International Journal of Multidisciplinary and Current Educational Research (IJMCER)
ISSN: 2581-7027 ||Volume|| 7 ||Issue|| 1 ||Pages 01-10||2025||

Bamboo Tourism Development through Kinetic Bamboo Architecture Design in Selaawi District, Garut Regency, West Java, Indonesia

[1,]Alvin Fernandez Komar, S.T., M.T. [2,]Ir. Amirani Ritva, M.T., [3,] Dr. Nancy Yusnita Nugroho, S.T., M.T., [4,] Suwardi Tedja, S.T., M.T. , [5,]Prof. Dr. Ir. Bagus Arthaya, M.Eng.

[1,]*Department of Architecture, Parahyangan Catholic University*
[2,3,45,]*Department of Architecture, Parahyangan Catholic University*

ABSTRACT : The Merdeka Belajar Kampus Merdeka (MBKM) program in Selaawi District, Garut Regency, West Java, Indonesia aims to develop the tourism sector through the exploration of bamboo materials with kinetic architecture technology. With a multidisciplinary approach, this project integrates kinetic bamboo architecture and solar panels to create an environmentally friendly and sustainable design. The research resulted in the design of facilities such as kinetic kiosks, glamping, and modular shelters that support local identity and increase the economic potential of the local community.

KEYWORDS :Bamboo, Kinetic Architecture, Selaawi, Solar Panel, Sustainable Architecture

I. INTRODUCTION

West Java, with a population of 46,497,175 million people (West Java SIAK Data 2015) and an area of 35,388.76 km2, is one of the largest provinces in Indonesia. With such an area and population, West Java has economic potential that can be developed and improved, one of which is economic potential in the tourism sector. In addition, natural resources are also West Java's potential for economic development and improvement. Garut is one of the regencies in West Java that has good tourism potential and natural resource commodities. Plantation, agricultural, fishery and energy resources are examples of some of the things that are produced in Garut. Geographically, Garut Regency, which borders directly with Bandung, Sumedang, and Tasikmalaya, has made Garut a tourist destination of choice for residents of these cities and their surroundings. One of the sub-districts in Garut that has superior natural resource and craft potential is Selaawi. In 2018, Selaawi Sub-district was designated as a Creative Bamboo Industry Village Area through its superior natural resource potential and bamboo crafts. Based on this decision, the Garut Regency Government has made various efforts to develop villages in Selaawi Sub-district to show bamboo crafts as the village's identity. One of the efforts made is to build the Selaawi Bamboo Creative Center (SBCC) with the aim of strengthening the village tourism sector and strengthening local arts and culture in Selaawi. Currently, SBCC is under construction and through the relationship established with the Faculty of Social and Political Sciences, UNPAR (Parahyangan University) , is interested in collaborating with UNPAR's Architecture and Mechatronics for further development of the masterplan and design of facilities with bamboo materials at SBCC. In accordance with research and learning in the Architecture and Mechatronics Study Program related to Kinetic Bamboo Architecture, UNPAR will collaborate by helping to design several facilities at SBCC with a kinetic bamboo system combined with solar panels. The design results are in the form of designs and working drawings, making small-scale prototypes, and are expected to reach the full construction stage in 2024. The bamboo building work that will be carried out is green and applies sustainable kinetic technology for the village environment in Selaawi sub-district.

The project aims to:

1. Enhance the appeal of bamboo-based tourism.
2. Utilize renewable energy technology.
3. Strengthen the creative economy through culture-based design.

The benefits of this project are:

- Providing environmentally friendly solutions through bamboo materials and kinetic technology.
- Providing real learning experiences for students.
- Developing the village's economic potential through design innovation.

The objectives of this project are:
- Integrating kinetic technology with local materials.
- Increasing energy efficiency through solar panels.
- Building local cultural identity as a tourist attraction.

The methods used in this project are as follows:
1. Initial Research: Field observation, data collection, and consultation with experts.
2. Design: The design process is carried out using Rhinoceros and Grasshopper software for parametric and kinetic simulations.
3. Implementation: Making a small-scale prototype that is tested in the field.
4. Evaluation and Development: Adjusting the design based on input from the community and the expert team.

Application of Kinetic Technology in Bamboo Structures : Bamboo plants are plants that have strength and stiffness that are comparable to other materials. Made from natural materials, bamboo plants certainly have a good environmental impact on the environment, because they do not pollute or produce carbon emissions. Therefore, this plant is widely used by humans as an alternative green and environmentally friendly building material. Today, along with the development of the era, many technologies have emerged that help green the earth from exposure to pollution smoke, carbon emissions, or global warming. One of the technologies that has emerged is to increase energy savings in buildings. An example is solar panels. Solar panels are a technology that utilizes natural sunlight and converts that light into energy in buildings. The energy produced can be used as a source of kinetic energy in bamboo structures. This study also involved village partners, namely Selaawi sub-district, Garut, West Java, Indonesia. Selaawi District is one of the districts in Garut that has superior natural resource and craft potential. There are seven villages in Selaawi District, namely Gawir, Putrajawa, Mekarsari, Samida, Cirapuhan, Selaawi, and Pelitaasih. Geographically, it has an area of approximately 32 km2. According to BPS Garut Regency records, the character of the area is in the form of highlands and mountains at an altitude of 553 meters above sea level. One of the abundant natural resources in Selaawi District is bamboo trees. This natural wealth has traditionally produced bamboo craft products for Selaawi until now. The majority of Selaawi residents work on bamboo weaving as their main livelihood, especially in Mekarsari Village and Putrajawa Village. The Selaawi bamboo industry is known as one part of the creative economic potential there.

In 2018, Selaawi District was designated as the Selaawi Creative Bamboo Industry Rural Area through the Decree of the Regent of Garut Number 410/Kep.352-Bappeda/2018. The development of the Selaawi Area as a Bamboo Tourism Area has given rise to various government efforts to strengthen the village tourism sector and strengthen local arts and culture, one of which is through the construction of the Selaawi Bamboo Creative Center (SBCC) which was inaugurated in 2021. The construction of the SBCC is also expected to motivate various parties to explore and utilize the potential of bamboo natural resources to obtain good and profitable benefits.

Figure 1: amplitheatre in Selaawi Bamboo Creative Centre

Figure 2: Selaawi Bamboo Creative Centre Complex

II. PROCESS AND IDENTIFICATION

This research is part of the MBKM (Merdeka Belajar Kampus Merdeka) program that involves students in the process. The things that are done in this program are:

- Dissemination of footprints for documentation and introduction to the atmosphere around the Village
- Initial design process
- Dissemination of initial designs

- Process and review of design development with experts
- Dissemination of development designs
- Reporting and publication

The MBKM activities carried out in the Selaawi Community Service (PKM) are divided into three groups, namely:

- Thematic Architecture Class as a forum for the design process of 4 simple building functions in Selaawi District, namely solar glamping, portable kiosks, entrance gates, and kinetic bamboo outdoor shelters. Thematic Architecture Classes are held every Wednesday, or Thursdays as an alternative class according to the schedules of students and lecturers.

- The Final Architecture Studio (SAA) which is being taken by one of the MBKM Selaawi participants as a forum for designing a three-star resort hotel as a supporting facility for Samida Village in Selaawi District which will be developed as a Tourism Village. SAA activities follow the schedule made by the person in charge of SAA 54 Genap 2022-2023.

- Architecture Thesis which is being taken by two MBKM PKM Selaawi participants as a forum for research on kinetic bamboo kiosks with solar panel installations in Selaawi to support tourism activities there. The quality and quantity of power of the solar panels were tested by comparing single-axis and dual-axis kinetic solar panels to static solar panels using Rhinoceros and Grasshopper software. The Architecture Thesis activities follow the schedule made by the person in charge of Thesis 54 Even 2022-2023.

Dissemination of footprints for documentation and introduction to the atmosphere around the Village : In the initial stage, socialization and field surveys were conducted to document the potential of the area. The data collected included the geographical, social, and cultural conditions of Selaawi Village. This observation aims to understand local characteristics that will be the basis for the design process. Documentation in the form of photos, videos, and interviews with local communities is the basis for developing designs based on community needs. The first thing that was done was the first visit to Selaawi District, Garut for initial socialization, data collection and information related to the design development that will be carried out in the MBKM Selaawi project. The planning for the development of this design was carried out by a team of students who taught the MBKM Selaawi Project, students of the Thematic Architecture course, lecturers and partners, namely the Selaawi District. A visit and socialization were carried out to the Selaawi District office for socialization with the sub-district and a survey of 2 locations that will be the design site, namely Selaawi Bamboo Creative Center (SBCC) and Kolam Dangiang Cibeger in Samida Village. Surveys of these locations are needed to obtain site data for the purposes of the Architecture Thesis and Final Architecture Studio.After the first visit was completed, the MBKM Selaawi proposal was made to be submitted to Parahyangan Catholic University by creating a background, timeline and budget plan, objectives and output of the proposal which were then finalized with the related data together with the lecturers. The official activities on campus began as a forum for design activities for the MBKM Selaawi project which is a community service project, namely in-depth study of the material through the MBKM Final Architecture Studio which designs a 3-star resort hotel in Selaawi, research on the design of kinetic bamboo kiosks in Selaawi that use solar panels. In addition, in-depth study of the material was carried out through Thematic Architecture which developed various other public facilities with various approaches, namely the creation of portable kiosks with an industrial approach, entrance gates with an interactive approach, solar glamping and outdoor shelters with a modular approach.

Figure 3: first visit to Selaawi by the teaching team

Figure 4: first visit to Selaawi by students

To support deeper research, a Kinetic & Smart Architecture Webinar: A Sustainable Design for The Future was also held. In the webinar, 4 presentations were given by international lecturers (Vincent Blouin, Ph.D, Qingqing Sun., Ph.D and Sida Dai Ph.D.) and a Mechatronics lecturer from Parahyangan Catholic University (Dr. Ir. Bagus Arthaya, M.Eng). The hope from this webinar is a deeper understanding of kinetic architecture and bamboo architecture which will later become the main research in this MBKM.

Figure 5: webinar: A Sustainable Design for The Future

Figure 6: webinar: A Sustainable Design for The Future

Initial design process : The design process begins with concept exploration using software such as Rhinoceros and Grasshopper. Students and lecturers are involved in designing prototypes such as kinetic bamboo kiosks, modular glamping, and tropical shelters. Initial ideas are discussed in thematic classes to get input from various parties. In this process, MBKM Selaawi participants attended a webinar on Bending Bamboo Rules: Post Digital Architecture Practice organized by the Bandung Institute of Technology by Prof. Dr. Ir. Arch Kristof Crolla which is expected to help in the process of developing thesis designs and thematic architecture. In addition, a workshop was also held at the Parahyangan Catholic University Architecture workshop for the development of designs related to public facilities needed by the Selaawi village. In this workshop, MBKM participants focused on the Solar Glamping design development group.

At the meeting, the inner frame and layers of the prototype model were made which would then be assisted to the team of lecturers. Based on the assistance, input was obtained that further understanding of the two layers was needed through exploration research on bamboo reciprocal-deployable gridshell construction and deployable bending active structures in the development of further designs. After the meeting with the lecturers, another discussion was held with the team to revise the glamping design.

Figure 7: the prototype drawing sample

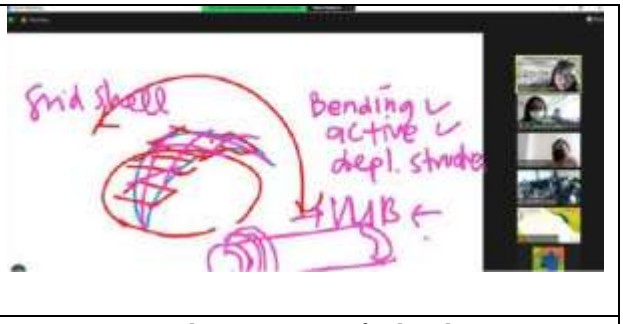

Figure 8: design process of solar glamping

Dissemination of initial designs : After the initial prototype was designed, the design was presented to the community and partners, including Selaawi District and Mekarsari Village. In Mekarsari Village, a project proposal presentation was delivered to introduce the plan in detail because the village was not yet familiar with the project. A positive response was received, with the hope that the kinetic bamboo design could be developed in Mekarsari Village in addition to SBCC. Further technical discussions were held with Pak Utang Maman, a local bamboo craft expert, who provided important input regarding the technical use of bamboo.After the activities in Mekarsari Village, the team continued to Samida Village for a friendly visit, presentation to the village, and a visit to the SAA site. Direct observation and learning about bamboo weaving were also carried out

to understand the local production process. All of these activities support the refinement of the design to be more appropriate to field conditions and community needs.

Figure 9: dissemination of initial designs

Figure 10: workshop and visitation

Process and review of design development with experts: Furthermore, design development focused on evaluating and refining the initial design based on the results of field observations and previous presentations. Intensive assistance was carried out with experts from the fields of architecture and mechatronics to optimize the design of glamping, kiosks, and modular shelters. The kinetic mechanism and efficiency of the solar panels were tested in depth using Rhinoceros and Grasshopper software, with a focus on parametric simulation and technical analysis to ensure the design meets sustainability and functionality standards.Technical testing included structural analysis, energy efficiency, and durability of bamboo materials. The team also developed a small-scale prototype to test the feasibility of the kinetic motion mechanism and sensor-based solar panel integration. Collaboration with mechatronics students is an important element in applying advanced technologies such as the Arduino sensor system to automatically regulate the movement of solar panels according to the position of the sun.In addition, each design group refined the digital model and prepared the physical design for the upcoming exhibition. Online and onsite assistance was carried out periodically with lecturers and related experts to discuss technical details, from designing the motion mechanism to planning the bamboo structure joinery. This collaborative approach ensures that the final design is not only innovative but also practical to implement in the field.

Figure 11: final presentation of solar glamping

Figure 12: model presentation

Dissemination of development designs : The results of the design development are re-socialized to the community to obtain final feedback. Presentations are done visually with small-scale physical models, simple prototypes, and digital portfolios. In addition to the solar glamping project, students also work on other projects such as thesis writing and final architecture studios.In the thesis activity, students produce a simple prototype that integrates solar panel technology with kinetic mechanisms. This prototype is technically tested to ensure its energy efficiency and structural feasibility. Meanwhile, final architecture studio students focus on developing the area in Samida, producing designs that combine aspects of sustainability and local cultural values.

All projects are evaluated by a team of competent lecturers from various disciplines. This evaluation process involves an in-depth analysis of the mechanisms, structures, and impacts of the design on the environment and local communities. Feedback from the community and evaluation results are used to refine the design before final implementation.

Figure 13: solar panel kiosk prototype from student's thesis

This kinetic bamboo kiosk equipped with solar panels will be a strong attraction in the tourism sector in terms of economy and technology. So it is necessary to know the factors that influence the acquisition of solar radiation on the kiosk's solar panels. One of these factors is the orientation of the solar panels to the position of the sun. This causes the need to create a kinetic solar panel design that is able to move the solar panels according to the optimal orientation that follows the direction of the movement of sunlight. Therefore, this study aims to find the effect of the effective tilt angle of the solar panels on the quality of the kinetic roof as a shade, find data on the effectiveness of the power produced by kinetic solar panels compared to static solar panels and their application to the form, construction system and mechanism of the bamboo model with the most efficient kinetic movement in terms of architectural aspects.

In the application of the kinetic movement system on the solar panel in the kinetic bamboo kiosk in Selaawi, consideration of other aspects is important to support the final design. The power capacity generated provides an overview of the most effective movement in terms of fulfilling electricity needs in the kiosk, in this case, the first order is held by the dual-axis mechanism because of its capability in capturing sunlight every hour with precision and optimally. However, other aspects such as structural strength, ease of movement mechanism, and space efficiency in the single-axis mechanism are superior to the dual-axis mechanism because they create longer durability and more effective interior space. All of the above create the most optimal shape, construction system, and movement mechanism in the final design of the kinetic bamboo kiosk in Selaawi.

The movement of the sun is caused by the rotation of the earth (apparent daily motion of the sun) and the revolution of the earth (apparent annual motion of the sun). The apparent daily motion of the sun causes the sun to move east-west (morning to night). While the apparent annual motion of the sun causes different lengths of day and night in certain areas. The sun that is always moving creates an urgency to maximize the use of kinetic solar panels that can adapt to the movement of the sun to the maximum. Through this quantitative experimental research, the focus of the research was on the movement of the kinetic solar panel roof to the east-west direction which was carried out at 6 research times. The research time includes March 21 and September 23 (test dates at the equator), March 11 and October 4 (test dates for the top sun position at 6o LS) with June 21 and December 22 (test dates at southern and northern latitudes) at 08.00-16.00 WIB. In order to obtain the maximum quality of the kinetic solar panel kiosk, several evaluations of aspects of consideration were carried out. These consideration aspects refer to the comparison of power capacity, the quality of the roof as a shade with other aspects related to the quality of the kinetic kiosk (ease of movement mechanism, space efficiency in relation to form, construction system, and kiosk mechanism).

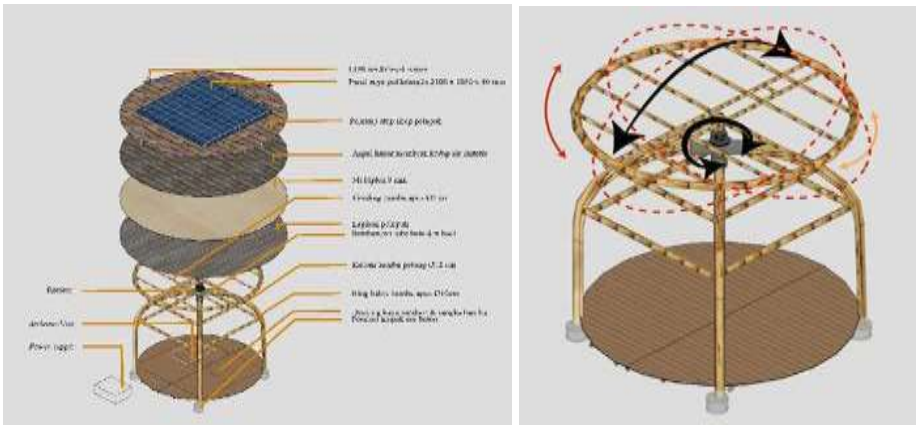

Figure 14: mechanism of the solar panel kiosk

Meanwhile, the final architectural studio assignment was to design a three-star resort hotel building, as one of the supporting facilities needed to advance tourism in the Samida tourist village. The site was chosen following the direction of the village, which is located in the tourism area, which is not far from the Dangiang Cibeger tourist swimming pool. The background of choosing the function of a resort hotel is after considering the needs of Samida village which aspires to develop into a tourist village. Therefore, a place to stay with supporting tourist facilities is needed without eliminating the identity of the village and Selaawi sub-district itself. By choosing the right material, showing the characteristics of the village's 'bamboo craft' culture, following the context of the surrounding environment, and providing natural recreation facilities will certainly show the identity of Selaawi sub-district in the design carried out.

The theme raised in this three-star hotel and resort assignment project is local tourism that focuses on aspects of bamboo craft production as well as rice fields and other existing natural lands. The achievement of the theme in the resort's built environment can be felt optimally through the availability of adequate recreational facilities to build the tourism side of Samida village. By providing facilities such as a gallery space for village-style bamboo crafts, a workshop space for making bamboo crafts, and recreational facilities for rice field trekking or lake boats, the theme that has been raised will be further realized. The arrangement of the building mass on the site is carried out based on the predetermined axis. Where, through the data, the three contour lines that pass through the site tend to be irregular. Then a 2-dimensional simplification is carried out through a smoother 'shadow contour line' in accordance with the character of the suburban environment. Then, the midpoint of each shadow contour line will be found, where a strong orientation is created diagonally northwest-southeast. So that this orientation is used as the basis for the design axis. By using the characteristics of bamboo plants that are round/circular, so that on the axis a center point (node) is determined which is then offset to help place the residential mass (hotels and resorts) as a whole on the site. The building mass applies the concept of tropical architecture and a rigid frame structure system. So that when viewed from the outside, it will look like a high-roofed mass as a binding element between the entire mass.

Figure 15: location of the site

Figure 16: model of the building

Reporting and publication : There are four designed projects where each project is a different object function, including entrance gate, portable kiosk, multifunction shelter, and glamping. Each group designs an object that can be moved through a certain mechanism so that the resulting design object produces a kinetic movement of each. These four objects were chosen because of a request from the village in order to advance the tourism aspect in the Selaawi Bamboo Creative Center (SBCC) area in Selaawi sub-district. SBCC itself is a communal area of Selaawi sub-district which is often used for togetherness events such as cultural festivals and other arts. And it is planned to be a tourist destination for tourists and local residents.

Figure 17: design concept on Selaawi Bamboo Creative Centre

Figure 18: the gate design

Figure 19: the portable kiosk design

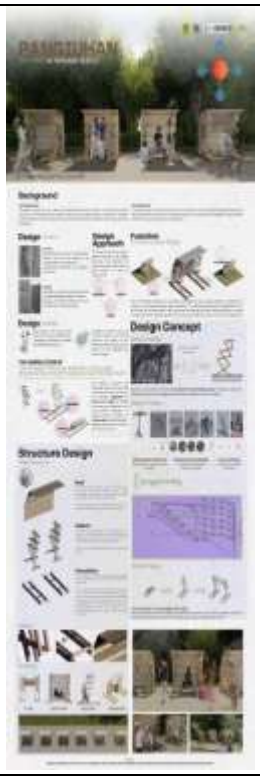

Figure 20: the shelter design

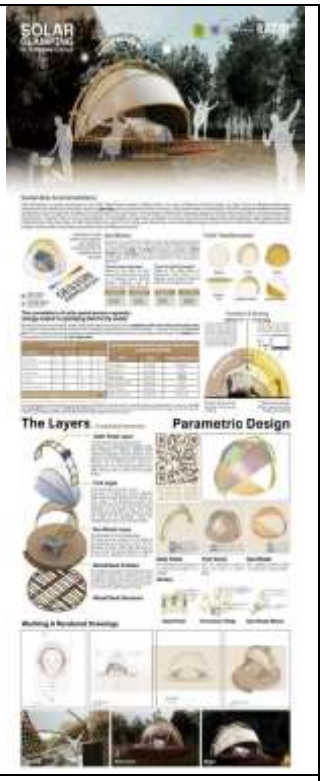

Figure 21: the solar panel glamping

The entrance gate is designed using a module, where the module can be arranged to fit the length of the gate desired by the user. Using mechanism systems such as arduino, dynamo pulleys, sensored floor plates, and movable bamboo, so that the gate module will perform a certain interactive kinetic force when passed by pedestrians. Kiosk buildings are needed to help local residents of the sub-district in entrepreneurship. Kiosks are designed to be portable, meaning that kiosk buildings do not depend on one place and can be moved according to user needs. This design uses a bamboo structure with a fairly simple structural system, so it will be an advantage if the sub-district wants to industrialize it. The multifunctional shelter design is useful as a temporary shelter facility in the SBCC area. Serving temporary shelter activities such as sitting and chatting. Using a deployable structure means that its shape is adaptive and portable so that it can be moved according to user needs.

The glamping building functions as a lodging facility in the SBCC area. This building is designed to form a dome using the main bamboo structure, where there are three layers that can each move, namely the solar panel layer, the tent layer, and the woven layer. First layer: This building is integrated with solar panels as the main energy source of the building. There are two photovoltaic cells according to the electrical energy needs required by the glamping building, which is 1000 w (according to group calculations). The two solar panels are designed based on the need for dual-axis sunlight, east-west (sun movement per day) and north-south (sun movement per month). However, to maintain convenience, the solar movement per month is taken according to the most optimal sun angle, which is on June 21.Second layer: This layer functions as an access in and out of the glamping building. This layer is formed by several bamboo arches whose ends rest on two points on both sides of the glamping building. This layer is made permanent on one side (on the private side of the building, so that the difference between the public area and the more private space area is clear. Made of white membrane material, it makes it easy for sunlight to enter the building but still maintains the privacy of the users inside.

Third layer: The last layer, which is the deepest, is the bamboo woven layer. This layer functions as a shade and also functions as a door for glamping. This layer is located on its own rail track, so it can be slid on its track. The woven pattern used is inspired by the Selaawi bamboo craft pattern The final report is prepared to document the entire process, from the planning stage to the evaluation. Publication is done through exhibitions of works, journal articles, and academic seminars. The design results that have been developed are also exhibited together with small-scale prototypes. This exhibition aims to introduce the concept of kinetic architecture and the use of bamboo as the main material to the wider community, while also providing education about the importance of innovation in sustainable architecture. Through this activity, it is hoped that it can open the insights and interests of various parties towards the potential of bamboo as an environmentally friendly material that can be applied to kinetic design, as well as increase appreciation for designs that support environmental sustainability.

Figure 22: the exhibition

Figure 23: the exhibition

III. CONCLUSION

The MBKM program in Selaawi District has successfully integrated modern technology and local culture to create innovative designs that support sustainability. The application of kinetic bamboo architecture equipped with solar panels not only provides a practical solution to increase tourist attractions but also strengthens the economic potential of the local community through the exploration of local resources. Through a collaborative process involving students, lecturers, and the community, various prototypes such as kinetic kiosks, modular glamping, and eco-friendly shelters have been designed with sustainability and energy efficiency in mind. This

Research also shows the importance of technology in supporting community-based tourism infrastructure, especially through the integration of a kinetic solar panel system designed to optimally follow the movement of the sun. The results of this program not only provide direct benefits to the community but also contribute to the development of science and technology through a multidisciplinary approach. The exhibition of works and prototypes that have been carried out also has a positive impact in the form of increasing public awareness of the importance of innovation in sustainable architecture. In the future, this research can be further developed with a focus on increasing the efficiency of kinetic mechanisms, diversifying the application of bamboo materials in modern designs, and developing more affordable and easy-to-implement renewable energy systems. In addition, the potential for collaboration with the international community can also be explored to expand the positive impact of this program and make Selaawi a model for a sustainable tourism area based on local culture.

REFERENCES

[1] Asif, M., & Muneer, T. (2007). Solar Energy in the Built Environment. Renewable and Sustainable Energy Reviews, 11(7), 1388-1411.
[2] Felicetti, P., & Trujillo, D. (2017). Bamboo in Construction: A Sustainable Material for the Future.
[3] Mahgoub, R., & Korsavi, S. S. (2021). The Role of Parametric Tools in Enhancing Solar Energy Systems Integration. Energy and Buildings, 243, 111057.
[4] Janssen, J. J. A. (2000). Designing and Building with Bamboo. International Network for Bamboo and Rattan (INBAR).
[5] Trigo, J., & Shimizu, E. (2019). Adaptive Solar Energy Mechanisms: Single-Axis vs Dual-Axis Systems. Solar Energy Journal, 182, 189-204.

Archives

[1] Archives from Selaawi, Garut, West Java, Indonesia