenges. It also seeks to contribute to Egypt's sustainable development goals by aligning with national strategies for social progress and economic growth, especially recycling garbage, improving the scientific and technological Environment for all, reducing, and adapting to the Effects of climate change, and increasing the Industrial and agricultural bases of Egypt. Drawing inspiration from Zaha Hadid's honeycomb building in Riyadh has showcased remarkable architectural innovation, even though the high cost of the materials and the fact that its non-eco-friendly make a horrible impact on the environment. The ZCB building in Hong Kong is a sustainable building that relies on solar energy as a permanent source and produces zero carbon emissions. Despite that, the material used in this building is non-degradable. On the other hand, the Philippines Bahay Kubo is a low-cost building built from bamboo, which is a natural material friendly for the environment. The weakness of this building is that it is a primitive house that isn't appealing to live in. All these houses don't depend on smart technology. Consequently, the chosen solution is a smart honeycomb building from cottonwood instead of burning it, which produces greenhouse gases and increases climate change. The eco-friendly building depends on 4 solar energies as its main electricity source and a combination of different sensors, such as a CO sensor to detect monoxide leakage from a gas heater and a humidity sensor. The chosen solution achieved the following design requirements: decreasing temperature by three degrees from the outer environment; detecting monoxide leakage from gas heaters by CO sensor to



Graph1: Climate change impacts

avoid frequent accidents due to CO leakage, which cause chocking by open the Window by servo motor; and using a using a DHT sensor to measure humidity and turn on the fan if humidity increases. The solution will achieve the required designs since cottonwood, a natural material, has a lower thermal conductivity than concrete. Solar energy is a quick type of energy, and for the Structure, honeycomb is marked by its light size and durability, and for its large surface area, it could distribute heat. The total volume of the building will be 0.121 m3.

I. Present and Justify a Problem and Solution Requirements

Egypt Grand Challenge(s)

• Improve the use of alternative energies.

• Recycle garbage and waste for economic and environmental purposes.

• Deal with urban congestion and its consequences.

• Work to eradicate public health issues/disease.

• Increase the industrial and agricultural bases of Egypt.

• Address and reduce pollution fouling our air, water, and soil.

• Improve uses of arid areas.

• Manage and increase the sources of clean water.

• Deal with population growth and its consequences.

• Improve the scientific and technological environment for all.

• Reduce and adapt to the effect of climatic change.

1-Increase the industrial and agricultural bases of Egypt:

Egypt's economy still heavily depends on agriculture. The agriculture industry generates around 11% of the GDP.

In a nation where agriculture employs 25% of the work force, cropland is increasingly vulnerable to rising temperatures and decreasing precipitation due to global warming. This might lead to a reduction in food production.

Obstacles continue to exist that affect efficiency and profitability:

Restricted amount of arable land merely 3% of Egypt's total land area is fit for farming, with most of this land being in the Delta, Fayoum, and Nile Valley. Agriculture is heavily dependent on irrigation since there is a shortage of water. Constraints on crop productivity: Over the previous 20 years, yields have experienced restrictions. Letting land clearance, subpar service delivery, inefficient irrigation, and inadequate drainage become excuses for failing to maintain agricultural economic resources. The potential effects of climate change on land include increased salt in soil, land development, elevated groundwater levels, coastal erosion, and the dislocation of people living along the northern shore.

Over-reliance on Conventional Irrigation Techniques: Without adequate water management, many farmers continue to employ floods irrigation, such as basin irrigation. Soil salinization, unequal distribution, and water waste might result from this. Monoculture and Insufficient Crop Rotation: A number of farmers persist in cultivating the same crop on the same plot of land every year. This reduces the nutrients in the soil and makes it more vulnerable to illnesses and pests. Inadequate Soil Testing and Nutrient Management: Farmers frequently use fertilizers carelessly when they don't do adequate soil

testing. Nutrient imbalances waste and contamination of the environment

May result from this. Manual Work for Tasks requiring a Lot of Labor: Weeding is one of the chores that are still done by hand. Although conventional, this method is less effective and takes more time.

Absence of Pest and Disease Monitoring: Conventional methods frequently include little or no monitoring for pests and diseases. Therefore, epidemics may be unreported until they cause serious harm.

Losses Following Harvest many farmers store their harvested crops in less-than-ideal circumstances, which can result in mold growth, spoiling, and decreased market value.

Reluctance to Adopt Modern types and Techniques: Out of habit or ignorance, some farmers are reluctant to embrace new crop types or better techniques.

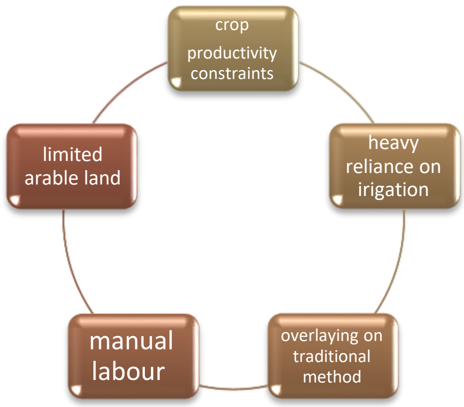


Table1: agricultural challenges

In industry:

Egypt's industrial sector plays a vital role in its economic development, contributing to about 15% of its GDP and employing millions of workers. However, Egypt also faces many challenges in its industrial development, such as low productivity, high energy costs, environmental degradation, and regional disparities.

The following results on texture industry:

1- There is a relationship and the impact of high cotton prices and low area and the deterioration of the textile industry where the correlation coefficient was 0.264 at a significant level 0.01.

2- There is a relationship and impact of the lack of funding necessary to modernize machinery and the deterioration of the textile industry where the correlation coefficient was 0.379 at a significant level 0.01.

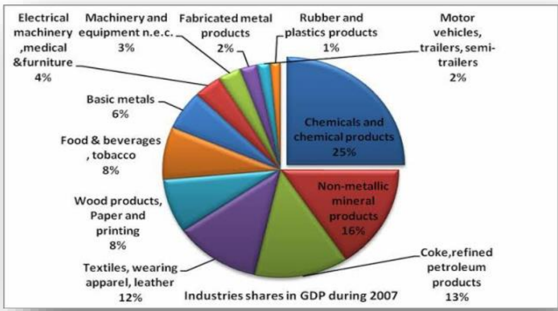


Figure 1: industry share in GDP

3- There is a relationship and the impact of weak performance of technical employment and the deterioration of the textile industry where the correlation coefficient was 0.481 at a level of 0.01.

4- A relationship and influence for the import of high-quality textile products low price and deterioration of the textile industry where the correlation coefficient was 0.482 at a significant level 0.01.

One of the main challenges for Egypt's industrial development is to shift from low-value-added to high-value-added, technology-intensive manufacturing segments. This requires enhancing innovation, competitiveness, and quality standards, as well as investing in human capital and infrastructure. Egypt has launched several initiatives to achieve this goal, such as the National Structural Reform Program (NSRP) 2021-24, which aims to improve the business environment, promote financial inclusion, and facilitate access to finance. The NSRP is aligned with Egypt Vision 2030, the country's long-term economic development strategy, which also emphasizes digital and green technologies and Industry 4.0.

A third challenge for Egypt's industrial development is to ensure environmental sustainability and social inclusion. Egypt is vulnerable to the impacts of climate change, such as water scarcity, desertification, and sea level rise.

2-Recycle garbage and waste for economic and environmental purposes:

Recycling is well-known for its environmental benefits, which include resource conservation, energy conservation and reductions in water and air pollution, including reductions in greenhouse gas generation, however, it also has significant economic benefits, many of which are often overlooked. Recycling is an important segment of the national and state economy, creates jobs and saves money. The businesses, institutions and local government entities all understand that recycling makes both environmental sense and economic sense. Since the environmental benefits of recycling are more often the focus of much of the recycling discussion.

Figure2:straw pales

Environmental developments:

Recycling also conserves resources and protects the environment. Environmental benefits include reducing the amount of waste sent to landfills and combustion facilities; conserving natural resources, such as timber, water, and minerals; and preventing pollution by reducing the need to collect new raw materials.

Economic developments:

Economic and community benefits include increasing economic security by tapping a domestic source of materials, supporting American manufacturing and creating jobs in the recycling and manufacturing industries.

Our goal in this project is to find wasted materials suitable for construction that we can recycle them and use them in building a smart home supported by all services.

An example of a recycled material used in construction is straw:

Straw-bale construction is a building method that uses bales of straw (usually wheat straw) as structural elements, building insulation, or both. This construction method is commonly used in natural building or "brown" construction projects. Research has shown that straw-bale construction is a sustainable method for building, from the standpoint of both materials and energy needed for heating and cooling.

Advantages of straw bale construction:

1- Cheap raw materials for construction.

2-Because straw bales are so tightly packed, they have three times the fire resistance of conventionally constructed walls. It seems counterintuitive, but straw bale is an excellent choice in areas prone to wildfires.

3-The thick, dense walls are soundproof, making the home a refuge from the noisy world.

4-Straw, if free of chemical fertilizers or insecticides, is non-toxic. No off-gassing and no hazardous materials.

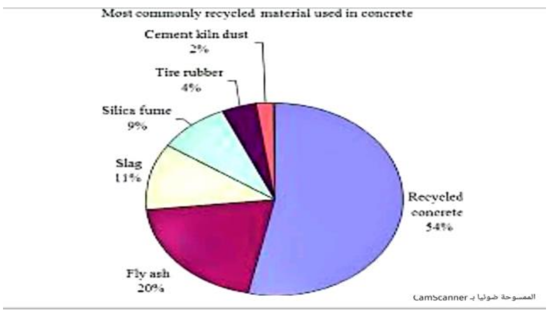


figure3: recycled materials in building

5-Construction can proceed rapidly, because the building materials are large and easy to assemble.

6-Straw bales are flexible enough to resist collapse during an earthquake, and heavy and dense enough to stand up to high winds.

Disadvantages of straw bale construction:

1-Straw bales are attractive to rodent and insect pests. The degree of infestation depends on moisture content, the percentage of grain residue and how long the straw was left out before being baled.

2-"Nebraska-style" straw bale homes may not meet building code requirements everywhere.

3-Lenders may regard straw bale homes as experimental or risky and refuse to finance them. Insurers may also decline coverage.

4_Cracks in the exterior coating must be repaired promptly to prevent the bales from getting wet.

cheap	insect atteactive
fire resistance	not smart
thick, flexible	risky
non-toxic	

table2: straw bale pros& cons

3-Reduce and adapt to the effect of climatic change:

Climate change is one of the most complex issues facing us today. It involves many dimensions – science, economics, society, politics, and moral and ethical questions – and is a global problem, felt on local scales, that will be around for thousands of years. Carbon dioxide, the heat-trapping greenhouse gas that is the primary driver of recent global warming, lingers in the atmosphere for many thousands of years, and the planet (especially the ocean) takes a while to respond to warming. So even if we stopped emitting all greenhouse gases today, one of the biggest factors of climate change is domestic usage. Firstly, Old buildings can have several negative effects on climate change due to factors such as higher energy consumption, inefficient resource utilization, and increased greenhouse gas emissions. Older buildings often lack modern insulation, HVAC systems, and energy-efficient windows, resulting in higher energy consumption for heating, cooling, and lighting. This inefficiency leads to increased demand for electricity and fossil fuels, which in turn results in higher carbon emissions and contributes to global warming. The materials that people use in constructing old buildings have a high amount of energy to produce them. The older buildings have a shortage of smart technologies such as sensors and platforms that can manage energy usage. Old buildings have bad water system which means that some of the wasted water is plumped in leaks which leads to more water consumption. The solution to this problem is to use smart buildings; smart buildings can have a significant positive impact on climate change mitigation and sustainability efforts. Smart buildings utilize advanced technologies such as sensors, automation systems, and machine learning algorithms to optimize energy usage. They can adjust heating, cooling, lighting, and other systems. Smart buildings can efficiently incorporate renewable energy sources like solar panels or wind turbines. They can intelligently manage, and store energy generated from these sources, reducing reliance on fossil fuels, and decreasing carbon emissions. They can optimize water usage, detect leaks, and reduce wastage, promoting water

conservation and sustainability.

Smart buildings play a crucial role in addressing climate change by optimizing resource utilization, enhancing energy efficiency, and promoting sustainable practices. Their impact extends beyond individual buildings to influence broader environmental and societal goals, making them essential components of a greener, more sustainable future.

4- Improve the scientific and technological environment for all:

Traditional construction methods are resource-intensive and frequently inefficient; they have a major negative environmental impact. The following are some ways that conventional building methods can harm the environment:

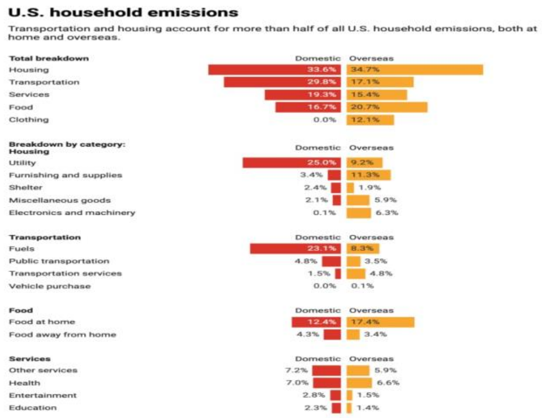


Figure 4: non-renewable energy used in traditional building

Resource Depletion: The extraction of natural resources, including steel, concrete, and timber, is a major component of traditional construction. Overuse of these resources can result in deforestation, habitat destruction, and soil degradation, which can upset ecosystems and lower biodiversity.

Energy Consumption: A significant quantity of energy is needed for the manufacture of building materials, the transportation of materials to the construction site, and on-site operations. Most of this energy comes from fossil fuels. This energy use aggravates climate change and adds to greenhouse gas emissions.

Waste Generation: Excess materials, packaging, and abandoned components are only a few of the waste products produced by traditional building. This garbage frequently finds up in landfills, which worsens the environment and causes pollution.

Pollution of the Air and Water: Construction operations discharge contaminants into the air and water. Air pollution is caused by dust, particulate matter, and emissions from construction equipment. Additionally, runoff from building sites can contaminate water bodies with chemicals and silt, which can negatively impact aquatic ecosystems.

Carbon Emissions: The energy-intensive procedures used to produce building materials, along with the usage of cars and equipment on the job site, result in the emission of greenhouse gases, including carbon dioxide. Climate change and global warming are exacerbated by these emissions.

Loss of Green Space: Conventional building methods and urbanization frequently result in the conversion of natural habitats and green spaces into constructed settings, which reduces the amount of greenery in urban areas and has a detrimental effect on biodiversity.

Transportation Impact: Using trucks and other vehicles to bring goods to the construction site is a need of traditional construction. More pollutants and traffic are produced by this transportation, especially in cities.

Long-Term Energy Use: Conventional structures built without energy-efficient design elements may use more energy for lighting, heating, and cooling, which will result in continuous carbon emissions during the building's lifetime.

Demolition and disposal: At the conclusion of a building's life cycle, demolition produces more garbage, which frequently needs to be disposed of using additional energy.

The building industry can lessen its adverse effects on the environment and help create a built environment that is more resilient and sustainable by implementing more sustainable construction methods.

Problem to be solved:

Unsustainable buildings are non-degradable and caused many environmental impacts: 35% of CO2 emissions, more than 40% of energy consumption, and more than 30% of material use and waste generation. Climate change has become a significant challenge for the entire world, especially Egypt. Because of climate change, Egypt's arid climate will suffer from additional environmental stresses, including extreme temperatures, elevated sea levels, and land subsidence. If the problem isn't solved, Egypt will suffer from negative sequences on its economy. The energy supply in Egypt is diminishing with the dynamic growth of the population, depending on fossil fuels, pollution, and climate change. So, if the problem is solved, more renewable energy resources will be saved, Egypt's crisis will diminish, there will be a decrease in sea levels and temperatures to suitable ranges, and agriculture in Egypt will be improved as a result of regulating precipitation and expanding green lands. The percentage of pollution will decrease.

Research:

We searched about grand challenges which are related to the challenge, improve the scientific and technological environment, recycling, and effects of climate change. We searched about types of materials for building such as cottonwood, bamboo. After that We searched about many shapes for the house. In addition, we searched about many sensors and prior solution and read more about smart houses.

Other solutions already tried:

Honeycomb Shaped Research Center in Riyadh:

The King Abdullah Petroleum Studies and Research Centre (KAPSARC) in Riyadh, Saudi Arabia's capital, is designed like a honeycomb and was constructed by Zaha Hadid Architects. Over 20,000 people attended a big public conference featuring ZHA's organic structure, which welcomed its first guests at Saudi Design Week, which took place between October 4–5, 2017.

Fig5: Honeycomb shaped house

KAPSARC is a non-profit organization that conducts independent research into policies that support the most efficient use of energy to promote global social wellbeing. The organization also creates economic frameworks and policies that lower the environmental impact and total cost of energy supply while facilitating workable technological solutions for more energy-efficient energy use.
The five structures that make up the 70,000 square meter celluloid-formed edifice include the Energy Knowledge Center, the Energy Computer Center, a Conference Center, and an Exhibition Hall and 300-seat theater, the Musalla, an inspiring location for worship on campus, and a Research Library with 100,000 volumes' worth of records.

Once again, ZHA's design strategy is based on a mathematical formula that yields the hexagonal prismatic honeycomb's structure and determines how little material is needed to produce a lattice of cells inside a certain volume.

The primary organizing strategy of the design is a cellular, partially modular " system that integrates different departmental buildings as a single ensemble with interconnecting public spaces," stated Zaha Hadid Architects.

KAPSARC's composition, which is an amalgamation of crystalline forms that develops from the desert terrain and evolves to best adapt to the environmental circumstances and internal program needs, is defined by this structural and organizational philosophy.

The natural wadi that extends to the west is mirrored in the honeycomb grid, which is crushed towards its center axis."
Aside from its general form, the formal composition of the research center can be expanded or modified without sacrificing the center's visual identity. This was done with consideration for the research center's fundamental purpose as a forward-thinking organization, and ZHA designed a flexible, adaptable, expandable structure to meet the institution's future demands.

"All of the plan's components are driven by similar organizational, spatial, and structural strategies produced by the modular design. In addition, ZHA stated that hexagonal cells' six sides have more potential for improved connection than rectangular cells' four sides. The five buildings that make up KapsARC are arranged differently in terms of size and purpose. Every facility is broken down into its individual tasks and is adaptable to changes in specifications or operational procedures."

"KAPSARC's honeycomb grid may easily be expanded to accommodate more cells in the future as the research center grows. The unique layout and design of KAPSARC's structures help to mitigate the Riyadh Plateau's intense light and heat, according to ZHA. The campus's buildings around a sizable public plaza that is shaded by canopies hung from a maze of intricately designed steel columns. The KAPSARC campus faces west and north, providing a strong shield from the intense southern sun. This allows the northerly winds to naturally cool the courtyard in the milder months and allows for easy access to any potential. All the campus's buildings are accessible to pedestrians via

this central public courtyard, which also functions as a gathering place and a bridge between buildings in the milder months. During the warmest months of the year, an underground tunnel is also available for use to connect the campus's main buildings.

The construction of KAPSARC is permeable on the inside, with a robust, weather-resistant shell on the outside that protects against extremes in temperature. Within each structure, sequences of covered courtyards are created by leaving specific hexagonal cells strategically open, allowing softly regulated sunshine to enter the interior. The prismatic architectural cells' crystalline shapes are oriented to hide internal areas from the sun and wind, increasing in height towards the south, west, and east. Direct sunshine, but the areas below receive indirect sunlight from the courtyards that are oriented toward the north and northwest.

The predominant breezes from the north are captured by "wind-catchers" built into the roof profiles on the southern sides of each courtyard, allowing the courtyards to cool.

KAPSARC's use of both passive and active solutions earned it a LEED Platinum certification from the US Green Building Council (USGBC).

The Bahrain World Trade Center:

Conceived by the architectural firm Atkins, stands as a significant emblem of sustainable architecture and inventive design. Comprising towers, each soaring to 34 stories, these structures showcase sail-like formations, not only adding to their visual allure but also fulfilling a practical purpose. These sail structures seamlessly incorporate three substantial wind turbines, each

Fig6: The Bahrain world trade center

boasting a diameter of 29 meters.

The design facilitates the utilization of wind energy to generate power for the building. At maximum capacity, the three wind turbines can supply a noteworthy share of the complex's energy needs, ranging from 11% to 15%. This translates to an annual energy production of approximately 1100 to 1300 megawatts.

To optimize the efficiency of the wind turbines, the towers are interconnected by three bridges, supporting the turbines, and optimizing wind flow. This innovative approach not only caters to the energy needs of the building but also underscores the commitment to sustainable practices in the region.

The complex encompasses a 3-story subterranean platform, housing an entertainment center with restaurants and shopping facilities. Furthermore, each tower incorporates office spaces, and a control tower is situated on the 42nd floor.

Advantages:

1. Distinctive Design: The sail-shaped towers of the Bahrain World Trade Center contribute to its unique and recognizable appearance, becoming a landmark both locally and internationally.

2. Sustainable Energy: The incorporation of wind turbines into the design showcases a dedication to sustainable practices, aligning with global initiatives to reduce dependence on non-renewable energy sources and decrease carbon footprints.

3. Commercial Hub: Functioning as a pivotal business center in Bahrain, the World Trade Center serves as a focal point for economic activities, encouraging business development and hosting key events.

Disadvantages:

1. Maintenance Challenges: The intricate system of wind turbines may present difficulties in maintenance. Sustaining the optimal performance of these turbines necessitates a well-executed maintenance plan to address potential technical issues.

2. Environmental Considerations: Critics argue that, despite its sustainable aspects, the construction of elaborate structures like the Bahrain World Trade Center should undergo careful evaluation for overall environmental impact. This involves assessing the materials used in construction and potential disruptions to the local ecosystem.

ZCB building in Hong Kong:

ZCB, the first Zero-Carbon Building in Hong Kong is developed as a platform for promoting low-carbon living to foster a cultural shift, as well as showcase low/zero-carbon design and technologies. ZCB is designed with the flexibility to switch from a tightly sealed air-conditioned environment to a highly porous cross-ventilated mode with low thermal storage to address the often-high humidity of Hong Kong. Building orientation and form are designed with thoughtful consideration of the site shadowing and wind environment. The site was formed in a balanced cut-and-fill manner and with a strategic undulating profile to help buffer against environmental nuisances from surrounding traffic. High greenery coverage (about 50%) provides amenity, mitigates heat island effect, and provides shade within the site as well as along its perimeter.

Fig7: ZCB building

Advantages:

1- ZCBs significantly reduce greenhouse gas emissions and play a crucial role in combating climate change by lowering the building's carbon footprint.

2- ZBC often incorporates features like natural ventilation, delighting, and non-toxic materials, creating a healthier and more comfortable indoor environment for occupants.

3- ZCBs set an example for sustainable construction practices, encouraging the adoption of environmentally friendly technologies and designs in the building sector.

Disadvantages:

1- Building a Zero Carbon Building typically involves higher upfront costs due to the use of specialized technologies and construction methods, which can be a barrier for some developers.

2- Limited Applicability in Some Contexts: In certain locations or building types, achieving zero carbon emissions may be more difficult due to constraints related to space, climate, or regulatory limitations.

BIG's Honeycomb:

BIG is renowned for their unusual constructions, which frequently leave one wondering, "How were they able to do that?" This is the situation with BIG's Honeycomb, an opulent eight-story condominium that is being built in the Bahamas right now. The hexagonal façade of the project, which consists of individual balconies with glass-fronted outdoor pools for each, is its defining feature. With each balcony (with pool water) weighing between 108,000 and 269,000 pounds (48,000-122,000 kilos) and cantilevering up to 17.5 feet (5.3 meters) beyond the structure, the façade was the biggest engineering difficulty of the project. DeSimone Consulting Engineers, who had previously collaborated with BIG on The Grove, were given this difficult task. Continue reading to learn more about the creative engineering of the Honeycomb. The use of a specially built concrete "super slab," which can cantilever over 17 feet without the need for wall brackets

Fig8: honeycomb shaped building

below, is essential to the Honeycomb's design. This was accomplished by lowering the slab's weight without sacrificing its rigidity or strength. "To control deflection and reduce self-weight, 12-inch (300 millimeter) diameter tubes were embedded in a 17-inch (430 millimeter) thick conventionally reinforced roof slab," as stated by Bill O'Donnell, the project lead at DeSimone. The slab is hollowed out by these cavities, which lowers its weight and improves the section's overall efficiency. Additionally, by removing the requirement for a post-tension slab, this procedure "eliminated the overall weight and reduced the project's cost". The actual balcony decks are built on a typically reinforced slab that is 13 inches (330 millimeters) thick. The fact that the slabs "fold down at the deepest point of the pool to align with the shear wall of the lower unit" for additional support is innovative and explains how the slab can be kept at 13 inches. Because of the Honeycomb's innovative structural system, conventional materials were able to be used, but used carefully. As all the concrete in the building is conventionally reinforced cast-in-place concrete, special attention was paid to the concrete mixture itself. To ensure durability, "limiting initial soluble chlorides, providing a tight water-cement ratio, and additional concrete cover over the reinforcing steel were critical design measures." Finally, for further protection, an integral waterproofing admixture and surface applied coating were also used.

Philippines Bahay Kubo:

Bamboo is a great 'Green Solution'. Bamboo is a wonderful replacement for trees with its short growth cycle and high carbon dioxide exchange rate. Bamboo is a grass with 80 genera and over 1200 documented species. A mature grove of bamboo sends up new shoots every year. These new shoots reach their full size in just a couple of months. Some grow 47 inches in 24 hours and can reach over 100 feet in height within 60 days. This short growth cycle makes it a great replacement for slow-growing forests that are being steadily cut back. It can screen out unsightly areas and pro a noise barrier in the process

In Philippines Bahay Kubo is a traditional Filipino house made primarily of bamboo and nipa palm leaves. It often serves as an icon of Philippine culture. The house is exclusive to the lowland population of unified Spanish.

Fig9: Philippines Bahay Kubo

Advantages of Bahay Kubo:

1- Bamboo is a great 'Green Solution'. Bamboo is a wonderful replacement for trees with its short growth cycle and high carbon dioxide exchange rate. Bamboo is a grass with 80 genera and over 1200 documented species. A mature grove of bamboo sends up new shoots every year. These new shoots reach their full size in just a couple of months. Some grow 47 inches in 24 hours and can reach over 100 feet in height within 60 days.

This short growth cycle makes it a great replacement for slow-growing forests that are being steadily cut back. It can screen out unsightly areas and pro a noise barrier in the process.

In Philippines Bahay Kubo is a traditional Filipino house made primarily of bamboo and nipa palm leaves.

It often serves as an icon of Philippine culture. The house is exclusive to the lowland population of unified Spanish.

2- The steep pitch allows water to flow down quickly at the height of the monsoon season while the long eaves give people a limited space to move about around the house's exterior when it rains.

Disadvantages of Bahay Kubo:

A Bahay Kubo is much prone to forest-fire because it's commonly built by woods, and of course, the life span of a Concrete House is way longer than a Bahay Kubo with a material capable of being rotten as time passes by.

Generating and defining a solution:

Solution and Design requirement:

We plan to address Egypt's Grand Challenges by developing a sustainable smart house. To decrease the dependence on traditional energy sources we intend to use renewable energy sources, such as solar panels, into the building design. To reduce its impact on the environment and encourage the construction of environmentally friendly buildings from natural materials, our prototype will use environmentally friendly building materials. Increasing energy efficiency and optimizing space usage. We will combine sustainable systems with sensor technologies to increase efficiency and automation which make the prototype achieve design requirements and manage Egypt grand challenges.

Design requirements:

Our design requirements are decreasing temperature at least 3 degrees than outside, measuring monoxide leakage by CO sensor from gas hotter to diminish death by chocking and send notification and open the window to exit the gas. Measuring humidity level by DHT sensor and decrease it by fan. Connecting the sensors by application to send notifications as feedback system. Using solar panels to produce renewable source of energy used inside the house.

Selection of solution:

After a lot of research about the previous and the current solutions, we decided to make a hexagonal smart building due to its advantages compared to traditional buildings, which have a significant impact on its internal temperature, due to the small surface area which can maintain a more stable internal temperature by minimizing heat transfer through the walls and roofs. We decided to use cottonwood as a construction material, it is a sustainable resource as a tree can be planted and harvested over time, and is a durable, natural, biodegradable material that has lower embodied energy compared to other building materials. Reduce heat transfer through walls, and floors due to its low thermal conductivity which is 0.087 W/mK. We decided to make a system organized by sensors to protect and help organize the whole house such as an ultrasonic sensor for making a security system. We can use humidity sensors to measure the difference of humidity between inside and outside the house. We will use a carbon monoxide sensor to detect the percentage of carbon monoxide in the air. All these sensors will be connected to a motor to take actions to adjust what the sensors detect. We will use solar panels to generate renewable energy instead of other energies which have a bad effect on the environment.

Selection of prototype:

The design of the prototype will be a hexagonal smart house like a honeycomb; it will have three hexagonal prisms which will effect on temperature to decrease is due to its surface area. We will build the house from cotton wood to decrease the temperature inside the house. First, we will grind cotton wood into tiny pieces, mix them with urea-formaldehyde glue, and put them in a hydraulic press to make boards of cotton wood. After that, we will slice them into 20*50*2 rectangular prisms and shape the house. After constructing the house, we will use plenty of sensors: a monoxide sensor to detect gas leakage from the hotter gas and using servo motor to open the window, a humidity sensor connected with a fan to turn on if humidity increases, which meets the design requirements. We use solar cells as an energy source for sensors to get renewable energy source and achieve design requirements.

Constructing and testing the prototype:

Materials and methods:

OBJECT	COST	PHOTO	DISCERPTION	SOURCE OF PURCHASE	USAGE	QUANTITY
RECHARGEAB LE BATTERY	60		REUSABLE, ECO-FRIENDLY ENERGY CELL	LAMBA TRONICS	USING RECHARGEABLE BATTERY POWERED BY SOLAR CELL	1
SERVO MOTOR	60		PRECISE MOTION CONTROLLERS IN ROBOTICS	LAMBA TRONICS	IMPLEMENTING SERVO MOTORS FOR CONTROL.	1
CO SENSOR	30		DETECTS DEADLY CARBON MONOXIDE GAS, ENSURING SAFETY	LAMBA TRONICS	UTILIZING CO SENSOR FOR MONITORING AIR QUALITY.	1
COTTON WOOD	WASTED		SOFT WOOD	GAMSA	FOR SUSTAINABLE BUILDING CONSTRUCTION	5KG
SOLAR CELL	250		CONVERT SUNLIGHT TO ELECTRICITY USING SEMICONDUCTOR	LAMBA TRONICS	UTILIZING SOLAR CELLS TO HARNESS RENEWABLE ENERGY .	1
ESP 8266	200		AFFORDABLE WI-FI MODULE FOR IOT DEVICES	LAMBA TRONICS	FOR CONDUCTIVITY IN THE SMART SYSTEM	1
FAN	50		AIR CIRCULATOR FOR VENTILATION	LAMBA TRONICS	EMPLOYING FANS AS ACTUATORS IN THE SYSTEM	1
UREA FORMALDEHY DE GLUE	150		A STRONG WOOD ADHESIVE	GAMSA	UTILIZING AS A ROBUST ADHESIVE FOR WOOD BONDING K	5 LITERS

Methods:

Fig1: Grind Cottonwood

Firstly, Cottonwood was grinded into tiny pieces and was mixed with urea-formaldehyde glue. After that the mixture was put in a hydraulic press to make boards of cotton wood. Then the boards were sliced into 20*50*2 cm rectangular prisms and the house was shaped with glue. Two hexagonal prisms were shaped from rectangular prisms. Furthermore, Solar cell was used to generate electricity putting above the building with Area equal 0.30016m^2. After

constructing the house: plenty of sensors were used Connected to ESP 8266: co sensor was connected to pin A0, DHT sensor was connected to pin D3, and two motors: servo

Fig2:Hexagonal Prism House

motor was connected to pin D1, and a fan connected to pin D2. Connected sensors to remote XY application to display readings and graphs finally, send notification if co increased above 10% or humidity increased above 40%.

Fig3:DHT sensor

Safety:

We do all work in Fab lab under monitoring from our teachers. We used safe materials for our building such as cottonwood, and glue. For safety we will used resistance to reach the current get from solar cell to the right voltage for sensors which is needs at most 5v and solar cell produce 9 volts. Sketching the circuit online before connecting them in real to the effective use of the board and for long life of it. Turn off the board if we didn’t use it to not burn.

Test plan:

First trial:

Fig4: CO sensor connected to ESP

Cottonwood was grinded into large pieces, so It did not hold together well, so it failed.

Second trial:

Measuring temperature outside and inside the house by temperature sensor after 2 minutes. After that, detecting the change of CO gas exiting from smoke minutes and detecting the change again after opening the window during 1m. Furthermore, detecting of humidity level increasing due to water vapor inside the house and after turning on the fan during 1minutes.

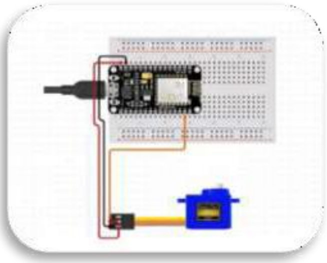


Fig5:DHT circuit Diagram

Third trial:

After increasing time to get more accurate sensors reading:

Firstly, repeating detection of temperature after 4m. Secondly, Detecting CO leakage again after 2m.

Finally, detecting the change of humidity after 3m.

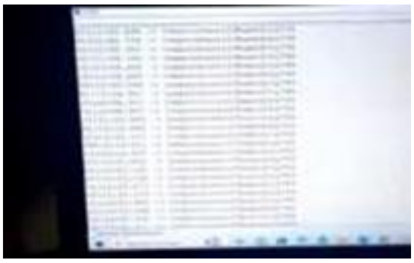


Fig7: Humidity and temperature reading

Fig6: IDE reading

Data collection:

We used MQ-7(CO sensor) (with error±3%), and DHT-11 sensor for measuring the temperature, and humidity (with error±2C for temperature, ±5% for humidity). After making the prototype and testing it multiple times to achieve design requirements we collected data and analyzed them as shown in table 1,2,3.

Time	0m	1m	1m30s	1m43s	2m	4m
Reading	28±2C	27±2C	26±2℃	25±2C	24±2c	23±2c
comment	Outside the house	Inside the house	——	——	——	The least inside T

Table1: Temperature measurement

Time	0m	1m	2m 30s	3m
Reading	98%±5%	85%±5%	58%±5%	38%±5%
comment	Fan turned off	Fan turned on	——	Least reading

Table2: Humidity Reading

Time	0m	30s	1m	2m
Reading	18.28%±3%	11.83%±3%	7.82%±3%	5.87%±3%
comment	Close window	Open window	——	Least reading

Table3: CO Reading

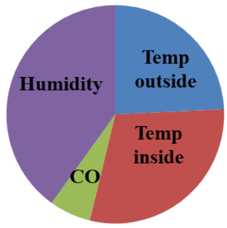
Evaluation, Reflection, Recommendations

Analysis &Discussion:

No.	Type of damage	Number of farmers	%	No.	Type of damage	Number of farmers	%
1	Air pollution	48	%32	7	Cause a black cloud to appear	30	%20
2	Canals water pollution	31	%21	8	Cause bad scenery on the roads	62	%41
3	Soil contamination	18	%12	9	Cause fires and disasters in houses and storerooms	107	%71
4	Danger to human health	16	%11	10	Cause the spread of insects, pests and mice	89	%59
5	Affect the crops grown and reduce production and quality	29	%19	11	Cause social problems among neighbors	30	%20
6	Harm animal health and reduces production	14	%9	12	Low cash income for farmer	78	%52

Table4:Agriculture waste pollution

Egypt faces challenges of climate change due to rapid industrialization and urbanization. Despite agricultural and industrial potential, gaps in technology adoption hinder progress. Rising pollution levels in the environment urgently require technological interventions for ecosystem protection and human health. The main challenges to be solved are climate change and technology improvement. The required solution to address these challenges is to construct a sustainable green house from natural materials such as cottonwood and was painted with natural organic paint to insult water and humidity as studied in **CH.2.10** and connect it with plenty of sensors, including a CO sensor and a humidity sensor. The prototype meets design requirements, which are detection of monoxide leakage from the gas heater and opening the window by a servo motor to reduce the gas. Also maintain a lower temperature than outside, as cottonwood has a lower thermal conductivity than other building materials. And measure the humidity with humidity sensor and decrease it by opening a fan for ventilation.



Grapgh2:Sensors Reading

The building depends on solar cell, which are renewable sources of energy. With efficiency measure depends on ME.2.05:

Efficiency of solar cell$=\frac{\textit{panel power in }(kw)}{\textit{panel length} \times \textit{panel width in }(m)} \times 100$

Length= 0.224m, width=0.134m, max power= 0.003 kw

So efficiency$=\frac{0.003}{0.224\times0.134}=10\%$

And with potential difference= 9 volt. Which make it appropriate for turn on sensors and actuators in the building.

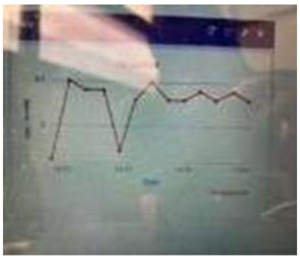
The design of prototype is hexagonal shape comes from honeycomb design which Is lighter and durable it characterized by its large surface which distribute the heat as found in **PH.2.14**.

THE Dimensions of the building as shown are:

Volume of hexagonal prism=$\frac{3\sqrt{3}}{2}a^2$h (a is the base and h is the height)

a= 0.2m, height=0.5m number of hexagonal prisms=2

So the volume= $\frac{3\sqrt{3}}{2}\mathbf{0.2^2 \times 0.5 \times 2 = 0.104}\boldsymbol{m^3}$



Graph3:1st co reading

Volume of triangular prism= area of triangle (width $\times\ hieght \times \frac{1}{2}$)$\times\ depth$

Width=0.20m, height=0.17m, depth=0.5m, number of triangular prism=2

Volume= $\mathbf{0.2 \times 0.17 \times 0.5}$ **=0.017**$\boldsymbol{m^3}$

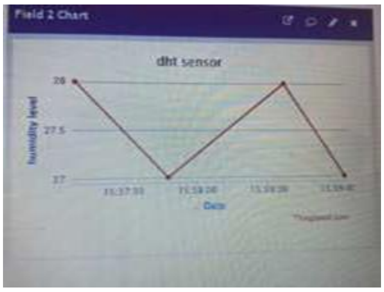
The total volume= 0.017+0.104=0.121$\boldsymbol{m^3}$**.**

In MA.2.7 the concept of limits is used to measure the amount of heat absorb by cotton wood and the relation with thickness:

$$\lim_{d\to .012} f(x) = \frac{KA\Delta T}{d}$$

F(x) is heat conductivity, K is thermal conductivity of cottonwood, A is surface area of the building, and T change in temperature, d is thickness.

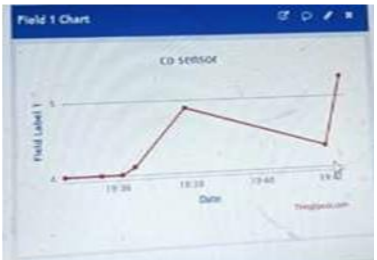
K= 0.2WmK, A= 1.4m^2, $\Delta T = 3$°C, d approaches to 0.012m.



So f(x) =$\frac{\mathbf{0.2\times1.4\times3}}{\mathbf{0.012}}$ $= \mathbf{70w/m.k.}$

Graph4: 1st humidity reading

Cottonwood is better insulator for heat than other constructing material, due to its low thermal conductivity compared to others, and the increasing of thickness of the building.



Graph5: 2nd co reading

First trial:

Cottonwood was grinded into large pieces which was inefficient and didn't mix with each other in hydraulic press.

Second trial:

As shown in the opposite graph 3 the Amount of monoxide gas variation detected ... sensor during 1 minutes. The humidity was detected by DHT during ...s shown in graph4. The second trial wasn't accurate due to the small ...g time.

The prototype has successfully as shown in graph 5,6 achieved design requirements after detecting co and humidity for 3 minutes for more accuracy. Temperature decreased 5℃ than outside during 4 minutes.

Graph6: 2nd humidity reading

Conclusion:

The project's purpose is to develop a smart building that can then be utilized to decrease the temperature inside the house compared to outside by not less than 3 degrees Celsius. Based on the data obtained and previous research, the solution design was able to overcome the difficulty of increasing temperature. To address this problem, the decided solution was to build a smart house made of cottonwood in a hexagonal shape and three feedback systems that will be powered by a renewable energy source, which is solar energy. The temperature, humidity, and CO emissions will be monitored by the three feedback systems to ensure that they remain in the ideal range. The outcome results after three trials were able to decrease temperature from 28 degrees Celsius to 23 degrees Celsius, humidity from 98% to 64% after opening the fan, and finally, CO level from 18.28% to 5.87% after opening the window. compared to (Dana, Martin, Monika, and Robert 2014), show that the most common wood in buildings (timbre) has a thermal conductivity of more than 0.17 W/mK compared to cottonwood, which has a thermal conductivity of 0.087 W/mK and decreases temperature 5 degreed than outside. That makes cottonwood the best low-cost recommended building material.

Recommendations:

In science, there is nothing called complete work; hence we did our best in this project. We got many ideas to improve the project, but we couldn't apply all in the prototype, due to the lack of time and limited capabilities, so we have some recommendations:

Using the DHT22 sensor to detect temperature and humidity is more accurate and efficient than DHT 11; due to its high price we replaced it with a lower price and efficiency sensor which is DHT11sensor. To ensure the success of this project, it can be constructed in the real life by the ratio 1:80 so, its volume should be 53248m3. Painting cottonwood with varnish which is organic insulator slows down degradable and humidity effects on cottonwood. Mix cottonwood with rice straw to raise durability and thermal insulation effect due to low thermal conductivity of rice straw. Using Aluminum with thermal breaks material to reduce heat transfer and UV protection. Working in this project helps us to identify Egypt grand challenges better, working with different natural material and identifying their importance in building. Also engaging in research experience help us to enhance our knowledge in EDP steps and research process to find solution achieves design requirements.

Learning outcomes:

SUBJECT	CONNECTION
CHEMISTRY.2.10	THE HOUSE WAS PAINTED WITH NATURAL ORGANIC PAINT TO INSULT WATER AND HUMIDITY AS STUDIED IN CHEMISTRY.
CHEMISTRY.2.11	THE SYSTEM WHOLE ENERGY COME FROM SUSTAINABLE ENERGY SOURCES WHICH WILL LESSEN POLLUTION LEVELS AND DECREASE CLIMATE CHANGES.
COMPUTER SCIENCE.2.05	FOR THE SYSTEM TO FUNCTION AUTOMATICALLY, LOOPS WERE USED IN THE CODE. SPECIFICALLY, IF LOOPS.
COMPUTER SCIENCE.2.06	IN ORDER TO RECEIVE A NOTIFICATION IF THERE ARE ANY CHANGES, WE MADE AN APPLICATION.
PHYSICS.2.09	THE ENERGY WILL BE STORED IN THE RECHARGEABLE BATTERY BY TRANSFERRING IT FROM THE SOLAR PANEL.
PHYSICS.2.14	THE HEXAGONAL SHAPE LARGE SURFACE HELPS IN DISTRIBUTE THE HEAT AS WE LEARNED IN PHYSICS.
MECHANICS.2.05	WE MEASURE THE EFFICIENCY OF THE SOLAR CELL USING MECHANICS.
MECHANICS.2.06	THE CONCEPT OF THE CENTER OF MASS WAS USED TO INCREASE THE STABILITY OF THE HOUSE.
EARTH SCIENCE.2.10	THE MATERIAL SELECTED TO WORK ON IS COTTON WOOD. USING THE INFORMATION WE LEARNED IN GEO.
MATH.2.07	WEUSED THE CONCEPT OF LIMITS IS TO MEASURE THE AMOUNT OF HEAT ABSORB BY COTTON WOOD AND THE RELATION WITH THICKNESS.
BIOLOGY LO.10	SIMULATION OF FEADBACK SYSTEM IN FEMALE REPRODUCTIVE SYSTEM TO THE FEADBACK SYSTEM IN HOUSE WHICH CONTROL SENSOR READING AND MOTORS
BIOLOGY.LO14	STYDY OF BIODEGRADABLE MATERIALS LIKE WOOD WHICH WE USED IN BUILDING AND HOW TO PROTECT IT FROM WORMS

Literature cites:

1-Akiner, Muhammed Ernur & Akiner, İlknur & Akiner, Nurdan & Zileska-Pancovska, Valentina. (2022). Using wood as a new generation building material in the context of sustainable development. Zastita materijala. 63. 68-78.DOI:10.5937/zasmat2201068A.

2- Bendor, J., Moe, T. M., & Shotts, K. W. (2001). Recycling the garbage can: An assessment of the research program. American Political Science Review, 95(1), 169-190. https://www.cambridge.org/core/journals/american-political-science-review/article/recycling-the-garbage-can-an-assessment-of-the-research-program/A09FF1D7653A3D41FBC4C0B198432ACC

3- Ding, D., Cooper, R. A., Pasquina, P. F., & Fici-Pasquina, L. (2011). Sensor technology for smart homes. Maturitas, 69(2), 131-136. https://www.sciencedirect.com/science/article/pii/S0378512211000983

4-Du Plessis, A., Razavi, N., Benedetti, M., Murchio, S., Leary, M., Watson, M., ... & Berto, F. (2022). Properties and applications of additively manufactured metallic cellular materials: A review. Progress in Materials Science, 125, 100918. https://doi.org/10.1016/j.pmatsci.2015.05.001

5- Kibert, C. J. (2016). Sustainable construction: green building design and delivery. John Wiley & Sons.

https://books.google.com/books?hl=en&lr=&id=2xgWCgAAQBAJ&oi=fnd&pg=PR15&dq=Green+Building+Practices+Reducing+Environmental+Footprint+in+Construction&ots=GaUpeRa1vu&sig=FhXbncxM9IlgNDjQxtUqw2PL0pQ

6- Koňáková, D., Čáchová, M., Vejmelková, E., Keppert, M.. Černý, R., (2014). Thermal Properties of Selected Timbers, 982, 101-103.

DOI: https://www.scientific.net/AMR.982.100

7- Kannan, N., & Vakeesan, D. (2016). Solar energy for future world:-A review. Renewable and sustainable energy reviews, 62, 1092-1105. https://www.sciencedirect.com/science/article/pii/S1364032116301320

8- Kumar, Parmod & Joshi, Laxmi. (2013). Pollution Caused by Agricultural Waste Burning and Possible Alternate Uses of Crop Stubble: A Case Study of Punjab. https://doi.org/10.1007/978-3-642-36143-2_22

9- Iannaccone, G., Imperadori, M., & Masera, G. (2014). Smart-ECO buildings towards 2020/2030: innovative technologies for resource efficient buildings.

https://books.google.com/books?hl=en&lr=&id=mXUeBAAAQBAJ&oi=fnd&pg=PR5&dq=Resource+Efficiency+in+Construction:+Sustainable+Approaches+and+Technologies+and+smart+building+&ots=dN7c6L3olH&sig=isSl9prv95N6nxZX0WuKCm7xQIQ

10- Metallidou, C. K., Psannis, K. E., & Egyptiadou, E. A. (2020). Energy efficiency in smart buildings: IoT approaches. IEEE Access, 8, 63679-/63699.https://ieeexplore.ieee.org/abstract/document/9050775

11- Moghadam, Z. S., Montazeri, H., & Blocken, B. (2018, March). Numerical analysis of urban wind energy potential using actuator disk models: A case study for the Bahrain world trade center. In FINAL CONFERENCE 2018 (p. 261).https://www.researchgate.net/profile/Andrzej-Wyszogrodzki/publication/338077703_Evaluation_of_the_wind_resources_in_Warsaw_on_the_onsite_measurements_and_numerical_model/links/5dfcd994299bf10bc36b9d14/Evaluation-of-the-wind-resources-in-Warsaw-on-the-onsite-measurements-and-numerical-model.pdf#page=270

12- Nižetić, S., Djilali, N., Papadopoulos, A., & Rodrigues, J. J. (2019). Smart technologies for promotion of energy efficiency, utilization of sustainable resources and waste management. Journal of cleaner production, 231, 565-591.https://www.sciencedirect.com/science/article/pii/S0959652619314982

13- Tadina,J&Trisha,S&Gojr,S&Faye,A&Park,D&Jakielou,M.(2019).Ilokano Bahay Kubo: Symbolisms and Dimensions.

https://www.scribd.com/document/436296305/Research-Paper-FullNaToh-docx

14- Vattano, S. (2014). Smart buildings for a sustainable development. Journal of Economics World, 2, 310-324.https://www.academia.edu/download/35920270/Economics_World_ISSN_2328-7144_Vol.2_No.5_2014.pdf#page=25

15- Zhuang, H., Zhang, J., CB, S., & Muthu, B. A. (2020). Sustainable smart city building construction methods. Sustainability, 12(12), 4947.https://www.mdpi.com/2071-1050/12/12/4947