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Green Architecture Approach to Integrated Laboratory and Greenhouse Design

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Abstract: The Green Architecture approach is a research theme in relation to environmental problems and global warming issues that affect building design. The purpose of this research using qualitative methods is to obtain design results with the Green Architecture concept and to highlight Acehnese architecture and Islamic architecture. Analysis is carried out on existing building data and interview results with users and stakeholders. The conclusion and suggestion are to obtain the design results of an integrated laboratory and greenhouse which aims to be a model that can be applied to similar buildings.

Keywords: Green Architecture, Sustainability, Agricultural Laboratory, Greenhouse

INTRODUCTION

The Green Architecture approach was the research theme before designing an integrated laboratory and greenhouse on the campus of Malikussaleh University (abbreviated as UNIMAL), located on Jalan Medan-Banda Aceh, Cot Teungku Nie Reuleut, Muara Batu District, North Aceh Regency, Aceh Province.According to the Great Dictionary of the Indonesian Language (2016), a laboratory is a specific place or room equipped with equipment to conduct experiments (investigations). In the Regulation of the Minister of State Number 03 concerning Strengthening State Institutions and Bureaucratic Reform concerning the Functional Status of Educational Laboratory Institutions and Their Credibility, it is written that a laboratory is an academic support unit in the form of a closed or open space in an educational institution. In the laboratory, testing, calibration, and/or production are systematically carried out on a limited scale, using equipment and materials based on certain scientific methods, in the context of teaching practices, research, and/or community service, both permanent and mobile.Based on the above definition, a laboratory (abbreviated as "lab") is a building where scientific experiments, research, learning practices, testing activities and/or a means of transporting building production with equipment and materials are carried out. based on certain scientific methods.Meanwhile, a greenhouse is an agricultural building used as a research facility for plant cultivation (Nafila, 2018). According to

Alahudin et al. (2013), research activities can be carried out in a greenhouse because environmental conditions can be manipulated to suit plant needs (agricultural environmental control). Plants in the building may be isolated from natural conditions and other unexpected external factors. In a greenhouse, conditions are created where plants can be isolated so that the lighting is good and optimal for plant growth (Inayah, 2007).Malikussaleh University (abbreviated UNIMAL) is a state university located on the northeast coast of Aceh, with its main campus currently located in Leruye, North Aceh, Aceh Province, Indonesia. The Faculty of Agriculture of Malikussaleh University (UNIMAL) is one of the leading faculties in the field of agricultural and fisheries development on the island of Sumatra, which was established on December 29, 1989 through the Decree of the Minister of Education & Culture of the Republic of Indonesia Number 0584/0/1989. The Faculty of Agriculture has a campus located on Jalan Medan-Banda Aceh, Cot Teungku Nie Reuleut, Muara Batu District, North Aceh Regency, Aceh Province.

Figure 1. Atmosphere of Suta Kasa Housing Planning Land (source: Hilman, 2023)
Departments at the Faculty of Agriculture UNIMAL:

- Agroecotechnology Department (S1)
- Agribusiness Department (S1)
- Department of Aquaculture (S1)
- Department of Marine Science (S1)
- Master of Agroecotechnology (S2)

Green Architecture

Green architecture is a field of architecture that focuses on buildings that are beneficial to the environment. Key factors include minimizing the use of natural resources, energy efficiency, innovative and sustainable water use, and environmentally friendly and recyclable materials. The green building approach is a method of planning development that aims to reduce environmental and natural damage to buildings. The characteristics of green architecture are becoming more apparent in response to increasing consumer and architect awareness of the natural limitations of processing rapidly depleting materials.

Green architecture can be defined as a building that is durable, environmentally friendly, and high-performance. An architectural concept that aims to prevent negative impacts on the natural environment and the human body and create healthier living spaces by using energy sources and natural resources efficiently. Talking about green architecture, various important terms appear such as sustainable development. This term refers to development that can meet the

needs of today's society without sacrificing natural resources that must be passed on to future generations.

Figure 2. Illustration of Green Architecture (source: https://www.architecturelab.net/the-administration-building-of-fpt-university-vo-trong-nghia-architects/)

Aceh Architecture

To discuss Acehnese Architecture, Acehnese House was chosen as the most representative building in exploring Acehnese Architecture. This house is shaped like a stage and consists of three main parts and one additional part. The three main parts of Acehnese House are Seuramoë Keuë (front porch), Seuramoë Teungoh (middle porch), and Seuramoë likôt (back porch). While the additional part is Rumoh Dapu (house kitchen). The roof of the house functions as a place to store family heirlooms.

Figure 3. Acehnese house (source: Hilman, 2023)

Figure 4. View of the Mashrabiya from Inside the Room (source: Hilman, 2023)

Islamic Architecture

Islamic architecture is a manifestation of the combination of human culture and the process of a human being's self-servation to God, which is in harmony with the relationship between humans, the environment and their Creator. Islamic architecture reveals complex geometric relationships, hierarchies of form and ornamentation, and profound symbolic meaning.

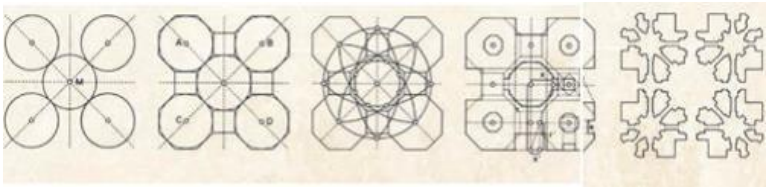


Figure 5. Successive Combination, source: Art Of Islam, 2007

Figure 6. Repetition in Islamic Architecture, source: Art Of Islam, 2007

Concept Study of Malikussaleh's Tomb Form

Sultan Malikussaleh was the founder of the Islamic Kingdom of Samudera Pasai, Meurah Silu, who was titled Malik al-Saleh or known as Malikussaleh. He was recorded as the first king of the Samudra Pasai Kingdom who had spread Islam in Southeast Asia around 1270-1297 AD.

Figure 7. Malikussaleh's Tomb (source: Hilman, 2023)

In this burial site complex, there is also the tomb of Sultan Muhammad Malik Al-Zahir or Malikuzzahir, the son of Sultan Malik Al-Shaleh who led the kingdom from 1297-1326 AD.

METHOD

Method of collecting data

The data collection method used is to conduct surveys and observations of similar buildings in the form of laboratories or buildings that apply the Green Architecture approach in processing building designs.

Observations on previous laboratories and greenhouses at the Faculty of Agriculture, Malikussaleh University (UNIMAL), to record space needs, dimensions, and space requirements. Interviews were conducted with users and managers of laboratories and greenhouses as accurate sources.

Qualitative research methods are research approaches that focus on in-depth understanding of complex social phenomena or situations. Qualitative research is often used to explore concepts, ideas, or phenomena that are not widely known or understood, and is particularly useful in contexts where numerical data cannot easily capture the nuances of the subject being studied.

The data collected is in the form of narratives, text descriptions, photographs, or previous construction drawings. Qualitative research methods are more flexible and can develop along with the progress of the research.

Data Analysis Methods

The location of the Integrated Agricultural Laboratory and Greenhouse is in the masterplan planning area of the Malikussaleh University campus. It has an area of about 2 Ha and is located in a contoured area. The planning location is also close to the Dean's Building of the Faculty of Agriculture.

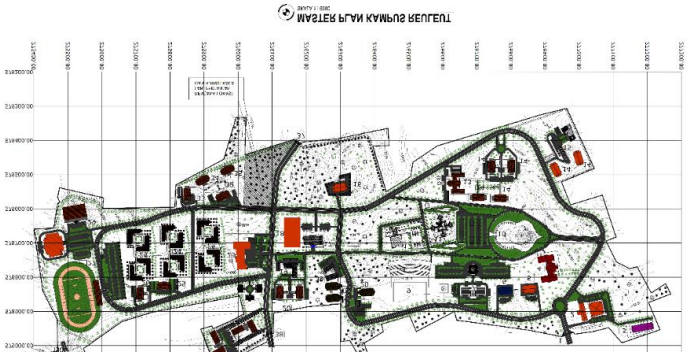


Figure 7. UNIMAL Campus Masterplan (source: UNIMAL)

Topographic Planning Measurement Results

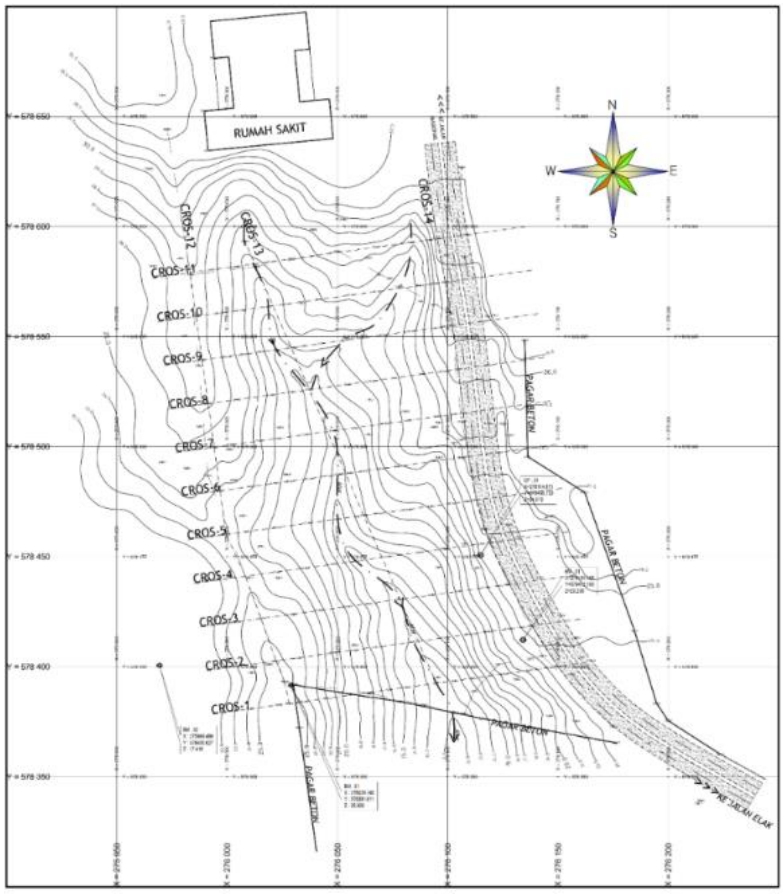


Figure 8. Topographic Measurement Result Map (source: Hilman, 2024)

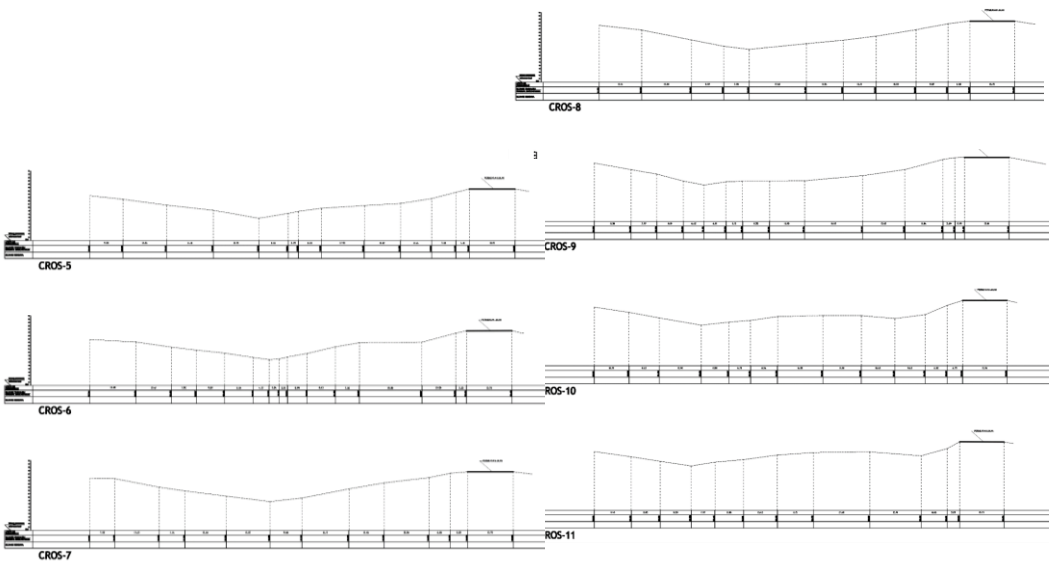


Figure 9. Topographic Measurement Result Section (source: Hilman, 2024)

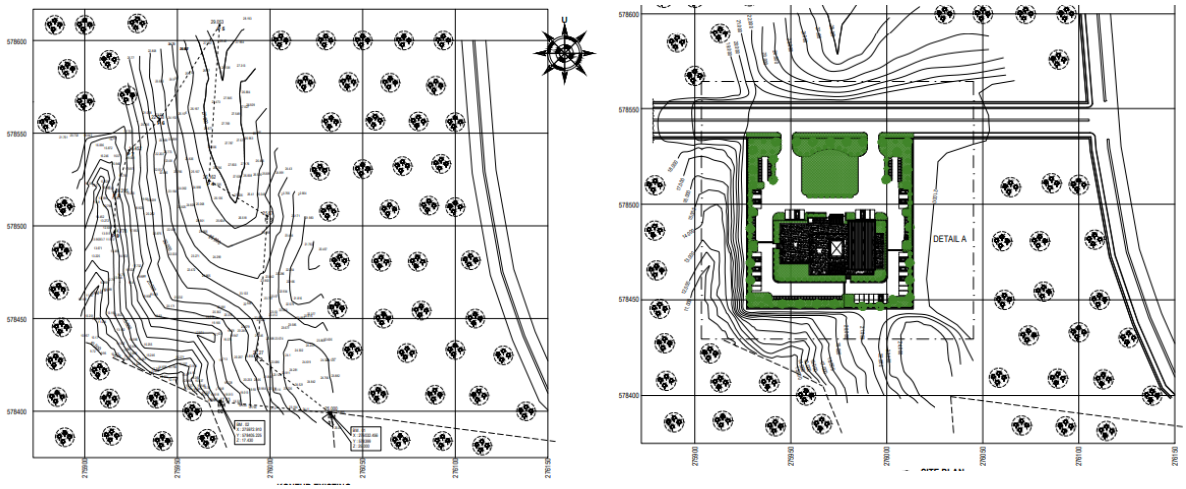


Figure 10. Topographic Plan of the Dean's Office Building (source: UNIMAL)

Figure 11. Existing Topography and Design of the Deanery Building (source: UNIMAL)

RESULTS AND DISCUSSION

The results of the survey, data processing, and interview results in the form of laboratory space programs, LPS proposals (total area of supporting space-circulation), capacity, space criteria, and relationships between spaces, were analyzed. The results of the analysis to obtain synthesis and processed into a laboratory design that applies the theories of Green Architecture, Aceh Architecture, and Islamic Architecture.

Laboratory Space Program

a) Space Requirements, Capacity, and Area

Based on the space requirement program, the total area of the Laboratory building in this study is **2,700 m2** · This building is divided into laboratory groups (L), support (P), and circulation (S). According to the space program prepared by the UNIMAL Faculty of Agriculture Team which we received from the PPK on June 9, 2020, this building consists of **11 laboratories,** with a laboratory floor area of 1797 m2 · The laboratory floor area (L) is equivalent to **2/3 (66.5%)** of building area, so that for the Supporting (P) and Circulation (S) spaces, **1/3 (33.5%)** of the total floor area of the building remains **(L : [P&S] = 66.5 : 33.5)** . The faculty team did not detail the space program for supporting and circulation, only adding three (3) spaces for supporting, namely: Head of Laboratory Room, Meeting Room, and Prayer Room.

b) Integrated Laboratory Space Program, Faculty of Agriculture, UNIMAL

UNIMAL created a space program for this building in the form of laboratory rooms. Each laboratory has 3-7 rooms in it. 30 of the rooms have a capacity of 10-25 students.

Table 1. List of Laboratory Names, Areas, and Positions in Building according to UNIMAL's Space Program

No	Laboratory Name	Area (m^2)	Position in the Building
1	Histology and Microscopy Lab.	159	Floor 1
3	Soil and Climatology Lab	232	
6	Plant Physiology Lab.	137	
8	Agricultural Product Technology Lab.	157	
10	Marine Science Lab	92	
11	Microalgae Aquaculture Lab	92	
	TOTAL AREA OF LAB FLOOR 1	**869**	
2	Biotechnology and Tissue Culture Lab	212	2nd Floor
4	Plant Protection Lab.	195	
5	Seed Technology and Plant Breeding Lab	197	
7	Agricultural Industrial Technology Lab.	227	
9	Agricultural Extension and Communication Lab.	97	
	TOTAL AREA OF LAB FLOOR 2	**928**	
	TOTAL AREA OF LAB FLOOR 1 & 2	**1,797**	

Table 2. Student Capacity in Laboratory Space Based on Data from UNIMAL

CAPACITY	Number of Spaces
10 0RANG	7
10-15 PEOPLE	11
15-20 PEOPLE	12
20-25 PEOPLE	3
AMOUNT	**33**

c) LPS Presentation Proposal

The total area of the laboratory on the 1st and 2nd floors is 1,797 or 2/3 of the total building area (2,700 m2), so that the remaining supporting and circulation space is only 1/3 or 33.5% of the total building area, which is 903m2 · However, the remaining floor area is not sufficient to meet the needs of supporting and circulation space, because from the floor plan design study that we conducted, it turns out that the need for supporting space is still very large. Circulation in this Laboratory building also requires access for everyone including people with disabilities and has a fairly wide evacuation route during a disaster, so that the need for lab spaces including supporting and circulation reaches 100% (2700 m2). In this proposal, the total area of the lab space (L), supporting (P), and circulation (S) on the 1st and 2nd floors is:

R. Laboratory (L) = 1742 m^2 (64.5%)
R. Supporting (P) = 344 m^2 (12.8%)
Circulation = 614 m^2 (22.7%)

The percentage is calculated against a total area of 2700 m^2.

d) Space Capacity

In the list of laboratory rooms, it is stated that the capacity of laboratory room users is 10 people, 10-15 people, 15-20 people, and 20-25 people.

e) Space Criteria

To get good light and ventilation, the building is designed to have *a courtyard* in the middle, so that sunlight can be utilized optimally.

Table 3. Lighting levels and color rendering according to SNI 6197:2020

Fungsi Ruangan	Tingkat pencahayaan rata-rata ($E_{rata-rata}$) minimum (lux) [a)]	Renderasi warna minimum
Lembaga Pendidikan		
Ruang kelas	350	80
Ruang baca perpustakaan	350	80
Laboratorium	500	90
Ruang praktek komputer	500	80
Ruang laboratorium bahasa.	300	80
Ruang guru	300	80
Ruang olahraga	300	80
Ruang gambar	750	80
Ruang Auditorium (exhibition)	300	80
Lobby	100	80
Tangga	100	80
Kantin	200	80

Likewise, *cross ventilation* can be attempted perfectly. Among the laboratory rooms, there are rooms whose positions must be considered so that users of this laboratory are protected from contamination, for example in the acid room. This laboratory also requires access for everyone including the disabled. Therefore, ramps *and* toilets are prepared for the convenience of the disabled.

The laboratory building is designed to be as air-conditioned as possible. However, there are certain rooms in the laboratory that must have air conditioning, so in the RFI, there is a column to fill in regarding the need for air conditioning.

f) Inter-Spatial Relations

In the building plan there is a main corridor on both sides *of the courtyard* . This corridor is the connector of the entire building, which is the main route to various rooms in the building, namely to the laboratory rooms and to the supporting rooms. The corridor is an evacuation route in the event of a disaster. Along the corridor, there are entrances to the laboratory that require separate doors that can be accessed directly. However, there are also laboratory rooms that are not accessed separately, and there are also laboratories that require more sterile conditions / isolated from public reach.

Laboratory and Greenhouse Design Interpretation

Interpretation of the laboratory and greenhouse design by reworking the spatial organization, the following floor plan is obtained.

Figure 12. Floor Plan of Laboratory Building 1st and 2nd Floor (source: Hilman, 2024)

In the plan there are four (4) stair locations, 2 at the front and 2 at the back. There are 2 lifts that can be used by the disabled. Men's and women's toilets are located at the back of the building, on the left for men and on the right for women.

There are 4 clear and barrier-free fire escape doors. All the room names listed are accommodated in this plan.

The Marine Science Laboratory (LIK) and the Microalgae Aquaculture Laboratory (LAM) are positioned at the back of the building, because they can cause odor and if placed in front can be disturbing. This causes changes in zoning in each Lab space. In addition, the building which was originally divided into 2 split levels was changed to 1 level only.

Green House

Normative Reference: SNI 7604-2010 Quality Requirements for Plantation Houses.

Greenhouse is an agricultural building used as a research facility for plant cultivation (Nafila, 2018). According to Koesmaryono et al. (1997), climate has an important influence on the functional conditions of the greenhouse in creating optimal conditions for plant cultivation.

According to Lindley and Whitaker (1996) natural ventilation is the exchange of air inside a building with the air outside without using fans or other mechanical equipment. Air exchange in greenhouses is essential to prevent excessively high temperatures and humidity. In addition, natural ventilation also maintains the availability of CO2, which is very important for the process of photosynthesis in plant leaves.

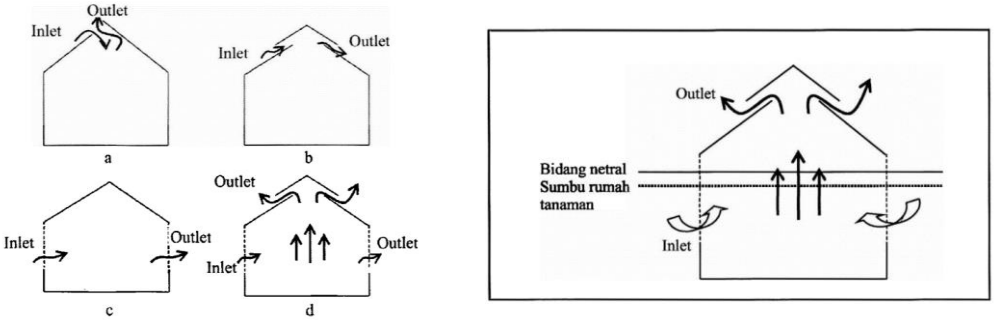


Figure 13. Ventilation Openings in Green House (source: Hilman, 2024)

Temperature, Humidity, and Light Control System in GreenHouse

The system must be able to sense temperature and humidity and control temperature, humidity, lighting and watering.

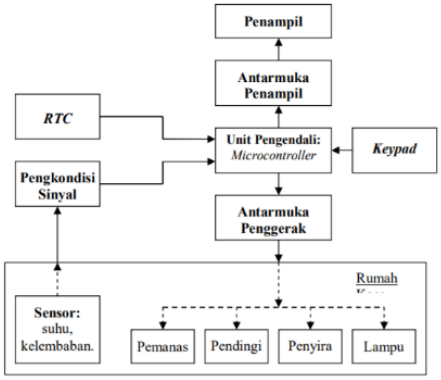
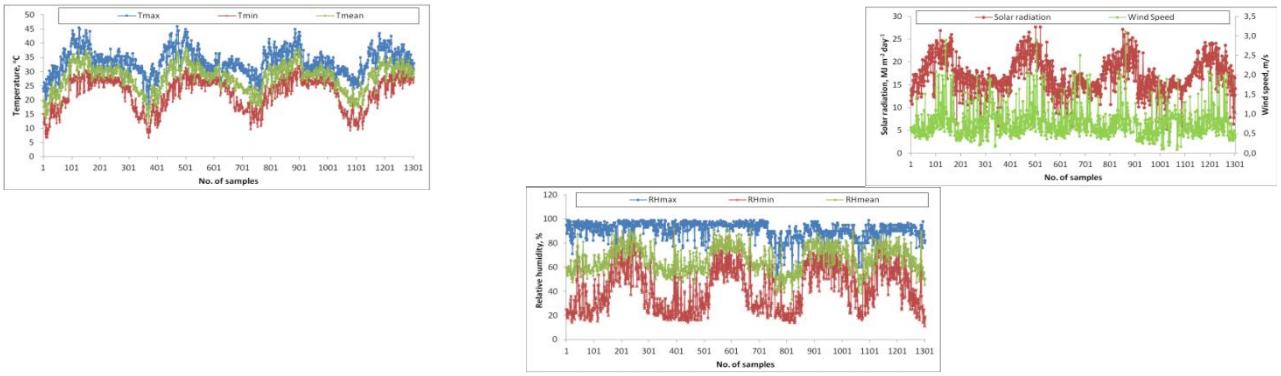


Figure 14. Block Diagram of the Electronic Part of the Control System (source: Hilman, 2024)

Activator for Micro-Climate

Temperature and humidity control in Greenhouse is a complex process, good temperature and humidity control is one way to control micro-climate to reduce plant stress, check the growth of harmful organisms, and improve the heating system. One of the technologies used to control the greenhouse to predict micro-climate parameters is ANN. The things that must be used as data are the maximum and minimum temperature, humidity in the greenhouse, and also the average speed of the wind outside, solar radiation. Here is one example of the use of ANN:



(a B C)

Figure 15. (a) maximum, minimum and average *greenhouse temperature*, **Figure 15.** (b) maximum, minimum and average *greenhouse humidity*, **Figure 15.** (c) daily solar radiation and outside wind speed (source: Hilman, 2024)

Green Building Concept

Figure 16. Green Building Concept (source: Green Building Council Indonesia)

The design strategy with the Green Building Concept is based on six basic criteria of the Green Building Concept from *GBCI (Green Building Council Indonesia)* :

1. *ASD (Appropriate Site Development)* : This is a criterion that requires a continuous relationship between a building and its surrounding environment.
2. *EEC (Energy Efficiency & Conservation):* This criterion requires minimal and optimal energy use.
3. *WAC (Water Conservation):* This criterion requires the greatest possible savings in water use from primary sources (groundwater and PDAM water) to then be replaced with alternative water sources such as rainwater and STP water processing.
4. *MRC (Material Resource Cycle)* : This criterion requires the use of materials that are not toxic to the environment such as CFCs and Halons.
5. *IHC (Indoor Health and Comfort):* This criterion requires the use of materials that are healthy and non-toxic to humans.
6. *BEM (Building Environment Management):* This criterion requires an environmentally friendly building management system, in terms of waste management, construction activities, independent commissioning tests and willingness to conduct user comfort surveys as well as periodic energy consumption monitoring.

Vertical Garden/Green Wall concept

Figure 17. Vertical Garden (source: Green Building Council Indonesia)

Vertical garden alias is a garden media with plants arranged vertically in a perpendicular or nearly perpendicular plane. The constraints of the limited open yard to be greened have triggered an explosion in demand for Vertical Garden / Green Wall .

Equipped with a watering system that works based on a program that we adjust to the type of plant we choose. This watering control includes duration, time, *sequence* (pause). Everything is controlled and programmed automatically.

Roof Garden

Figure 18. Roof Garden (source: Green Building Council Indonesia)

The increasingly limited land for green open spaces due to urban development requires the application of the green infrastructure concept in every development implementation. The green infrastructure implementation is through *green roofs* .

Solar Panel

Figure 19. Solar Panel (source: https://www.britannica.com/science/solar-energy)

Solar panels are power plants that use Solar Photovoltaic (PV) cells. This technology converts solar radiation into electrical energy. Indonesia as a tropical country located in the equatorial region, has abundant solar energy potential shining throughout the year. Therefore, solar panel systems can be installed throughout Indonesia as long as the location is exposed to sunlight and is not blocked by the shadow of any object. Given its enormous potential and is an unlimited and environmentally friendly source of energy, solar energy can be the main source of energy in the future.

CONCLUSION

In the conclusion section of this research, the results are presented in the form of an Integrated Agricultural Laboratory and Greenhouse Design.

Block Plan Concept

Figure 20. Block Plan Concept (source: Hilman, 2024)

Building View

Figure 21. Front and Side View Concept of Building (source: Hilman, 2024)

Zoning Concept

Ground Floor
1,288 m2

Upper Floor
1,412 m2

Figure 22. Zoning Concept (source: Hilman, 2024)

Exterior 3D Perspective

Figure 23. Front View and Rear View

Figure 24. Front Isometry and Rear Isometry

(source: Hilman, 2024)

Figure 25. Bird's Eye Perspective of Front and North East Direction (source: Hilman, 2024)

Figure 26. Front Perspective of the Lab. East and West Directions (source: Hilman, 2024)

Figure 27. Perspective of the South and North Directions of the Greenhouse (source: Hilman, 2024)

Figure 28. Perspective of the Greenhouse Atmosphere (source: Hilman, 2024)

SUGGESTION

The following suggestions are for the next steps if the Integrated Laboratory and Greenhouse at the Faculty of Agriculture, Malikussaleh University (UNIMAL) is constructed, then:

1. **Infrastructure Improvement:** Routine maintenance and improvement of existing facilities is needed to ensure smooth operation of laboratories and greenhouses.

2. **Use of Renewable Energy:** It is recommended to integrate more renewable energy technologies such as solar panels to reduce conventional energy consumption and support the green building concept.

3. **Human Resources Training and Development:** Provide ongoing training for laboratory staff and students on the use of the latest laboratory equipment and technology.

4. **Research Collaboration:** Developing collaboration with other research institutions both domestically and abroad to improve the quality of research and innovation in the agricultural sector.

5. **Waste Management:** Implementation of an effective and environmentally friendly waste management system to reduce negative impacts on the surrounding environment.

6. **Thank You**

In connection with the implementation of the Green Architecture Approach research on Integrated Laboratory and Greenhouse Design at the Faculty of Agriculture, Malikussaleh University (UNIMAL), Jalan Medan-Banda Aceh, Cot Teungku Nie Reuleut, Muara Batu District, North Aceh Regency, Aceh Province. We would like to thank: Rector of Winaya Mukti University, LPPM Winaya Mukti University, Dean of the Faculty of Engineering, Planning and Architecture Winaya Mukti University, and the Research Team of the Architecture Department of Winaya Mukti University.

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