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Implementation of Biophilic Architecture in the Design of the Agricultural Center of Indramayu Regency

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ABSTRACT

The growing global demand for food necessitates the development of innovative, efficient, and sustainable agricultural systems. As one of the main sectors supporting the economy and food security, agriculture requires research centers that can respond to these challenges through science- and technology-based approaches. The Agricultural Research Center is designed as an integrated hub for research, education, and innovation in modern agriculture. The building incorporates principles of green architecture, sustainability, and energy efficiency to create an environment conducive to research while being ecologically friendly. By taking into account the geographic, social, and economic context, this center is expected to serve as a catalyst in promoting climatae-resilient agriculture and meeting global market demands. The design emphasizes a holistic approach that accommodates laboratory research functions, training facilities, exhibition areas, and experimental gardens. The design process involved an in-depth analysis of user needs, integration with the natural landscape, and implementation of smart technologies to enhance operational efficiency. Thus, this center is not only a functional space but also a symbol of innovation and sustainability in the agricultural sector. The design outcome is expected to catalyze the development of an inclusive, modern, and competitive agricultural system, contributing to environmental conservation, improving community welfare, and achieving sustainable food security.

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KEYWORDS: Sustainable architecture, research center, green architecture, smart technology, agricultural innovation

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1. INTRODUCTION

As an area designated as one of the regional activity centers to carry out the function of national food producers, land use in Indramayu Regency is dominated by paddy fields, which account for 56.08% of the total land area. Forest land ranks second in land use, with a proportion of 14.74% of the existing land area. A total of 4.27% of the existing land area is designated as plantation land. So that when added together, the land area utilized for agricultural and plantation activities reaches 75.09% of the entire area of Indramayu Regency. Agricultural cultivation areas have enormous potential to be developed as one of the main economic drivers in Indramayu Regency. This can be seen from the magnitude of the existing potential, where the area of food crop areas amounted to 92,370 hectares spread across each sub-district.

One of the main commodities of the agricultural sector in Indramayu Regency is rice. The Regional Spatial Plan of Indramayu Regency in 2011-2031 stipulates that the LP2B in Indramayu Regency is 92,730 Ha, as one of the efforts to increase rice production is also carried out through increasing rice productivity. The rice planting area was 208,740 Hectares in 2020, down from 253,498 Hectares in 2019. Rice production in 2020 was 1.5 million tons, a decrease compared to 2019 and 2018, but higher than 2017 production, which reached 1.34 million tons. The decrease in production can be caused by a decrease in the area planted as well as rice productivity. Efforts to increase the productivity of the agricultural sector cannot be separated from the support of agricultural development and human resources. In 2019, there were 2,311 farmer groups incorporated in 311 farmer group associations in 31 sub-districts in Indramayu Regency.

Basically, all development has a goal to achieve and requires stages to achieve this goal, starting from the planning background, the problem issues that become the benchmark for planning, to analyzing the development of positive impacts

resultingfrom the planning. For this reason, this design has important aspects that need to be analyzed from the beginning of its planning so that it can produce development that has a positive impact on the environment. The design aims to reduce negative impacts on the environment through efficient energy use and sustainable water management. The aspects that need to be achieved include: the potential of natural resources, increasing agricultural productivity, and improving the welfare of farmers based on the biophilic architecture approach.

This Biophilic Architecture approach is based on Government Regulation Number 27 of 1999 concerning Environmental Impact Analysis, which states: "All businesses or activities cause impacts on the environment that need to be analyzed from the beginning of planning, so that steps to control negative impacts and develop positive impacts can be prepared as early as possible". In addition, the biophilic approach also aims to strengthen the positive relationship between humans and nature (Browning et al., 2014). According to Kellert (2015) in his book entitled The Practice of Biophilic Design, biophilic design is about creating a good habitat for humans as biological organisms in an artificial environment. Biophilic design seeks to fulfill this innate adaptation to nature in modern artificial environments to improve human physical and mental health and wellness. In conclusion, the use of a biophilic approach is to apply a good relationship with nature to produce a design that reduces negative impacts on the environment and provides a comfortable life for its users, motivated by the design of an agricultural center that will have many natural elements, and from the Indramayu area whose land is dominated by rice fields.

The biophilic architecture approach refers to the theory of "14 Patterns of Biophilic design" written by Terrapin (2014). Of the 14 principles, there are 3 main categories that make up biophilic architecture. The author emphasizes the most relevant principles in the design of this building. These principles include: Visual Connection With Nature, which aims to provide a direct view of natural elements that strengthen the positive relationship between humans and nature. Biomorphic Forms & Patterns, which aims to provide uniqueness and characteristics to the building by adopting natural patterns, can also have a positive impact on users, such as presenting feelings of awe, and can increase love for nature. Prospect, which aims to present a broad view of nature, can still provide a sense of protection to its users. Of the three principles, it does not rule out the possibility of the author using other principles because this biophilic design has its uniqueness and characteristics in each principle to be implemented into the design of the agricultural center.

2. LITERATURE REVIEW

2.1 Definition and Basis of Design of the Agricultural Center

Center can be defined as the core, the main room, the main, the base, or the focus and collecting nature (Poerwadarminta, 2003). In English, center means center, defined as a place at which an activity or complex of activities is carried out. Meanwhile, agriculture is a biological science that discusses a whole series of human activities in processing, producing, and marketing plants and livestock for food and clothing. The series of activities in question includes selecting plant seeds, cultivating agricultural land, planting various types of plants, raising animals, milking, fishing, and preserving various food ingredients (Andrian, 1994). Based on the explanation above, the agricultural center is the main space that accommodates all activities in conducting, developing, and maintaining agricultural activities. Agriculture has a goal, which is to obtain a high level of production and quality by fulfilling all the food needs of the middle and lower class communities, so as not to produce damage or losses. Agriculture benefits from economic growth and development by meeting the food needs of the community. Especially for countries that are still highly dependent on agricultural products, such as Indonesia and several other Asian countriesIn the context of agricultural development, research is one of the important factors for the progress of agriculture in general, both in terms of changes in farmer behavior, increased production, effectiveness, and efficiency of farming, and even the accuracy of government targets and policies related to agriculture depends on the extent of research progress in a country. With the low exchange rate of farmers and the lack of harmonious coordination between sectors related to agricultural development, agricultural development in the future faces many challenges.

2.2 Principles of Agricultural Center Design

The design of the agricultural center is based on the principle of increasing agricultural productivity based on research and development of agricultural technology using a biophilic architectural approach that refers to the theory of "14 Patterns of Biophilic Design" written by Terrapin (2014). In the Journal of Agricultural Implementation 4.0 (Saiz-Rubio & Rovira-Mas, 2020), there are 3 categories in agricultural implementation, which include several elements, namely:

Table (1) Grouping of modern agricultural categories

Category	Elements
New Production Methods	Hydroponics
	Algae Raw Materials
Food Efficiency	Vertical Farming/Urban Farming
Cross-Industry Technology Implementation	Drone Utilization
	Extensive & Accurate Data Analysis
	Connectivity
	Precision Agriculture

2.3 Facilities and Infrastructure of the Agricultural Center

To carry out activities and develop agriculture, of course, requires facilities and infrastructure that will accommodate these activities. In this planning, there are main and supporting facilities based on standards (GSA, 2017), Banlitbang Kementan facilities (Balitbangtan, 2016), and research (Adinugroho, 2018), formulated as follows:

Table (2) Main facilities of the agricultural center

Infrastructure	Elements
Innovation in Agriculture	Laboratories (Soil, biotechnology, agromania, horticulture, hydroponics, computing & media)
	Growing room (greenhouse, plant room)
	Rice fields & plantations Library
Adaptation of Meeting Results	Training & consultation room
	Auditorium
	Exhibition Room

Table (3) Supporting facilities of the agricultural center

Infrastructure	Elements
Supporting Space	Administration & Management
	Warehouse
	Food Court
	Health Unit
	Sports Room
	Restrooms
	Parking

2.4. Definition and Design Principles of Biophilic Architecture

Biophilia is the inherent human tendency to be at one with nature, which, even in the modern world, is important for people's health and well-being both physically and mentally. (Wilson 1986, Kellert dan Wilson 1993, Kellert 1997, 2012) Wilson 1986, Kellert and Wilson 1993, Kellert 1997, 2012). Biophilic architecture is a design based on aspects of biophilia with the aim of producing a space that can participate in improving the physical and mental well-being of human life by fostering a positive relationship between humans and nature (Browning et al., 2014). Biophilic design seeks to create a good habitat for humans as biological organisms in the modern environment by promoting human health, fitness, and well-being (Kellert & Calabrese, 2015). In a book entitled "14 Patterns of Biophilic Design," written by Terrapin (2014), there are 14 principles in biophilic architecture
that can be applied in building design. From all of these principles, biophilic design can be divided into three main categories. These categories are:

- **Nature In The Space Patterns.**
  Nature in the space patterns pays attention to the direct presence of nature. Elements include plant life, water, and animals. The strongest nature in the space experience is achieved through creating a meaningful direct relationship with natural elements through diversity, movement, and multi-sensory interaction. The principles include:Visual Connection with Nature

1. Non-visuall Connection with Nature
2. Non Rhytmic Sensory Stimuli
3. Thermal & Airflow Variability
4. Presence of Water
5. Dynamic & Diffuce Light
6. Connection With Natural Systems

- **Nature Analogues Patterns.**

  Nature analogues can be realized in the form of artwork, ornaments, furniture, and the use of natural materials in the design, each of which provides an indirect connection with nature. There are 3 points in this principle, namely:

1. Biomorphic Forms & Patterns
2. Material Connection With Nature
3. Complexity & Order

- **Nature of the Space**

1. Prospect
2. Refuge
3. Mystery
4. Risk/Peril

3. METHODOLOGY

3.1. Data Stage

The regulations of the Indramayu Regency Spatial Plan 2011-2031 stipulate the existence of Strategic Areas, Prajapolitan Areas, and Agropolitan Areas. While the location of the site is in Widasari Sub-district because it covers all the criteria mentioned, and has superior regional potential in strategic areas, proximity to urban centers, and development potential in agriculture. The site location is on Jalan Raya Pantura Jatibarang - Lohbener, Ujungaris Village, Widasari, Indramayu, West Java (45271) with a site area of 19,932 m2. According to data from the Indramayu Urban Area Spatial Detail Plan 2023-2043 regulations, the building design is included in the city scale public service facilities zone and tourism zone located on Arterial Roads with details:

1. Basic Building Coefficient:
   Given a site area of 19,932 m² with a basic building coefficient of 60%, then:
   19.932 x 60% = 11.959 m²
   In conclusion, the maximum base area of the building to be constructed is 11,959 m².
2. Building Floor Coefficient:
   According to the Indramayu Regency Detailed Spatial Plan regulations, buildings that have functions as city-scale public service facilities and tourism have a maximum KLB of 3.6, so:
   Building Floor Coefficient = Total land area - Total land area that can be built x Building Floor Coefficient
   = (19.932 – 100) x 3.6
   = 19,832 x 3.6 = 71.395 m²
   With the calculation of the amount of space with a total of 9685.767 m² and a KDB of 11,959 m², the building height used is sufficient for 2 floors.
3. Green Basic Coefficient
   It is known that the basic building coefficient area is 60%, then the building floor coefficient used is 40%, with calculations:
   19,932 x 40% = 7,972 m²

3.2. Analysis Stage

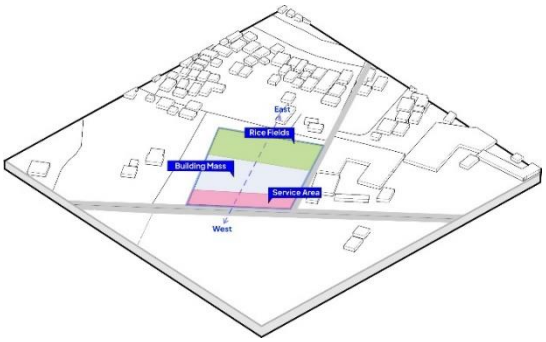

Figure (1) Site Zoning

- **Site Zoning**

Identification:

1. The zoning of the site is divided based on function, accessibility, and the fall of sunlight into the site.
2. Main activities such as research and operation of technological tools require safe, comfortable, and quiet spaces.
3. Supporting activities such as auditoriums, exhibition halls, and workshop rooms are placed as areas connecting spaces with other spaces.
4. Accessibility and circulation are differentiated based on user flow and service flow to avoid crossing circulation.

Zoning Analysis Response:

1. The function of the main research activities, such as laboratories, is in private zoning, which can be placed at the corner of the site.
2. The function of supporting activities is in public and semi-public zoning, which can be placed in the middle area of the site.
3. Service activities, such as loading and unloading, are placed on alternative roads, while user activities use the main circulation.
4. Green Open Space is located at every corner of the site and building, either as agricultural land or as a response to the biophilic concept.

- **Massing & Building Orientation**

Identification:

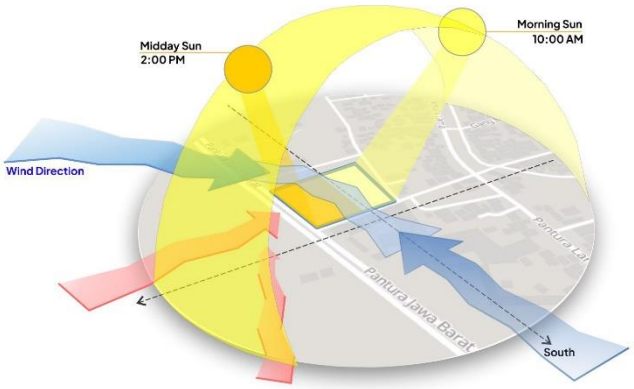

Figure (1) Sun & Wind Analysis

1. Sun and wind analysis is the main factor in how the shape of the building is created. Sourced from existing data, the site is located between rice fields and settlements, which will result in a mass form.
2. Adjustment to the function of the building to create space that meets the standards will produce a form of mass change that facilitates user circulation and can produce efficient space.

Building Mass & Orientation Analysis Response:

1. The mass form is linear and consists of several masses to respond to the main and supporting functions. The shape of the mass crosses from west to east to minimize the fall of sunlight into the building.
2. The main orientation of the building faces south and north, which maximizes natural ventilation and reduces solar heat. The flow of space uses a linear pattern. The use of a linear pattern facilitates the accessibility of circulation for users because the arrangement of spaces is connected in one axis.

3.3. Concept Stage

Figure (2) Area view of Agriculture Center

Figure (3) Site plan for the Design of the Agriculture Center

4. RESULT & DISCUSSION

The conclusion of the application of the Biophilic Architecture concept is implemented through various designs that have been analyzed previously, resulting in a design that is in accordance with the values of biophilia. Below is the conclusion of the design implementation that has been considered by fulfilling the responses from the site analysis and the analysis of the Biophilic Architecture approach. The implementation of the design concept includes:

- **Nature In the Space Patterns**

  Creating a strong experience through direct connection with meaningful natural patterns through variety, movement, and multi-sensory interaction

  1. Visual Connection with Nature

     The use of natural elements such as vegetation, especially ornamental plants, is one of the main strategies to feel the

presence of nature in buildings. The response with variations in the use of ornamental plants, shade trees, and farmland can strengthen the natural elements present in the building.

2. Non Visual Connection With Nature
   Stimuli of human senses that can feel the presence of natural elements directly, such as hearing and touch. Responded to by creating natural sounds in the building environment, such as gurgling water and chirping birds.
3. Non Rhythmic Sensory Stimuli
   A stimulation strategy that provides a special, fresh, and interesting moment of stimulus that is brief, but gives the user pleasure. Such as the use of hedgerows to attract species of bees, butterflies, and animals or insects that help pollinate plants and create new ecosystems.
4. Thermal & Airflow Variability
   Spaces with good ventilation and varied air circulation provide freshness and comfort. Responded with the use of natural ventilation to create variations in air circulation, room temperature, and humidity. The use of varied windows and room voids can provide good cross ventilation.
5. Presence of Water
   The presence of water is essential and provides a positive experience in the built environment that reduces stress and improves health. For example, by creating artificial ponds from rain analysis responses that utilize rainwater harvesting as a backup and cyclical use of water, with the use of fountains or waterfalls to produce a serene gurgling sound.
6. Dynamic & Diffuce Light
   Lighting design affects the mood in a space, and different lighting conditions affect the psychological response of its users, so lighting has an impact on performance, mood, and mental well-being. Responded with the use of voids or skylights to create movement of light and shadows from sunlight that attract attention.
7. Connection with Natural Systems
   Create ecosystem relationships that are responsive to natural changes and have harmonious characteristics. The response is by using vegetation types that respond to climate change, such as Bougainvillea and Tabebuia flowers that will bloom perfectly during the dry season

- **Nature Analogues Patterns.**

Nature analogues that can be realized in the form of artworks, ornaments, furniture, and the use of natural materials in design, each of which provides an indirect connection to nature.

8. Biomorphic Forms & Patterns
   The purpose of biomorphic shapes and patterns in design is to provide a representation of shapes and patterns that exist in nature in the building by applying analogous patterns of landscapes that exist in nature, such as contours, topography, boulders, and wood pattern structures, to the design of interior and exterior spaces.
9. Material Connection with Nature
   The use of material patterns related to alma to explore the characteristics and quantity of natural patterns that provide positive impacts and psychological responses. The response in design is the use of natural materials in interior and exterior design, both as the main function and as decoration, such as walls, facade materials, furniture use, and interior surface accents.
10. Complexity and Order
    Spaces that have complexity and good order will feel interesting and rich in information as an interesting balance between designs that integrate from nature by prioritizing the use of artwork and material selection that presents geometric shapes and hierarchies, such as ceiling designs or wall panels that have complex shapes.

- **Natural Analogues Patterns**

11. Prospect
    The view of a large open space that still gives a sense of security and control, especially when alone in a new environment. By making the farmland a wide and open visual view, coupled with the presence of a building garden that applies various types of vegetation as a barrier or boundary that provides a sense of security and control.
12. Refuge
    Some places provide a sense of protection for humans. Such as office and library spaces designed with the use of low ceilings that provide an intimate scale for users, such as drop ceilings, the use of acoustical paneling, or long canopies.
13. Mysteri
    The mystery pattern appears that a person basically has a basic need to "understand" and "get away" in a new environment by implementing a long linear circulation pattern that gives a sense of curiosity about what is in front of

the user while passing through the circulation.

14. Risk/Peril

    There is a sense of danger that remains safely protected while still attracting attention. The response is to apply an architectural cantilever as a balcony overlooking the farmland, pond, and garden of the building.

5. CONCLUSION

The design background was obtained after analyzing global, local, and building issues. As a result, the conclusions of these issues are linked to the concept of the Biophilic Architecture approach. The following are some of the issues concluded:

- Global Issues: Covers food security available to the wider community, uneven distribution of food to reach remote areas, and poor quality and safety of food for consumption.
- Local Issues: Includes declining rice productivity, declining paddy fields, and declining rice production, causing problems in the agricultural sector, farmers' welfare, and the GRDP of Indramayu Regency.
- Building Issues: These include the environmental impacts of buildings and the reduction of the positive relationship between humans and nature, resulting in a decrease in the physical and mental well-being of users.

In conclusion, the purpose of this design is to improve agricultural productivity and the welfare of farmers in Indramayu Regency through the provision of facilities that support agricultural technology development and training. Empowerment of the local community and improvement of the local economy are also important objectives of this design, with the hope that this center can increase the knowledge, skills, and competitiveness of regional agricultural products. In addition, the center is expected to be an educational tourist attraction that attracts visitors who are interested in innovations in architecture and sustainable agriculture.

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