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Application of Parametric Architecture in the Design of Technology Park Agriculture of Gorontalo State University in Bone Bolango Regency

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ABSTRACT

A Technology Park is an area where technology is showcased, developed, and commercialized. Additionally, a Technology Park can accommodate various activities related to Science and Technology (S&T), such as research and development for commercial and applied research purposes, laboratory analysis services, business incubation, pilot plants for small-scale production, scientific conferences, training, workshops, business meetings, and more. In the province of Gorontalo, agriculture plays a significant role in contributing to the regional economic growth, with many output results generated from agricultural research. This design aimed to create an area capable of accommodating all research activities in the field of agriculture in Gorontalo, utilizing parametric architecture as one of the approaches, while still considering the main functions of the area and buildings. The method employed in this design involves field surveys to observe and gather data on the current conditions and developments in agriculture. Interviews are conducted to obtain expert opinions on potential exemplary crops based on the data collected on the current conditions and developments in agriculture in Gorontalo. Literature reviews and benchmarking studies are also conducted to find relevant data related to the design object and the parametric architecture approach. The design output produced is the Technology Park Agriculture design product using a parametric architecture approach, along with a design concept and implementation report for the object which then serves as a reference in the designing of the Technology Park Agriculture.

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1. INTRODUCTION

The role of technology in the agricultural sector has become very important in the context of globalization and the industrial revolution. Modern agricultural technology has the potential to redefine methods of production and management of agricultural products, increase efficiency and productivity, and ensure the sustainability of the sector in the future. As the core of the economy and food security, the agricultural sector is required to adapt to technological advances to meet changing global demands and challenges. Agriculture is vital in maintaining economic stability and food availability, and contributes substantially to global food security (Saputri Mendrofa et al., 2024).

Gorontalo is a province that was established from the province of North Sulawesi, officially sanctioned on December 22, 2000. Gorontalo Province is recognized as the 32nd province in Indonesia. Gorontalo Province has a wealth of natural resources, particularly in the agricultural sector, which serves as the main driver of the region's economic growth, with main commodities such as rice, coconut, and cloves. Overall, the economic structure of Gorontalo Province between 2017-2022 shows that the agriculture, forestry, and fisheries sector remains the main contributor to economic growth, with an average contribution of 38.55% (Olii et al., 2023).

Referring to the significant natural resource sector in agriculture and as the main driver of economic growth, there is a strong push to adopt modern agricultural advances in the industrial revolution 4.0. One form of implementation is a facility in the form of a Science and Technology Park. Technopark is an integrated area that combines industry, higher education, research and training centers, entrepreneurship, banking, and both central and local government in a single location, facilitating more efficient and rapid information and technology flow. The construction and development program of technoparks throughout Indonesia is a priority that will be implemented at the central, provincial, and district/city levels (Leny Septiana, Aida Andrianawati, 2018).

"Techno" comes from the words “technology,” meaning “science” or “knowledge,” and “park,” meaning “garden.” It is a recreational park with rides and play areas that offer education, technology, and science. A park is a recreational park with rides and play areas that offer education, technology and science. One of the tools that allow institutions to connect with the business world is Technopark (Leny Septiana, Aida Andrianawati, 2018).

The Government of Indonesia has set the development of Science and Technoparks (STPs) as a national priority. In 2016, the government launched the construction and development of 100 STPs across Indonesia, with Science Parks at the provincial level and Techno Parks at the district or city level (WIDYANDINI & UMAROH, 2021).

Since 2002, the Indonesian government has encouraged the development of STPs. This is indicated in Article 14 of Law No. 18 of 2002 on the National System for Research, Development and Application of Science and Technology (Law 18/2002), which states that “The government, local governments, and/or business entities can build areas, demonstration centers, and other science and technology facilities and infrastructure to facilitate synergy and growth of institutional elements and foster a culture of science and technology among the community”(Wibowo, 2017).

Based on applicable laws, the development plan of Technology Park Agriculture of Gorontalo State University in Bone Bolango Regency has the ability to improve the innovation results of current research and research by using Technology Park Agriculture facilities such as pilot factories for small-scale production or pilot production, laboratories for commercial research and development and applicative research, analyst services, scientific conference venues, and other facilities (Wibowo, 2017).

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As a Technology Park Agriculture, technological elements must be displayed. Displaying the building with parametric architecture is a solution to realize the visualization. Parametric design is a new approach to architectural design that relies on the concept of changing parameters to generate various forms of complex geometry. By using parametric modeling software, this approach is growing because it is able to generate many design alternatives instantly (generative) (Sunarya et al., 2022).

2. RESEARCH METHOD

The method used in the design of Technology Park Agriculture Gorontalo State University in Bone Bolango Regency with a parametric architectural approach is a qualitative descriptive method, which is an attempt to formulate problems that guide research in depth and comprehensively in exploring social situations that take place in real life. observation of similar objects and design themes, searching for related literature studies, and interviews with experts to get accurate information.

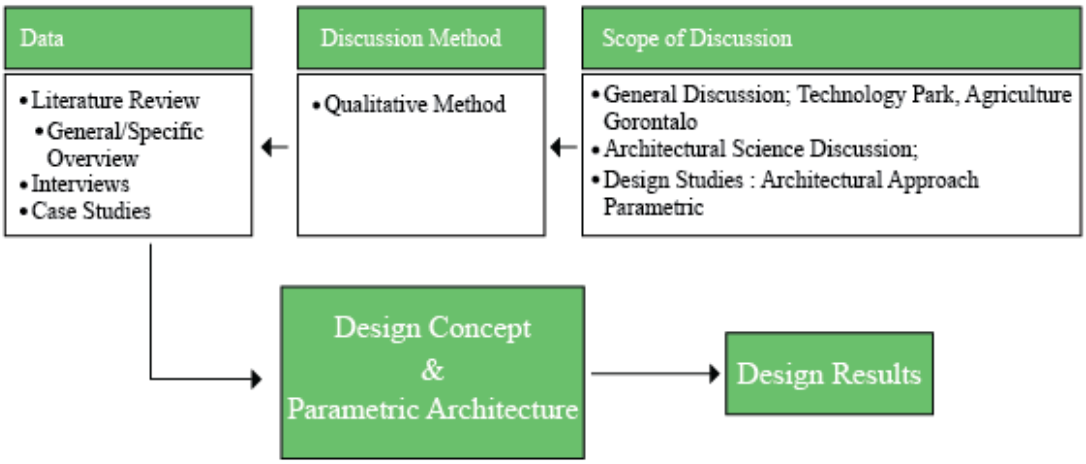

Figure 1: Graphic Stages of Research Methods
(Source: Author's Concept, 2024)

3. RESULTS AND DISCUSSION

3.1 Discussion Content

A Technology Park, also known as a Science Park, is a building area dedicated to the research and development of technology and science for the benefit of businesses. Techno Parks aim to boost local government, attract new companies to the city, and increase the tax base and employment opportunities for citizens. Techno Park is also an attractive location with beautiful architectural buildings that serves as a center for science and research and development (R&D) of companies to produce new inventions or technological applications, as well as cooperation in R&D with well-known companies with universities to benefit from the resulting technology so that technology transfer between universities, research laboratories and industry occurs (Meutia et al., 2017).

Indonesia builds Technology parks to support local resource-based innovation. According to the Global Competitiveness Index 2007-2019, Indonesia fell from 34th in 2014-2015 to 50th in 2018-2019 and dropped to 41st in 2016-2017 (Rahmani et al., 2023).

Technology Park is basically a place for learning. As the name suggests, the learning material is supported by technology. Because it is very dynamic, science changes and develops with high intensity (Putri, 2017).

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Technoparks have various facilities, such as business incubators, angel capital, seed capital, and venture capital. The government (usually the local government), the research community (academia), the business community, and the financial community are the main stakeholders (Tamawiwy, 2016).

Oh and Kang (2009) divided the main structure based on its functions and components. The main functions include research and development, connected business and entrepreneurship, management and globalization, and infrastructure (Aldianto et al., 2018).

Among the 78 new STP development sites for 2015-2016 and 8 existing STP sites, Gorontalo Province is not included in this category. Nonetheless, Gorontalo's agriculture contributed 36% to the province's GDP in the second quarter of 2015. Gorontalo has a lot of room for agro STP development. On the other hand, there are agricultural products that have the potential to be developed but have yet to improve the welfare of its people. Therefore, it is expected that each region can build agro-industrial areas to improve the leading sector and create added value (Tolinggi et al., 2018).

Table 1. Technology Park Functions and Components

Main Functions	Components
Research and Development (R&D)	Higher Education Institutions, public R&D, collaboration R&D, Technology Commercialization
Business & networking entrepreneurship	Entrepreneurship, incubation, venture capital, networking
Management and globalization	Training programs, financial assistance, marketing, property for rent, globalization
Infrastructure	Land use, R&D facilities, business facilities, management facilities, housing and residential

With a known classification, it is easier to design this design area. After knowing what classifications must exist in this area, then understand the approach used, namely parametric architecture.

More than fifty years ago, the term parametric was known and used in mathematics. James Dana first wrote about it in 1837 in his work On the Drawing of Figures of Crystals. Eric Weisstein says that in mathematics, the term “parametric” can be defined as an equation that describes a quantity as a clear function of independent variables called parameters (Atthaillah, 2014).

Parametric design is a design approach that uses variations of a simplex design to show differences by changing the design flow. Model parametricity is used to implement design parametricity. A parametric model is a computer representation of a design consisting of geometric units that have varying and fixed completeness (properties). To find alternative solutions to any design problem, the parameters of the parametric model are changed. In parametric design, designers create an initial design by utilizing parameters. To create innovative geometries from complex models with enough variability to tolerate changes requires careful consideration. Therefore, to determine the type of transformation that will form the basis of parametric design, the designer must prepare a range of variations to be explored. Due to the unpredictability of the design process, this is quite a difficult task (Hibatullah & Aqli, 2024).

The conceptualization process using a parametric approach can be more participatory as the client can interactively assess and select various design options generated from the parametric model (Wendy Sunarya, Yusvika Ratri Harmunisa, Rizka Tiara Maharani, 2022).

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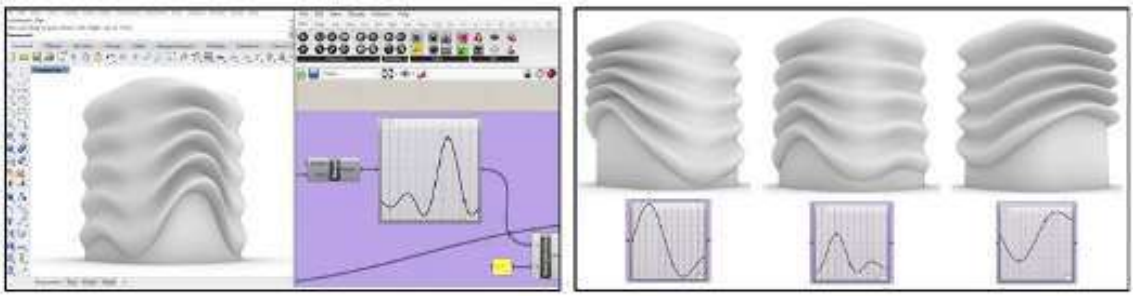

Figure 2. Conceptualization and Exploration of unique shapes in Rhinoceros-Grasshopper
(Source: (Wendy Sunarya, Yusvika Ratri Harmunisa, Rizka Tiara Maharani, 2022)

In precedent studies, parametric design can be used to find hidden patterns and rules of design objects that can be translated back in programming. Two models reinterpreted and developed from past design forms are shown in Figure 3. These are The Roofless Church in Indiana and Rasmi Dome, a historic Iranian architectural dome. The translation process can help designers understand the concept of precedents that can be improved in a quick time (Wendy Sunarya, Yusvika Ratri Harmunisa, Rizka Tiara Maharani, 2022).

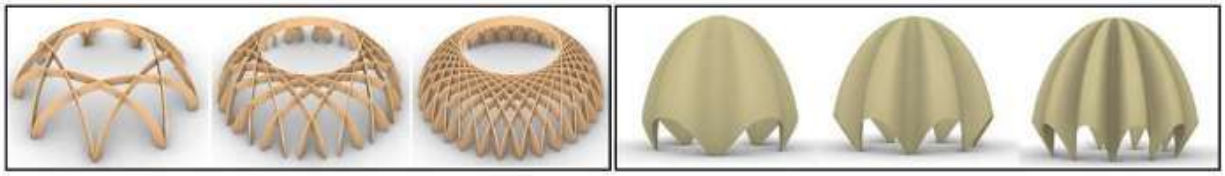

Figure 3. Conceptualization and Exploration of unique shapes in Rhinoceros-Grasshopper
(Source: (Wendy Sunarya, Yusvika Ratri Harmunisa, Rizka Tiara Maharani, 2022)

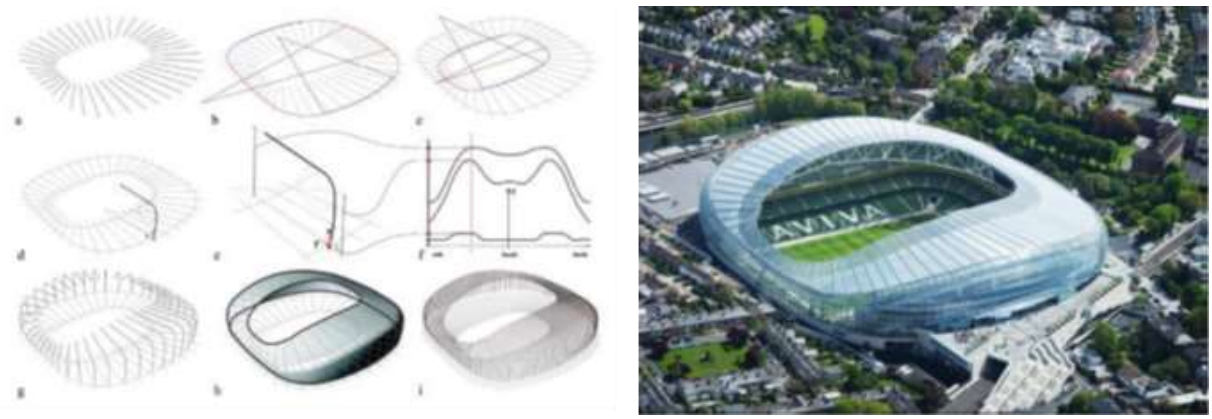

Figure 4. Conceptualization and Exploration of unique shapes in Rhinoceros-Grasshopper
(Source: (Sampieri, n.d.)

Figure 4 on left side shows the process of computer programming the structure at Aviva Stadium, and figure 4 on right side shows the final design. Using CAD software program technology, you can explore the structure. The program has a generative system to calculate the logic of the shape and the possibility of applying the right structure (Sampieri, n.d.)

The result of the design of Gorontalo State University's Agricultural Technology Park in Bone Bolango Regency, which uses a parametric architectural approach, contains a flexible concept. The outer covering material chosen is panel cladding. This was chosen for aesthetic purposes as it makes the building look monolithic and makes it read as a continuous volume as well as serving as a transition to the plaza surface. The cladding material must meet utility requirements such as ultraviolet ray resistance and light reflectivity. easy to clean due to the large amount of air pollution (Idedhyana, 2017).

Parametric Architecture in the design is first done by explaining the data about the location of the research area as follows:

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1. Research location

This site is located on Dr. Zainal Umar Sidiki Street, Tilongkabila Sub-district, Bone Bolango Regency, Gorontalo. The site selection was carried out through a site score weighting process which then selected one site with a high score and in accordance with the Bone Bolango Regency RTRW criteria. The design location was analyzed with the intention of knowing the advantages and disadvantages of the location.

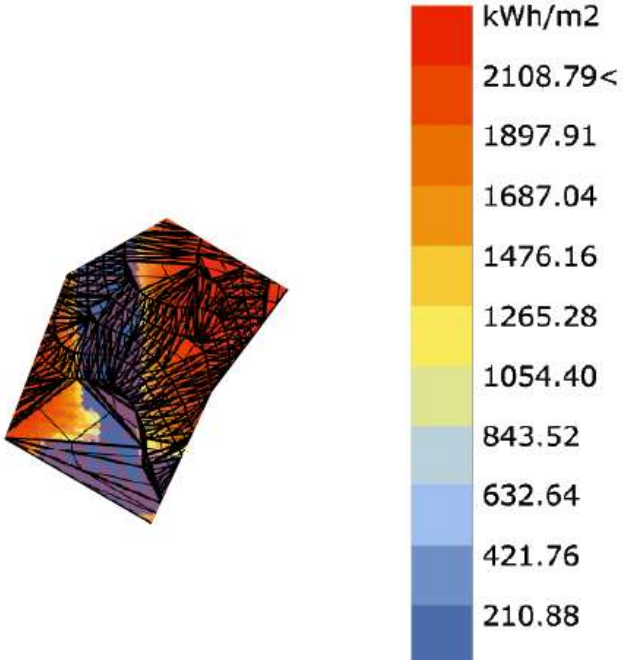

Figure 5. Sunlight Radiation Analysis & Simulation
(Source: Author's Concept, 2024)

Based on simulations in the Rhinoceros application, solar radiation exposure on the site is almost all exposed areas, which are marked with red areas with an intensity of ± 2108 kWh / m2. The solution that can be used is the use of glass polycarbonate material that is able to reduce the sun can be a solution in reducing the intensity of radiation.

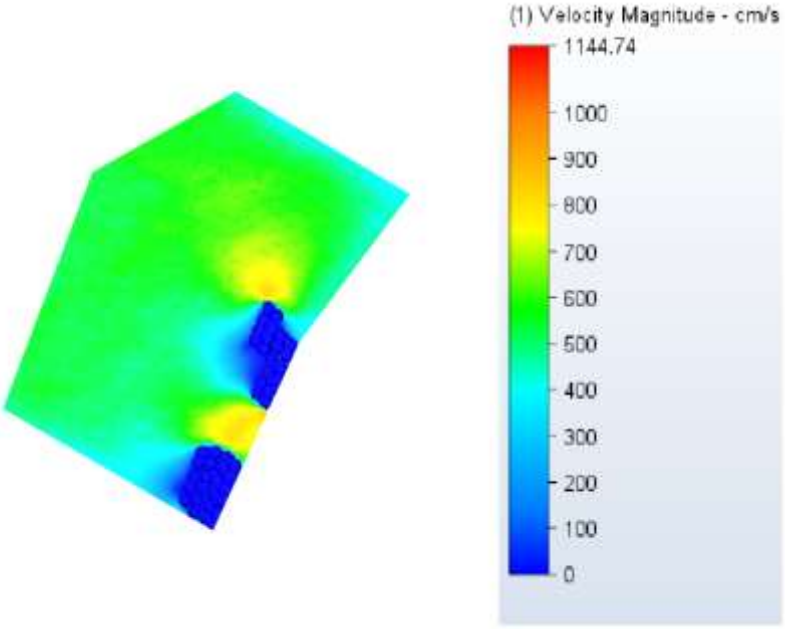

Figure 6. Wind Analysis & Simulation
(Source: Author's Concept, 2024)

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Based on simulations in the Autodesk CFD application, the site area and the area around the site have wind speeds that are not too strong, as evidenced in the green area which in the application is marked with moderate intensity wind speed, the yellow area has an intensity above medium and below high. While the blue-colored area is an area that has trees where the wind speed is low intensity.

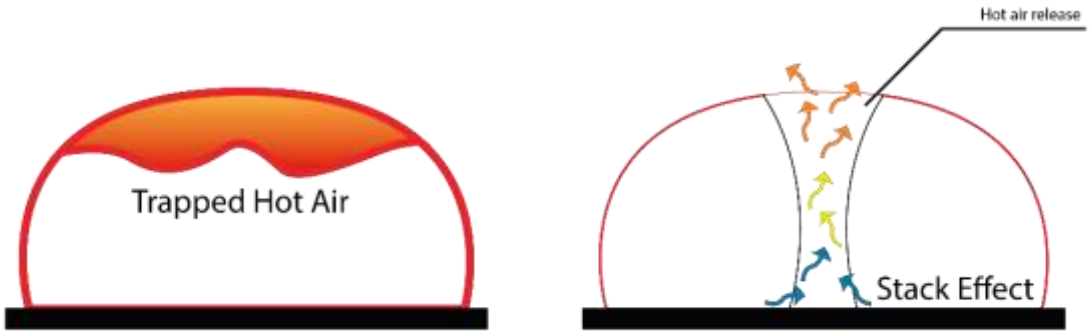

Figure 7. Concept & Simulation of Building Ventilation
(Source: Author's Concept, 2024)

Thermal strength is determined by the difference in density and thickness caused by the temperature difference between the air of the outer space and the inner space. At the peak of the roof, lighter and warmer air will flow out, and at the bottom, denser and colder air will flow in. Koenigsberger later stated that special provisions for this could be made in the form of ventilation shafts. With taller shafts, larger cross-sectional areas, greater temperature and pressure differences will cause more air to be displaced. A good vertical ventilation system has an air outlet and inlet at the bottom. The larger the air holes and the distance between them, the greater the air movement generated upwards. As the height difference of the holes gets bigger, the chimney will make the upward moving air move faster (Yohana & Novariawan, 2013).

2. Application of Parametric Architecture in Building Design

The Parametric Architecture concept applied to the building design pays attention to the suitability of the shape concept taken, this time the design adopts the shape of a plant cell called amyloplast with an oval shape. The basic oval shape is then assembled into a multi-mass building pattern consisting of seven buildings with three main buildings.

Figure 8. Form of Area Mass Pattern
(Source: Author's Concept, 2024)

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The concept of the basic form of the mass layout pattern of the area is then made in the process of making a form of change through the application process so that the form of the building is obtained as follows:

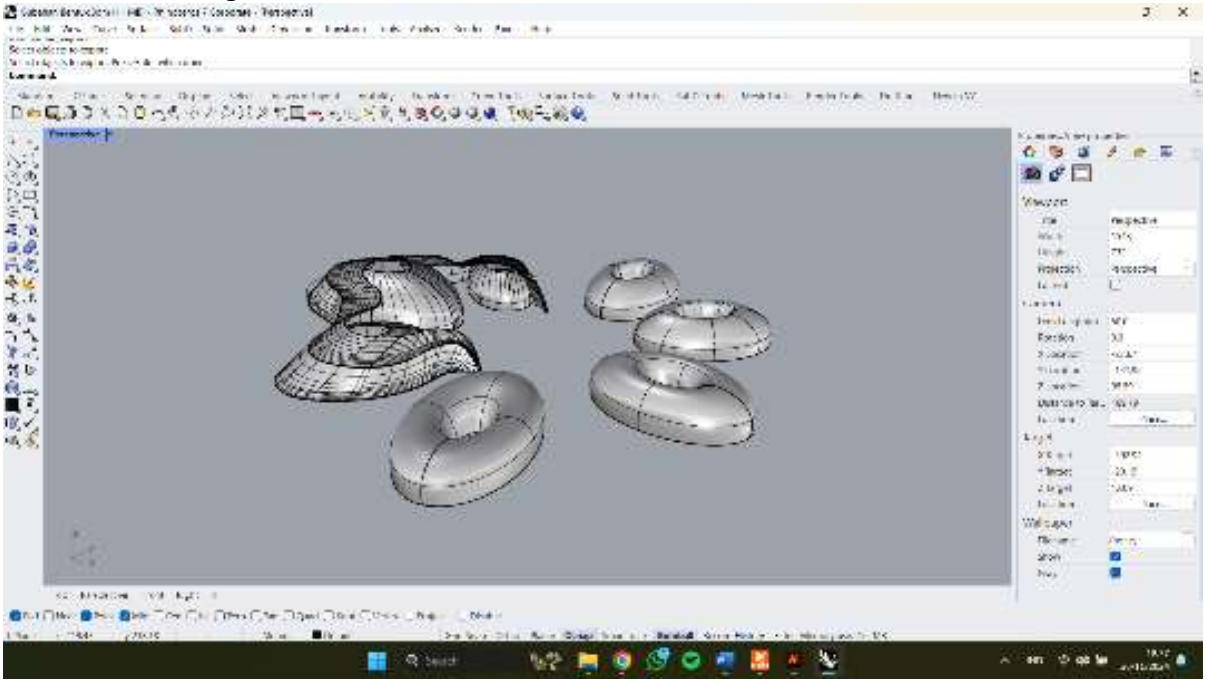

Figure 9. Application Process of Area Mass Pattern
(Source: Author's Concept, 2024)

From the process of applying the existing compositions, it will then enter the drawing process both technically and architecturally. In order to support the complicated drawing process, we will use the BIM application to facilitate the shape fabrication process, in this case the application used is Autodesk Revit.

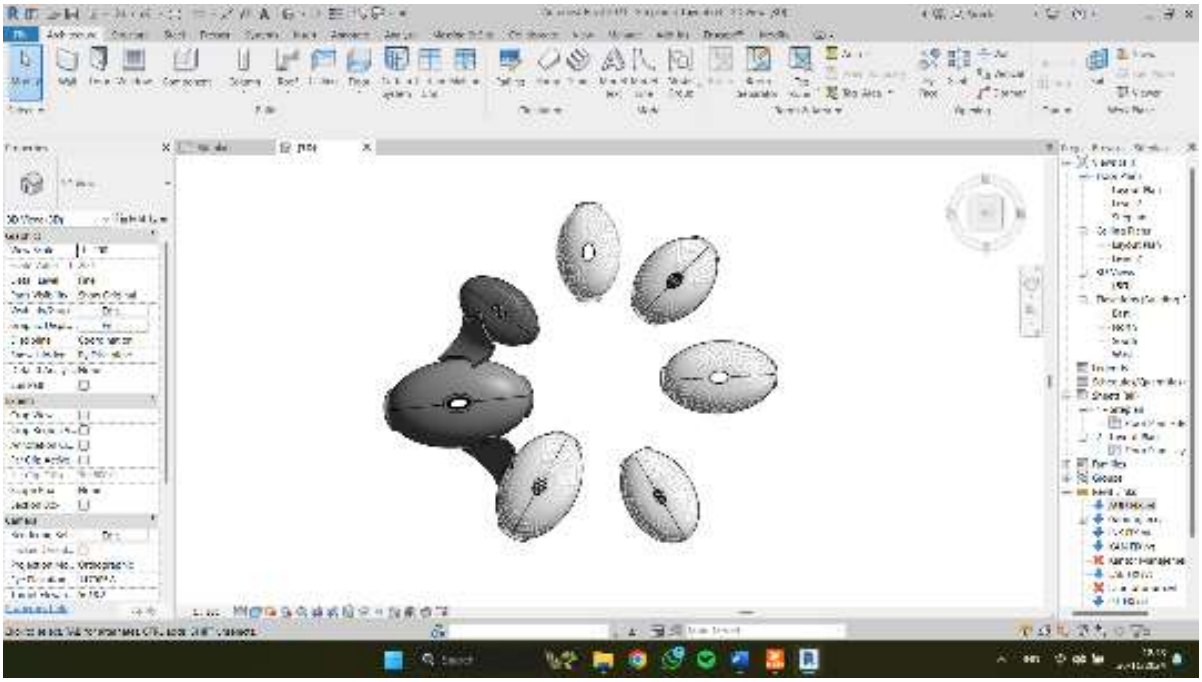

Figure 10. Results of the Application of Building Mass Pattern
(Source: Author's Concept, 2024)

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3. Parametric Architecture Displayed Through Site Mass Layout Pattern

The mass layout pattern of the site is made as much as possible with curved elements, both from the circulation pattern, placement and shape model of the facilities inside.

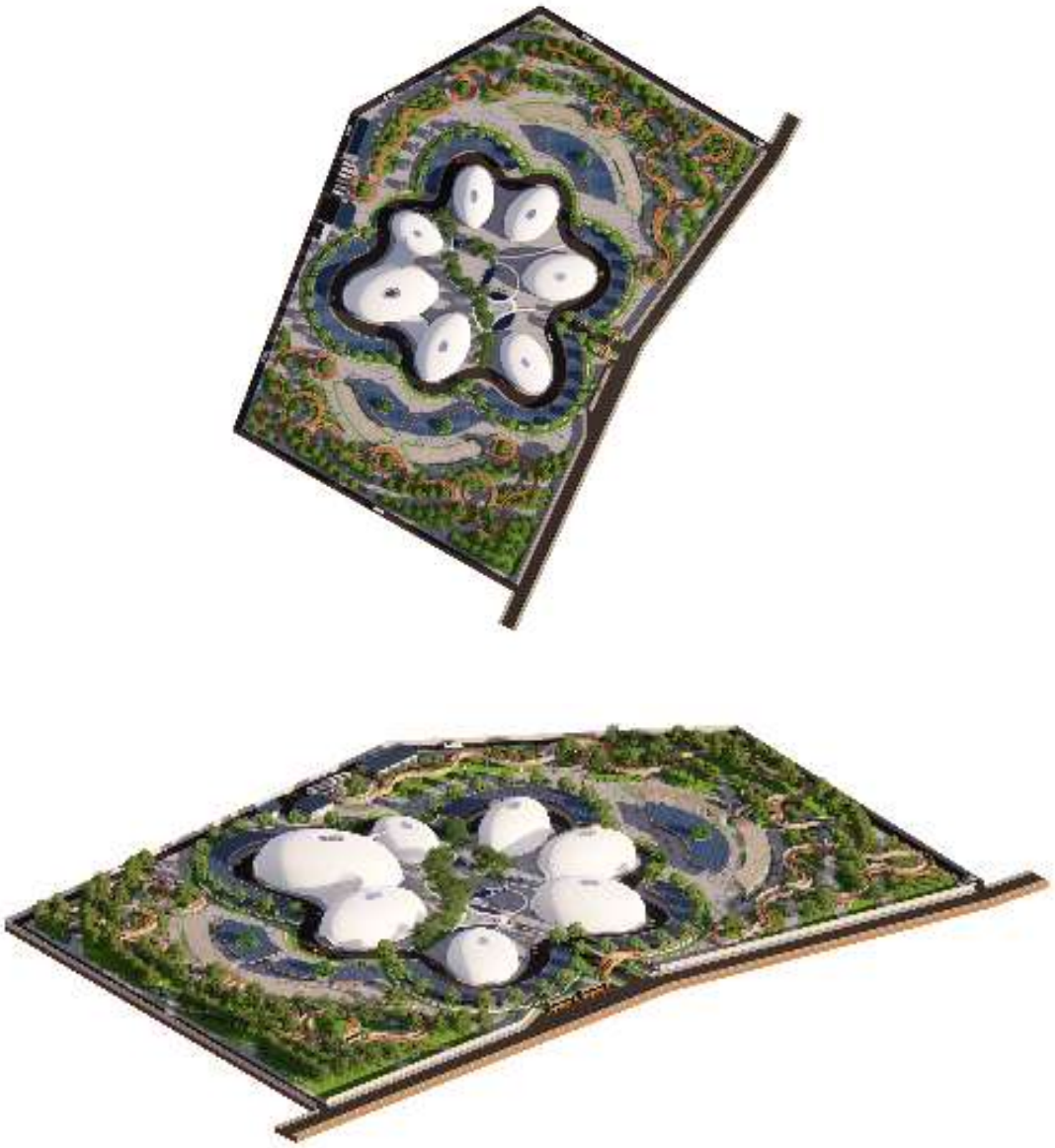

Figure 11. Siteplan Layout
(Source: Author's Concept, 2024)

This curved characteristic is not only adopted in the form of siteplan circulation but also adopted in the placement and model of existing facilities. An example is the adoption of the model of the pilot planting area on the site, the pilot planting area on the site there are two areas namely the pilot planting area 1 and the pilot planting area 2. In the pilot planting area has two types of pedestrians for pedestrians namely pedestrians with elevation 0 or plaza and pedestrians with elevation up 3 meters or called pedestrian bridge. The procurement of two types of pedestrians is held to achieve access for visitors to see all activities in the pilot planting area.

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4. Outdoor Space Concept

Figure 12. Demonstration Planting Area 1
(Source: Author's Concept, 2024)

Figure 13. Demonstration Planting Area 2
(Source: Author's Concept, 2024)

The demonstration planting area is a public area that can be accessed by anyone, therefore this place is made with various facilities that support public visitors. The facilities are pedestrians for pedestrians, plazas, canopy plazas which are also seats and shelters for visitors.

Figure 14. *View of Demonstration Planting Area 1*
(Source: Author's Concept, 2024)

Figure 15. *View of Demonstration Planting Area 2*
(Source: Author's Concept, 2024)

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Figure 16. *View of* Plaza *Demonstration Planting Area 1*
(Source: Author's Concept, 2024)

Figure 17. *View of* Plaza *Demonstration Planting Area 2*
(Source: Author's Concept, 2024)

Figure 18. *View* of Pedestrian Bridge
(Source: Author's Concept, 2024)

5. Concept of Space in the Building

With the main function of the area is a research area, the main building in this area is a laboratory. The laboratory in this area conducts direct research on plants grown by themselves in the demonstration planting area in the form of seedling output or other products. The provision of various types of labs that must support research activities is important in order to maximize the results that come out.

Figure 19. *Laboratory Hall & Corridor*
(Source: Author's Concept, 2024)

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Figure 20. Researcher's Room
(Source: Author's Concept, 2024)

Figure 21. Laboratorium
(Source: Author's Concept, 2024)

6. Building Structure Concept

The structural concept used is a combination of conventional structures and space frame structures. One of the wide-span structures is the space frame structure, also known as space frame. Space frames consist of free-standing rods, bearing centric compressive and tensile forces, and connected to each other by a three-dimensional system (Siswoyo, 2008). The shape of the space frame is developed from a grid pattern with rods connecting the grid points in a three-dimensional manner (Rahmania, 2021).

The form of space frame used is in the form of domes / sepherical domes for this oval-shaped regional building. Sepherical dome is a dome-shaped space frame that requires tetrahedron or pyramid modules as constituents and is assisted by a membrane structure (Kurniawandy et al., 2023).

Figure 22. Structure Concept
(Source: Author's Concept, 2024)

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4. CONCLUSION

The design of Technology Park Agriculture Gorontalo State University in Bone Bolango Regency with Parametric Architecture Approach is intended as a place to provide progress in agriculture in Gorontalo through researchers with existing research results so as to improve the quality of regional commodities. This design uses the Parametric Architecture approach with the aim of achieving visual results of sites and buildings that are not monotonous but do not reduce existing functions. The concept of Parametric approach in this case adds curved aspects of the basic form taken and transformed, intended for the future can make the design of Technology Park Agriculture more attractive and able to become a regional landmark so as to attract local and non-local visitors. The use of appropriate applications such as rhinoceros-grasshopper greatly facilitates the shape fabrication process, coupled with the depiction method using BIM through the Autodesk Revit application is able to complete complicated time-consuming drawings.

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