E-ISSN: 2962-6110
P-ISSN: 2964-7843
JSRET
jsret.knpub.com
Journal of Scientific Research, Education, and Technology

Contextual Architectural Design for Horticultural Research Facility in Trenggalek

Achmad Wildan Hafidz, Farida Murti, Andarita Rolalisasi
University of 17 Agustus 1945 Surabaya, Surabaya, Indonesia

ABSTRACT

This study aims to formulate a design concept for a horticultural research facility in Trenggalek Regency using a contextual architectural approach. The method used is descriptive qualitative through literature study, analysis of regional planning documents, and precedent studies of similar buildings. The results show that a horticultural research facility requires the integration of research, production, and educational functions within a unified spatial system. In addition, zoning arrangements, controlled circulation, and environmental systems that support research activities are necessary. The "Bhumi Loka" concept is formulated as the design foundation, emphasizing the relationship between land as the primary medium of horticulture and space as a container for human activities. This concept produces a contextual, sustainable design approach that aligns with the agricultural characteristics of Trenggalek.

Keywords: *Horticulture Research Facility, Contextual Architecture, Agricultural Design*

Corresponding author
Name: Achmad Wildan Hafidz
Email: 1442200024@surel.untag-sby.ac.id

INTRODUCTION

Trenggalek Regency has significant potential in the agricultural sector, particularly horticulture, which is one of the main drivers of the regional economy (BPS Kabupaten Trenggalek, 2024). However, the development of this sector still faces limitations in research, innovation, and integrated supporting facilities. This condition indicates the need for facilities that can accommodate horticultural research activities in a systematic and sustainable manner.

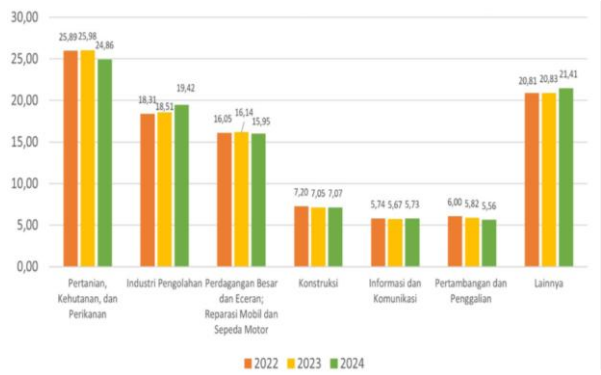

Chart 1. Gross Regional Domestic Product Structure by Sector, 2022–2024
Source: (BPS Trenggalek Regency, 2025)

The development of agricultural areas in Trenggalek Regency is also supported by spatial planning policies that designate the region as an agropolitan area (Regional Regulation RTRW Trenggalek, 2012). However, the implementation of this policy has not been fully supported by the existence of research facilities capable of linking production activities with knowledge development. This indicates a gap between regional potential and supporting infrastructure.

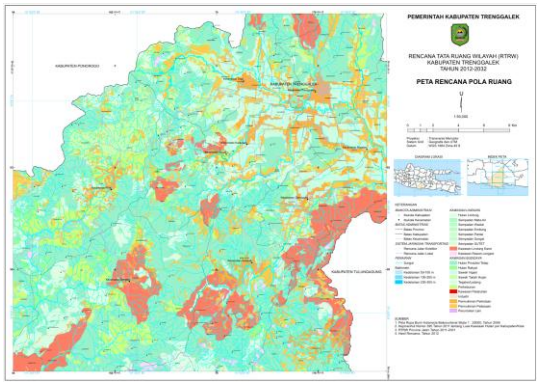

Figure 1. Spatial Plan Map of Trenggalek Regency
Source: Trenggalek Regency Spatial Plan 2012–2032

Previous studies show that modern research facilities function not only as technical spaces but also as media for education and public interaction (Brolin, 1980). In addition, the contextual architectural approach emphasizes the importance of the relationship between buildings and their surrounding environment (Frampton, 1983). However, the application of this concept in horticultural research facilities is still not widely developed specifically.

Based on these conditions, the research problem is how to design a horticultural research facility that can integrate research, production, and educational functions within a contextual spatial system aligned with the agricultural environment.

This study aims to formulate a design concept for a horticultural research facility using a contextual architectural approach. The contribution of this study lies in the

development of the “Bhumi Loka” concept as a design approach that directly connects research activities with the characteristics of agricultural land.

METHOD

This study uses a descriptive qualitative approach with an architectural design orientation to examine the characteristics of horticultural research facilities and formulate a contextual design concept for the site in Trenggalek Regency. This approach is chosen to understand the relationship between spatial needs, user activities, and environmental conditions, and to translate them into an architectural design concept.

The study focuses on analyzing three main aspects: object characteristics (horticultural research facility), user and activity characteristics, and location characteristics based on regional conditions. These aspects are derived from problem identification in the background as well as theoretical studies and precedent studies that have been conducted.

Data collection was carried out through literature study, analysis of regional planning documents, and comparative studies of similar buildings such as Agrotopia Research Center, Hengshui Vertical Farm, and Beijing Vertical Farm. The collected data include zoning systems, circulation patterns, spatial organization, environmental systems, and integration between research and production functions.

Data analysis was conducted qualitatively by identifying spatial needs and design criteria based on the relationship between activities, space, and environmental context. Precedent studies were used to identify recurring design patterns and principles. The results of the analysis were then synthesized by considering object, user, and location characteristics.

The final stage of this process is the formulation of the “Bhumi Loka” concept as the basis of architectural design, emphasizing the relationship between land as the primary medium of horticulture and space as a container for human activities.

FINDING AND DISCUSSION

RESEARCH RESULT

Regional Conditions and Potential

Trenggalek Regency has agriculture as one of the main sectors in the regional economy. Based on data from the Central Bureau of Statistics of Trenggalek Regency in 2024, the agriculture, forestry, and fisheries sector contributes 24.86% to the Gross Regional Domestic Product (GRDP).

The distribution of agricultural subsectors shows that food crops are dominant, followed by plantation, livestock, and horticulture subsectors. This condition indicates that horticulture still has strong potential for further development.

Based on the Regional Spatial Plan of Trenggalek Regency 2012–2032, regional development is directed toward strengthening the agricultural sector through the development of agropolitan areas, increasing agricultural productivity, and providing supporting infrastructure for horticulture.

Comparative Study Results of Similar Facilities

Figure 2. Agrotopia Research Center (Belgia), Hengshui International Horticultural Research & Vertical Farm (Tiongkok), Beijing Vertical Farm (Tiongkok)
Source: www.archello.com

The comparative study of three objects—Agrotopia Research Center (Belgium), Hengshui International Horticultural Research & Vertical Farm (China), and Beijing Vertical Farm (China)—reveals several common characteristics:

- Spatial zoning is divided into research, production, and educational zones
- User circulation is separated between researchers and visitors
- Spatial systems integrate research and educational activities within a single building
- Space utilization is optimized through vertical approaches or adaptation to land conditions
- Buildings use transparent materials to maximize natural lighting
- Water and energy systems apply recycling and resource efficiency principles

Table 1: Summary of Literature and Comparative Study

No	Parameter	Agrotopia (Belgium)	Vertical Farm Beijing (China)	Vertical Farm Hengshui (China)	Design Application Concept
1	Location & Context	Located on top of the REO auction building (industrial rooftop) in Roeselare	Located within an agricultural research campus (CAAS), Beijing	Located in the Hengshui International Horticultural Expo Park	The facility is positioned near agricultural or research centers to support research activities
2	Management	Inagro (research institution) + REO (auction facility)	National research institution (CAAS campus)	AgriGarden (developer + horticultural industry)	Management involves research institutions to ensure optimal research activities
3	Main Function	Research + public	Research + education +	Production + research +	The facility integrates

		education + plant production	limited-scale production	education + demonstration	research, production, and education within a single area
4	Size & Scale	±9,500 m² (large, horizontal on rooftop)	±3,500 m² (small, 3-story vertical)	±12,800 m² (large, 4-story vertical)	Building scale is adjusted based on land availability and production capacity
5	Massing Concept	Integrated into a single greenhouse mass on an existing building	Vertical mass surrounding a central atrium	Multi-level mass with a large central atrium	Centralized massing is used to facilitate circulation and supervision
6	Zoning System	Divided into plant zones, human zones, and buffer zones	Cultivation zones surrounding the atrium with educational paths	Zoning per floor (LED, laboratory, education, rooftop greenhouse)	Functional zoning is separated to prevent activity interference
7	Circulation System	Researcher circulation is separated from visitor circulation	Educational paths circulate around the atrium	Vertical circulation through the main atrium	Separation of visitor and researcher circulation to avoid interference
8	Interior Spatial System	"Space within space" concept (box-in-box)	Open space with a central atrium	Multi-level open space with visual connections between floors	Spaces are arranged to ensure comfort for humans within plant environments
9	Cultivation System	Greenhouse with climate control + partial vertical system	Combination of LED (indoor) + rooftop greenhouse	LED (lower floors) + greenhouse (upper floors)	Combination of indoor and outdoor systems for production flexibility
10	Structure & Material System	Concrete (base) + steel and glass (greenhouse)	Steel structure with transparent glass	Multi-level steel and glass structure	Use of transparent materials to maximize natural lighting

11	Water System	Rainwater is collected and reused	Irrigation water is recycled	Water is reused in a closed-loop system	Water recycling system is applied for efficiency
12	Energy System	Utilizes residual heat from the environment (incinerator)	Heat from sunlight and LED lighting is reused	Solar heat and LED heat are reused	Utilization of residual energy to reduce additional energy demand
13	Climate System	Temperature control using ventilation, shading, and misting	Natural ventilation and evaporative cooling	Natural ventilation + evaporative cooling	Use of natural ventilation and simple cooling systems
14	Public Interaction	Educational paths surrounding research areas	Visitors follow educational circulation paths within the building	Visitors observe processes through atrium and circulation paths	Educational paths are provided to enhance public understanding
15	Building Character	Large greenhouse on top of an industrial building	Transparent building with a central atrium	Multi-level vertical building with a striking appearance	The building is visually open to display internal activities

Source: Author Analysis based on Agrotopia, Hengshui, and Beijing Vertical Farm case studies (2026)

Characteristics of Horticultural Research Facilities

Based on the comparative study, the main characteristics of horticultural research facilities are:

- Facilities are educational and open to the public
- Spatial organization is based on clear functional zoning
- User circulation is structured and separated
- Space utilization is efficient
- Environmental conditions are controlled according to plant and human needs
- Building systems apply water and energy efficiency
- Production processes are presented as part of the spatial experience

Design Condition Analysis (SWOT)

Based on the analysis, the following conditions are identified:

- Strength: alignment with agricultural area characteristics
- Weakness: complexity of contextual analysis requirements
- Opportunity: development potential of the regional horticulture sector
- Threat: conversion of agricultural land

Table 2: SWOT Analysis

	***Strength* (S)**	***Weakness* (W)**
	• The building can adapt to the characteristics of the surrounding area, creating harmony between the building and its environment. (Brolin, Brent C. 1980. *Architecture in Context: Fitting New Buildings with Old*) • A contextual approach enables building design to support the horticultural activities of the local community. (RPJMD Trenggalek Regency 2021–2026 – Agricultural Sector Development Chapter) • The building can strengthen the identity of the area as a horticultural region through a design approach that responds to local characteristics. (RTRW Trenggalek Regency 2012–2032 – Agricultural Area Development Directive)	• A contextual architectural approach requires in-depth analysis of site conditions, including physical, social, and cultural aspects of the environment. (Brolin, 1980) • The design process requires adjustments to various environmental aspects, resulting in a longer planning duration. (Trancik, Roger. 1986. *Finding Lost Space*)
***Opportunity* (O)** • The potential for developing horticultural areas as a leading regional sector. (BPS Trenggalek Regency, *Trenggalek in Figures 2024*) • The facility can be utilized as a medium for agricultural education and research. (BRIN,	**S + O** S1 + S2 + O1: The design of a horticultural facility can adapt to the characteristics of the area while supporting the development potential of the regional horticulture sector.	**W + O** W1 + O1 + O2: In-depth site analysis can be utilized to design horticultural facilities that are aligned with environmental characteristics while supporting research and agricultural education activities.

National Research Master Plan 2017–2045) • The development of horticultural facilities can enhance the attractiveness of the area and support local economic development. (RPJMD Trenggalek Regency 2021–2026)	S3 + O2 + O3: A contextual architectural approach can strengthen the identity of the horticultural area while supporting educational activities and increasing regional attractiveness.	
***Threat* (T)**	**S + T**	**W + T**
• The conversion of agricultural land into non-agricultural areas (RTRW Trenggalek Regency 2012–2032) • Uncontrolled regional development may reduce the environmental character of agricultural areas (RTRW Trenggalek Regency 2012–2032)	S1 + T1: A contextual design allows the building to remain aligned with the environment, thereby anticipating land-use changes in the surrounding area. S2 + S3 + T2: Strengthening the identity of horticultural areas through contextual design can preserve regional character despite ongoing development.	W1 + W2 + T1: In-depth site analysis is required to ensure that the design remains aligned with environmental characteristics despite land-use changes. W2 + T2: A design process that considers various environmental aspects can help the building remain relevant to regional development.

Source: Author's Analysis

DISCUSSION

The results show that the design of a horticultural research facility cannot be separated from the integration of research, production, and educational functions. Findings from the comparative study indicate that the success of research spaces is determined not only by facility completeness but also by how effectively and contextually activities are integrated. Therefore, the design approach must go beyond functional considerations and include the relationship between object characteristics, location, and users.

This interpretation leads to the understanding that spaces within horticultural facilities must be adaptive to the environment and capable of supporting interactions between humans and production processes. This is important because horticultural

activities are not limited to enclosed spaces but are strongly connected to site conditions and ecological systems.

Compared to literature, this principle aligns with the contextual architectural approach emphasizing harmony between buildings and their surroundings. Furthermore, the integration of functions found in precedent studies reinforces the idea that boundaries between research, education, and production spaces can be more fluid without losing zoning clarity.

However, this study has limitations, particularly in the number and variety of case studies used. Additionally, the analysis focuses more on spatial aspects and does not deeply explore quantitative technical performance such as energy efficiency or utility systems.

Based on this interpretation, a design concept integrating object, location, and user characteristics is formulated. The synthesis of these aspects results in the "Bhumi Loka" concept, which positions land and space as an integrated system in designing horticultural research facilities. This concept emphasizes that buildings should function as a medium connecting human activities, research processes, and environmental context comprehensively, creating a sustainable relationship between environment, activities, and users.

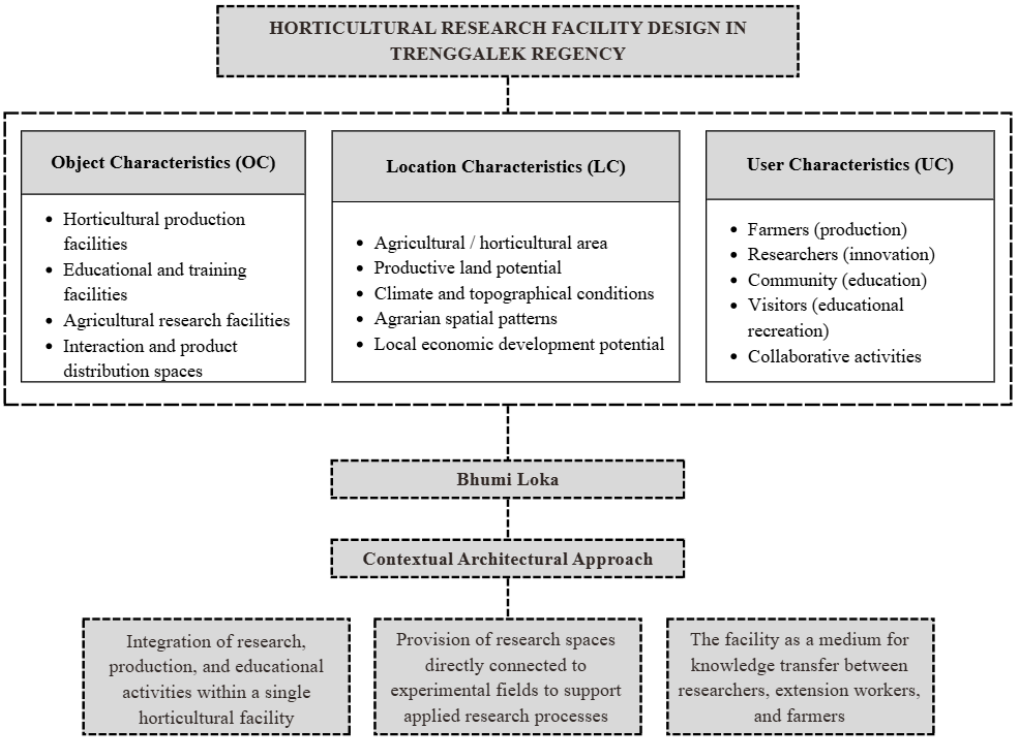

Figure 3. Concept Application Scheme
Source: Author's Analysis

Furthermore, the concept is translated into concrete design strategies, including spatial zoning, user circulation management, efficient space utilization, and

environmentally responsive building systems. Thus, “Bhumi Loka” is not only conceptual but also operational in shaping space and user experience.

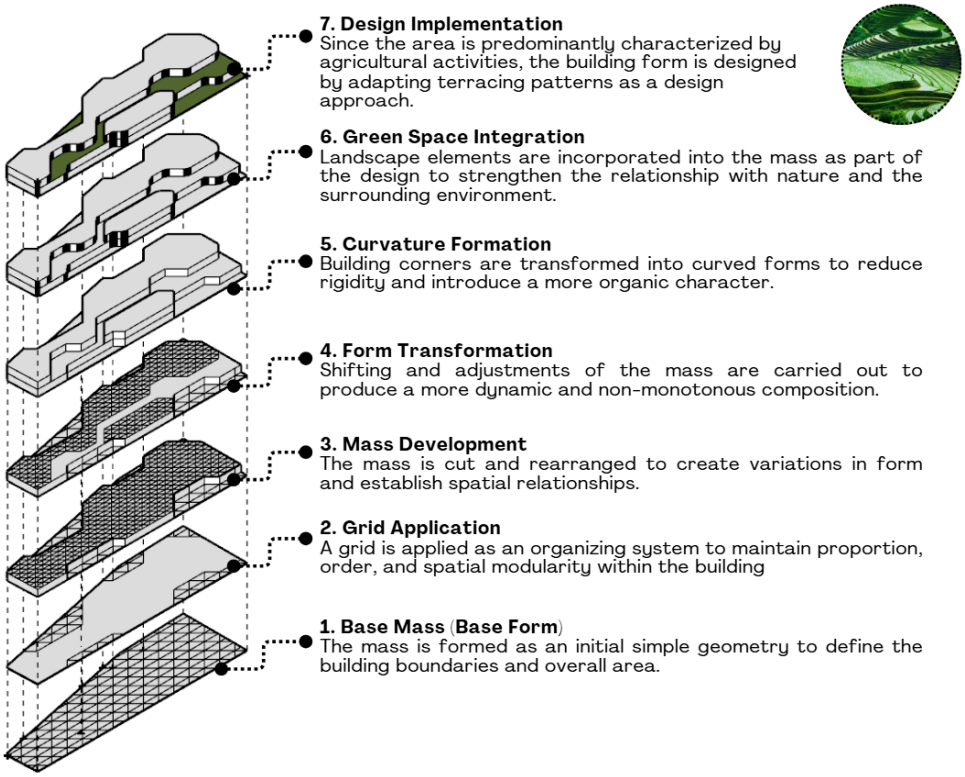

Figure 4. Design Transformation Scheme
Source: Author’s Illustration

The implications of this study indicate that a contextual approach based on system integration is relevant for designing horticultural research facilities, particularly in areas with strong agricultural potential. This approach enhances spatial efficiency and strengthens the relationship between buildings and their environment. Future research should further explore technical building performance and its impact on productivity and user comfort.

CONCLUSION

This study shows that the design of a horticultural research facility in Trenggalek requires an approach that considers not only function but also the relationship between activities, space, and environmental context. The analysis indicates that integrating research, production, and educational functions within a unified spatial system is essential for creating an effective and adaptive facility.

The contextual architectural approach proves relevant in addressing these needs, particularly in responding to agricultural area characteristics and supporting environmental sustainability. The “Bhumi Loka” concept represents an effort to connect land as the

primary medium of horticulture with space as a container for human activities within an integrated system.

The application of this concept implies that the design of horticultural research facilities must consider spatial system integration, resource efficiency, and openness to the public as part of the educational process. Future research is recommended to further examine technical aspects such as energy performance, utility systems, and their impact on productivity and user comfort.

REFERENCES

Badan Pusat Statistik Kabupaten Trenggalek. (2024). *Kabupaten Trenggalek dalam Angka 2024*. Trenggalek: BPS.

Badan Pusat Statistik Kabupaten Trenggalek. (2025). *Pertumbuhan Ekonomi Kabupaten Trenggalek Tahun 2024*. Trenggalek: BPS.

Brolin, B. C. (1980). *Architecture in Context: Fitting New Buildings with Old*. New York: Van Nostrand Reinhold.

Frampton, K. (1983). *Towards a Critical Regionalism: Six Points for an Architecture of Resistance*. In H. Foster (Ed.), *The Anti-Aesthetic: Essays on Postmodern Culture*. Seattle: Bay Press.

Pemerintah Kabupaten Trenggalek. (2012). *Rencana Tata Ruang Wilayah Kabupaten Trenggalek Tahun 2012–2032*. Trenggalek.

Pemerintah Kabupaten Trenggalek. (2021). *Rencana Pembangunan Jangka Menengah Daerah (RPJMD) Kabupaten Trenggalek 2021–2026*. Trenggalek.

Badan Riset dan Inovasi Nasional (BRIN). (2017). *Rencana Induk Riset Nasional 2017–2045*. Jakarta.

Trancik, R. (1986). *Finding Lost Space: Theories of Urban Design*. New York: Van Nostrand Reinhold.