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Development of TOGA Edu-Tourism with Augmented Reality Technology

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ABSTRACT

The development of Edu-tourism based on family medicinal plants (TOGA) in Tirta Jaya Village, supported by Augmented Reality (AR) technology, can enhance education, environmental conservation, and local economic opportunities. This Edu-tourism initiative offers an innovative and sustainable tourism model that positively impacts the tourism sector and the economy. This study aims to explore and analyze the potential for developing TOGA-based Edu-tourism with AR technology support as an innovative educational tourism model, providing benefits to the community and the environment, while adding value to sustainable local products. This study employs a qualitative descriptive approach with three main stages: a literature review and field data collection to analyze the potential of TOGA and AR technology; an evaluation of TOGA potential based on tourism attraction feasibility, flagship product prioritization, and value-added analysis using the Hayami method; and the development of AR components for interactive education. The results indicate that the combination of TOGA and AR technology can increase public awareness of health, medicinal plant conservation, and local economic empowerment through interactive educational tourism. The educational tourism attraction TOGA Tirta Jaya Village has a high feasibility index, with an average score above 79%, making it worthy of development.

1. INTRODUCTION

Educational tourism, or Edu-tourism, has increasingly become an attractive alternative for educating communities while enjoying the beauty of nature and culture. One promising form of Edu-tourism involves utilizing family medicinal plants or TOGA (*Tanaman Obat Keluarga*). TOGA, is often overlooked as a natural resource, carries multiple value: not only as a natural remedy but also to preserve local plant biodiversity, crucial for environmental sustainability and community health (Mistriani *et al*., 2024). In Indonesia, a study by Lestari *et al*. (2023), found that 83.33% of tourism awareness group members expressed a positive interest in utilizing and preserving TOGA, following educational initiatives aimed at enhancing their knowledge and engagement in wellness tourism. Developing TOGA-based Edu-tourism can significantly benefit local communities in terms of education, health, and economic empowerment (Latifah *et al*., 2021). Furthermore, TOGA-based products offer substantial added value, whether as health products or agro-industrial goods. Family medicinal plants processed into various products, such as herbal remedies, cosmetics, and healthy food and drinks, have a growing market. This aligns with the rising public awareness of the importance of healthy and eco-friendly lifestyles (Navelin, 2020). Leveraging TOGA in developing local products enables communities to create sustainable economic opportunities. Such TOGA-based products can be marketed as unique and superior flagship items, catering to both local and national markets (Lutfiyah *et al*., 2024).

To enhance the appeal and effectiveness of this educational tourism, technology plays a vital role in creating more interactive and engaging experiences. Augmented Reality (AR) is a technology that overlays digital content, such as

images, sounds, or information, onto the real-world environment in real-time. Unlike Virtual Reality (VR), which creates a completely immersive virtual world, AR enhances the user's perception of the physical world by adding interactive elements. These digital elements are typically viewed through devices such as smartphones, tablets, or AR glasses, and they are integrated seamlessly with the physical surroundings, allowing users to interact with both the real and virtual components simultaneously. AR is commonly used in various applications, including education, gaming, healthcare, marketing, and tourism, to provide enriched and engaging user experiences. AR technology is widely adopted in various sectors, including tourism, for its ability to transform how visitors interact with information. AR enables users to visualize data more attractively via smart devices such as smartphones, tablets, smart glasses, AR headsets, and smartwatches (Aristana *et al*., 2024). In the context of TOGA-based edu-tourism, AR provide in-depth information about different medicinal plants, their cultivation, health benefits, and processing techniques. These can be delivered through 3D visualizations or direct interactions that enhance educational value (Darmawan *et al*., 2024).

The combination of TOGA and AR technology is expected to enrich visitor experiences, enhance knowledge about family medicinal plants, and empower local communities to leverage TOGA as superior agro-industrial products with added value. This research aims to explore and analyze the potential for developing TOGA-based Edu-tourism with AR technology as an innovative educational tourism model, benefitting both the community and the environment while adding value to sustainable local products. The development of educational tourism based on family medicinal plants (TOGA) has a positive impact on increasing community knowledge, environmental conservation, and local economic empowerment.

2. MATERIALS AND METHODS

This study was conducted in Tirta Jaya Village, located in Tanah Laut Regency, South Kalimantan Province, which holds significant potential for developing TOGA-based Edu-tourism supported by Augmented Reality (AR) technology. The village is renowned for its diverse family medicinal plants and natural resources, which can serve as valuable assets for both education and tourism. By involving the local community in managing and developing TOGA-based products, sustainable economic opportunities can be created, thereby improving the quality of life for the village residents.

This study employs a qualitative descriptive approach, systematically structured into several stages to develop TOGA-based Edu-tourism and enhance the added value of TOGA products, supported by AR technology. The research was conducted over a period of six months in Tirta Jaya Village, Tanah Laut Regency, South Kalimantan Province. The methodology consists of three main stages: preliminary study, potential analysis, and AR technology development for TOGA-based Edu-tourism. The research utilized purposive sampling, intentionally selecting respondents from among bureaucratic experts and academics with relevant knowledge and experience in the development of family medicinal plants (TOGA), educational tourism, and AR technology.

2.1. Preliminary Study Stage

The study begins with an in-depth literature review and field data collection to gather information regarding the potential of TOGA-based Edu-tourism, TOGA products, and the application of AR technology. The literature review aims to explore relevant concepts of Edu-tourism, the utilization of TOGA as an agro-industrial product, and the development of AR technology in the tourism and education sectors (Riana *et al*., 2022). The sources include scholarly journals, books, articles, and previous research reports. Additionally, field data is collected through interviews with five respondents, including experts from the bureaucracy and academia. The data collected includes information on the presence of TOGA in Tirta Jaya Village, local community use of TOGA, and respondents' perceptions of the potential development of TOGA-based Edu-tourism and the use of AR technology to enhance the educational tourism experience (Muladi *et al*., 2022).

2.2. TOGA Edu-Tourism and Product Potential Analysis Stage

In this stage, an analysis of the potential for TOGA-based Edu-tourism and its products is carried out to evaluate the feasibility of developing TOGA-based Edu-tourism initiatives. This analysis employs a qualitative descriptive method

aimed at systematically describing and explaining the Edu-tourism potential based on data collected through field observations, interviews, and documentation. The focus of the analysis is to identify key strengths, existing challenges, and potential opportunities that can be developed from local resources to support the growth of TOGA tourism. Thus, this analysis serves as a fundamental initial step in optimizing the use of local resources to create a sustainable, appealing, and competitive tourism model. The analysis covers several key aspects:

2.2.1. Tourism Attraction Feasibility Index

The assessment evaluates factors such as natural, cultural, and educational attractions offered by Tirta Jaya Village. Specifically, the following aspects are considered: Natural Attractions, Cultural Attractions, and Educational Value. This feasibility index measures how well TOGA-based Edu-tourism can attract visitors by combining these elements to create a unique and enriching experience. High scores in this index indicate strong potential for Tirta Jaya Village to become a significant educational eco-tourism destination (Lestari *et al*., 2023). The calculation of tourism object attraction feasibility is based on the guidelines issued by Departemen Kehutanan (2003). The total score for each assessment criterion can be determined using the following formula:

$$S = N \times B \quad (1)$$

where S = score of a specific criterion, N = total score of the elements within the criterion, and B = weight value. The score for each assessment criterion is determined using an index value, ranging from 51 as the lowest score to 200 as the highest. The score for each criterion is the sum of the values of its related elements or sub-elements. The overall score of each tourism object assessed is calculated by summing the total scores of all criteria, each multiplied by its respective weight (Departemen Kehutanan, 2003).

In this study, 15 criteria were assessed in the tourism attraction feasibility index. These 15 criteria include: Attraction, Market Potential, Accessibility, Surrounding Area Condition, Management and Services, Climate, Accommodation, Supporting Facilities, Availability of Clean Water, Relationship with Nearby Attractions, Security, Area Carrying Capacity, Visitor Management, Marketing, and Market Share. The standard assessment criteria for tourist attraction objects can be seen in Table 1.

According to Karsudi *et al*. (2010), after calculations are carried out, the feasibility index is obtained in percentage form. The feasibility levels of a tourist area are classified as follows:

1. Feasibility level > 66.6%: Suitable for development.
2. Feasibility level 33.3%–66.6%: Not yet suitable for development.
3. Feasibility level < 33.3%: Not suitable for development.

2.2.2. TOGA Flagship Product Prioritization

Based on surveys and interviews, an analysis is performed to identify TOGA products with the best market potential. Prioritization is based on product advantages, with flagship products being determined through comparisons of revenue versus production and marketing costs. Products with a higher R/C ratio are considered more profitable. The Revenue-to-Cost (R/C) ratio is a financial metric used to assess the profitability of a product. It is calculated by comparing the revenue generated to the costs incurred in its production. A higher R/C ratio indicates greater profitability, as it reflects a larger amount of revenue relative to the associated costs. Therefore, products with a higher R/C ratio are considered more economically advantageous and profitable. Additionally, the analysis considers the suitability of products with market trends, such as herbal health and cosmetic products, targeting both local and international markets. Products with good cost efficiency and optimal profits are prioritized for further development (Lestari *et al*., 2023).

2.2.3. TOGA Product Added Value

This study also evaluates the added value generated from TOGA-based products, such as herbal drinks made from ginger, turmeric, temulawak, and other spices. The analysis aims to identify aspects that can improve the competitiveness of products in the market, such as packaging, standardization, and branding (Nuzuliyah, 2023). The value-added analysis uses the Hayami method for calculation, as shown in Table 2.

Table 1. Standard criteria for assign tourist attraction objects (Departemen Kehutanan, 2003).

Criteria	Weight	Total Score	Classification Score	Remarks
Attraction	6	1.440	480–800	Low
			801–1120	Medium
			1121–1440	High
Market Potential	5	950	230–470	Low
			471–710	Medium
			711–950	High
Accessibility	5	900	105–370	Low
			371–635	Medium
			636–900	High
Surrounding Area Condition	5	1.200	450–700	Low
			701–950	Medium
			951–1200	High
Management and Services	4	360	80–173.33	Low
			173.34–266.67	Medium
			266.68–360	High
Climate	4	480	120–240	Low
			241–360	Medium
			361–480	High
Accommodation	3	90	30–50	Low
			51–70	Medium
			71–90	High
Supporting Facilities	3	180	45–90	Low
			91–135	Medium
			136–180	High
Availability of Clean Water	6	900	270–480	Low
			481–690	Medium
			691–900	High
Relationship with Nearby Attractions	1	100	0–33.33	Low
			33.34–66.67	Medium
			66.68–100	High
Security	5	600	250–366.67	Low
			366.68–483.33	Medium
			483.34–600	High
Area Carrying Capacity	3	450	90–210	Low
			211–330	Medium
			331–450	High
Visitor Management	3	90	30–50	Low
			51–70	Medium
			71–90	High
Marketing	4	120	20–53.33	Low
			53.34–86.67	Medium
			86.68–120	High
Market Share	3	270	105–160	Low
			161–215	Medium
			216–270	High
Total		8.130	2,305– 4,246.67	Low
			4,246.68–6,188.30	Medium
			6,188.34–8,130	High

2.3. AR Technology Development in Edu-Tourism Stage

The AR technology development stage represents the core of this research, aimed at enhancing visitor interactivity and engagement in learning about TOGA and the educational tourism attractions. By integrating AR technology, the project seeks to create a dynamic and immersive learning environment that combines digital innovation with traditional knowledge. The development process includes several carefully planned steps.

Table 2. Value-Added Calculation Using the Hayami Method

No	Information	Calculation Formula
	I. INPUT, OUTPUT, AND PRICE	
1	Output (kg/proses)	(1)
2	Input/Raw Material (kg/proses)	(2)
3	Direct Labor (HOK/Proses)	(3)
4	Conversion Factor	(4) = (1) : (2)
5	Direct Labor Coefficient (HOK/Kg)	(5) = (3) : (2)
6	Output Price (Rp/Kg)	(6)
7	Average Direct Labor Wage (Rp/kg)	(7)
	II. ADDED VALUR AND PROFIT	
8	Input/Raw Material Price (Rp/kg)	(8)
9	Other Input Price (Rp/kg)	(9)
10	Output Value (Rp/kg)	(10) = (4) x (6)
11	a. Added Value (Rp/kg)	(11a) = (10) - (8) - (9)
	b. Added Value Ratio (%)	(11b) = (11a) : (10) x 100%
12	a. Labor Compensation (Rp/kg)	(12a) = (5) x (7)
	b. Labor Compensation Ratio (%)	(12b) = (12a) : (11a) x 100%
13	a. Profit (Rp/kg)	(13a) = (11a) – (12a)
	b. Profit Rate (%)	(13b) = (13a) : (11a) x 100%
	III. PRODUCTION FACTOR COMPENSATION	
14	Margin	(14) = (10) - (8)
	a. Labor Income (%)	(14a) = (12a) : (14) x 100%
	b. Contribution of Other Inputs (%)	(14b) = (9) : (14) x 100%
	c. Processor/Business Profit (%)	(14c) = (13a) : (14) x 100%

2.3.1. AR Design Preparation

In this initial phase, preparations are made for designing and creating AR content, including selecting the software and techniques to be used in visualizing TOGA plants and interactive elements to be displayed through AR technology, such as Blender, Unity Vuforia SDK, and Figma. This step lays the groundwork for a visually rich and technically robust AR experience, ensuring the application meets the needs of both tourists and educational institutions.

2.3.2. AR User Interface (UI) Design

This phase focuses on designing the UI of the application, ensuring that users can easily and structurally access various features and information. Some of the main components in the app's UI design include Home, Main AR, Gallery, Guide, and About. These components, when structured effectively, enhance user experience and enrich their understanding of TOGA's benefits. The UI design emphasizes clarity, functionality, and aesthetic appeal to ensure a seamless and engaging user experience.

2.3.3. AR Technology Development for Edu-Tourism

In this phase, AR technology is developed and implemented in the Edu-tourism application. The main components developed for AR technology include 3D Models, Interactive Maps, AR Markers, and Audio. Additional considerations during this phase include testing the application for performance, compatibility, and user satisfaction. Ensuring the accuracy of visualizations and the responsiveness of AR interactions is critical for delivering a high-quality experience.

3. RESULTS AND DISCUSSION

The initial phase of this study investigates the potential of TOGA-based Edu-tourism supported by Augmented Reality (AR) technology to enhance educational appeal. The literature review indicates that TOGA serves not only as a source of natural health but also supports the conservation of local plants. TOGA-based edu-tourism can educate the commu-

Table 3. Results of the Assessment of Edu-Tourism Attraction Objects

Criteria	Weight	Total Score	Score (N x b) Index (%) Classification ODTW				
			1	2	3	4	5
			930	930	960	930	900
Attraction	6	1440	64.58	64.58	66.67	64.58	62.50
			M	M	M	M	M
			925	925	950	950	950
Market Potential	5	950	97.37	97.37	100	100	100
			H	H	H	H	H
			900	900	900	900	900
Accessibility	5	900	100	100	100	100	100
			H	H	H	H	H
			825	800	800	825	825
Surrounding Area Condition	5	1200	68.75	66.67	66.67	68.75	68.75
			M	M	M	M	M
			260	200	260	240	260
Management and Services	4	360	72.22	55.56	72.22	66.67	72.22
			M	M	M	M	M
			280	260	300	280	280
Climate	4	480	58.33	54.17	62.50	58.33	58.33
			M	M	M	M	M
			90	60	75	75	75
Accommodation	3	90	100	66.67	83.33	83.33	83.33
			H	H	H	H	H
			180	180	180	180	180
Supporting Facilities	3	180	100	100	100	100	100
			H	H	H	H	H
			870	870	840	870	870
Availability of Clean Water	6	900	96.67	96.67	93.33	96.67	96.67
			H	H	H	H	H
			100	100	100	100	100
Relationship with Nearby Attractions	1	100	100	100	100	100	100
			H	H	H	H	H
			475	475	475	450	475
Security	5	600	79.17	79.17	79.17	75	79.17
			M	M	M	M	M
			285	285	285	285	285
Area Carrying Capacity	3	450	63.33	63.33	63.33	63.33	63.33
			M	M	M	M	M
			60	60	45	60	60
Visitor Management	3	90	66.67	66.67	50	66.67	66.67
			M	M	L	M	M
			120	120	120	120	120
Marketing	4	120	100	100	100	100	100
			H	H	H	H	H
			225	225	225	210	195
Market Share	3	270	83.33	83.33	83.33	77.78	72.22
			H	H	H	M	M
Total Score			1,250.42	1,194.17	1,220.56	1,221.11	1,223.19
Average Index (%)			83.36	79.61	81.37	81.41	81.55

Description: Expert respondents consist of heads of SKPD in Tanah Laut Regency and academics from the Tanah Laut State Polytechnic, including: 1) Bapperida, 2) Tourism Department, 3) Education Department, 4) Manpower and Industry Department, and 5) Academic representatives.

Table 4. Feasibility Levels of Edu-Tourism Attractions

Respondent	ODTW	Index (%)	ODTW Classification	Remarks
Bappeda	TOGA Edu-Tourism	83.36	High	Suitable for Development
Tourism	TOGA Edu-Tourism	79.61	High	Suitable for Development
Education	TOGA Edu-Tourism	81.37	High	Suitable for Development
Manpower and Industry	TOGA Edu-Tourism	81.41	High	Suitable for Development
Academics	TOGA Edu-Tourism	81.55	High	Suitable for Development

Note: ODTW = Objek Daya Tarik Wisata

nity about the benefits and processing of medicinal plants while empowering the local population. AR technology enriches the tourist experience through 3D visualizations and interactive, easily accessible information, allowing visitors to learn about the types, cultivation, and utilization of TOGA as health products and agro-industrial goods. The combination of AR and TOGA makes Edu-tourism more engaging, increases awareness of the importance of medicinal plants, and encourages community involvement in conservation. The results of this study demonstrate that the TOGA and AR-based Edu-tourism model has the potential to raise environmental awareness, health consciousness, and economic opportunities in nature- and technology-based tourism sectors.

3.1. Tourism Attraction Feasibility Index

This comprehensive assessment provides a feasibility indicator for development by considering various crucial aspects, where a high score indicates that the project has strong development potential. Furthermore, the assessment of the educational tourism object in Tirta Jaya Village is carried out based on 15 criteria. The results of the assessment of tourism attraction objects in Tirta Jaya Village, Tanah Laut Regency, can be seen in Table 3.

Overall, the average index ranges between 79.61% and 83.36%. This indicates that the Edu-tourism attractions in this village are generally at a good level (moderate to high), with potential for further development in several key aspects, particularly in management, visitor regulation, and enhancing the surrounding environmental conditions. To refine the analysis, this study assessed attraction feasibility involving five respondents, consisting of experts from both bureaucrats and academics. The feasibility level of Edu-tourism attractions can be seen in Table 4.

Based on the evaluation results from various expert respondents, the eco-tourism attraction of TOGA Edu-Tourism in Tirta Jaya Village has a high feasibility index, with an average score exceeding 79%, categorized as suitable for development. Each respondent, including representatives from the Regional Development Planning Agency (Bapperida), Tourism, Education, Manpower and Industry, and Academics, provided positive assessments, with indices surpassing the 66.6% threshold for feasibility. These evaluations indicate that TOGA Edu-Tourism has strong potential for further development as an eco-tourism attraction, supported by adequate aspects such as appeal, accessibility, and supporting facilities. Consistent evaluations from diverse perspectives affirm that this project holds significant opportunities to contribute to the local tourism sector and community empowerment.

3.2. TOGA Flagship Product Prioritization

The feasibility analysis reveals that each herbal drink powder product made from red ginger, temulawak, turmeric, kencur, and spices has its unique advantages and challenges in terms of production costs, profitability, and efficiency value. The evaluation results indicate that all herbal drink powders have broad market potential and stable demand, supported by a growing trend of consumer preference for natural and health-oriented ingredients. The prioritization of these flagship products is based on efficiency value calculations. Products recommended as the top priority for further development are deemed the most economically feasible and hold competitive market potential. The prioritization values for these products can be seen in the flagship product priority table in Table 5.

Table 5. Flagship product priorities based on efficiency value

Product Name	Efficiency Value	Priority (Rank)	Health Benefits
Herbal drink powder: Temulawak (*Curcuma zanthorrhiza*)	2.70	1	Supports liver function, improves digestion, and boosts the immune system
Herbal drink powder: Turmeric	2.40	2 or3	Acts as an anti-inflammatory, antioxidant, and supports joint and skin health
Herbal drink powder: Kencur (*Kaempferia galanga*)	2.40	3 or 2	Relieves fatigue, enhances appetite, helps with respiratory issues
Herbal drink powder: Red Ginger	2.30	4	Warms the body, relieves nausea, improves circulation, and reduces inflammation
Herbal drink powder: Spices	2.18	5	Enhances metabolism, improves digestion, and supports general wellness

3.3. Added Value of TOGA Products

After determining product priorities, an added value calculation is performed to reinforce the feasibility of the products and better understand the extent of their profitability. A summary of the added value for the five products can be seen in Table 6. The added value analysis, using the Hayami method, highlights significant differences in the profitability of each TOGA-based herbal drink powder product temulawak, turmeric, kencur, red ginger, and mixed spices. Each product demonstrates varying levels of profitability depending on production costs, selling prices, and consumer preferences.

Table 6. Added value analysis of herbal drink powder products according to Hayami method

No	Description	Temulawak	Turmeric	Kencur	Red Ginger	Spices
I.	**Input, Output, and Price**					
1	Output (kg/proses)	4	4	4	4	4
2	Input/Raw Material (kg/proses)	3	3	3	1.5	2.63
3	Direct Labor (HOK/Proses)	1	1	1	1	1
4	Conversion Factor	1.33	1.33	1.33	2.67	1.52
5	Direct Labor Coefficient (HOK/Kg)	0.33	0.33	0.33	0.67	0.38
6	Output Price (Rp/Kg)	100,000	100,000	100,000	100,000	100,000
7	Average Direct Labor Wage (Rp/kg)	6,875	6,875	6,875	6,875	6,875
II.	**Added Value and Profit**					
8	Input/Raw Material Price (Rp/kg)	27,000	45,000	45,000	37,500	175,000
9	Other Input Price (Rp/kg)	71,400	71,400	71,400	86,400	78,900
10	Output Value (Rp/kg)	133,333	133,333	133,333	266,667	152,091
11	a) Added Value (Rp/kg)	34,933	16,933	16,933	142,767	101,808
	b) Added Value Ratio (%)	26.20	12.70	12.70	53.54	66.94
12	a) Labor Compensation (Rp/kg)	2,291	2,291	2,291	4,583	2,614
	b) Labor Compensation Ratio (%)	6.56	13.53	13.53	3.21	2.57
13	a) Profit (Rp/kg)	32,641	14,641	14,641	138,183	104,422
	b) Proft Rate (%)	93.44	86.47	86.47	96.79	102.57
III.	**Production Factor Compensation**					
14	Margin	106,333	88,333	88,333	229,167	22,908
	a) Labor Income (%)	2.16	2.59	2.59	2.00	11.41
	b) Contribution of Other Inputs (%)	67.15	80.83	80.83	37.70	344.41
	c) Processor/Business Profit (%)	30.70	16.58	16.58	60.30	455.82
IV.	**Efficiency Value (R/C Ratio)**					
	a) Revenue	400,000	400,000	400,000	400,000	400,000
	b) Total Cost	148,377	166,377	166,377	173,877	183,527
	c) Income/Profit	251,623	233,623	233,623	226,123	216,473
	d) R/C Ratio (a/b)	2.70	2.40	2.40	2.30	2.18

Among the five analyzed products, the spice-based drink powder stands out as the most profitable, with the highest added value (101,808 IDR/kg), profit (104,422 IDR/kg), and an impressive profit rate of 102.57%. This superior performance is largely driven by several key factors. First, the high market demand for multi-spice health beverages positions this product at a premium price level. Its appeal lies in the combination of natural, functional, and immune-boosting ingredients, which aligns with current consumer trends and heightened health awareness. Second, despite relatively higher raw material costs, the value added through processing, packaging, branding, and product diversification exceeds the input expenses. The mixture of various local spices not only enhances health benefits but also increases the product's competitiveness in the herbal beverage market. Additionally, the low labor compensation ratio (2.57%) suggests efficient production with minimal labor intensity. In comparison, single-ingredient powders such as turmeric, kencur, and temulawak exhibit moderate profitability and lower added value, though they still possess potential. Among these, red ginger shows higher added value (142,767 IDR/kg) and conversion efficiency, fueled by consumer interest. However, it incurs higher labor costs, slightly reducing its overall profitability.

Based on the findings, the spice-based drink powder is recommended as the flagship TOGA product due to its high market potential, excellent profitability, and substantial added value. It is well-positioned to support community-based agro-industrial initiatives and serve as a key component in the integration of TOGA with educational tourism development.

3.4. AR Technology Development in Edu-Tourism Stage

3.4.1. AR Design Preparation

Blender is an open-source software used to create 3D models of medicinal plants. These models are designed to allow visitors to view detailed three-dimensional structures of the plants. Creating these 3D models enhances visual quality and provides a more realistic experience.

Unity with Vuforia SDK was chosen as the primary platform for developing the AR application. The Vuforia SDK enables marker development and visual recognition, allowing users to scan objects and view AR visualizations of TOGA directly on their devices.

Figma was utilized to design an intuitive and user-friendly application interface (UI), prioritizing seamless navigation for users interacting with the AR application. Figma simplifies the layout design process, covering features such as Home, Main AR, Gallery, and User Guide pages (Bukhari & Sela, 2024).

3.4.2. AR User Interface (UI) Design

The home page (Figure 1) serves as the entry point to the AR application. It offers an introduction to the application and a well-organized navigation menu, guiding users to explore features like Main AR, Gallery, User Guide, and About pages. This page ensures that users can intuitively access the application's main functionalities. The Main AR page (Figure 2) is the centerpiece of the application, allowing users to scan markers placed on TOGA plant objects. Upon scanning, users can view real-time augmented reality visualizations of the plants. This feature enhances engagement by offering an interactive and immersive way to learn about TOGA plants.

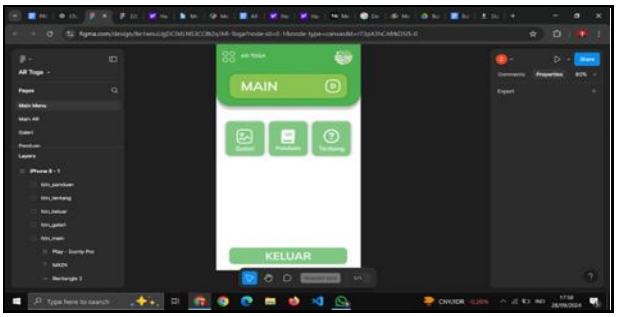

Figure 1. AR Application Home Page

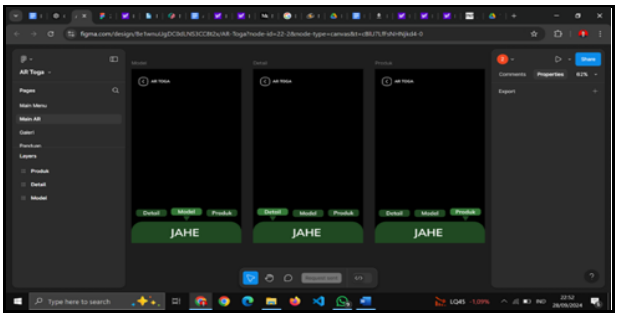

Figure 2. Main AR Page

The Gallery page (Figure 3) showcases a collection of photos accompanied by concise descriptions of various TOGA plant species found in Tirta Jaya Village. This page acts as a reference library, helping users visually identify and learn about the plants outside the AR experience. The User Guide page (Figure 4) provides step-by-step instructions for navigating the AR application. This section ensures that even first-time users can understand the app's features and how to use them effectively. The About page (Figure 5) contains background information about Tirta Jaya Village, highlighting its potential as a TOGA Edu-tourism destination. It also explains the purpose of developing TOGA Edu-tourism and the benefits of TOGA products for health and local economic development. This page helps users connect with the broader goals of the application and project.

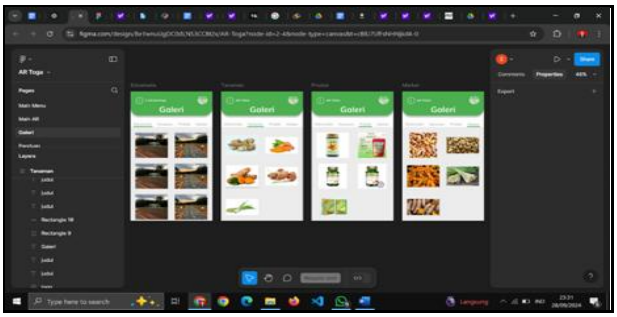

Figure 3. Gallery Page

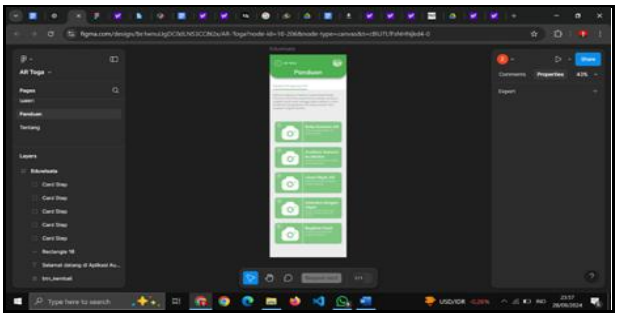

Figure 4. User Guide Page

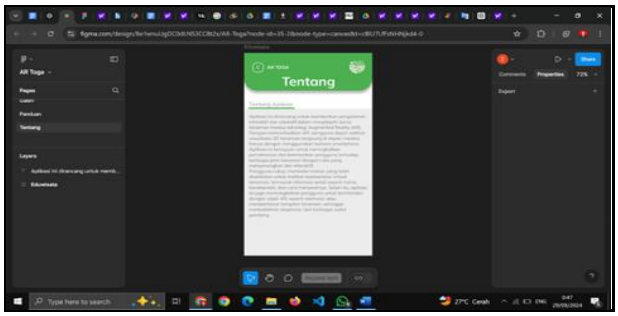

Figure 5. About Page

3.4.3. AR Technology Development for Edu-Tourism

The integration of 3D models and interactive maps in the TOGA-based Edu-tourism AR application significantly enhances educational outcomes by fostering deeper engagement and improving learning retention. The highly realistic 3D visualizations allow users to interact with each TOGA plant virtually, examining its structure, texture, and botanical details in a lifelike manner. According to Krajčovič *et al*. (2021), such visual immersion increases cognitive engagement and supports experiential learning, which has been shown to boost long-term memory retention and conceptual understanding.

Moreover, the interactive map provides an intuitive and spatially contextualized learning experience. By enabling users to explore TOGA plant locations and access detailed information in real-time, this feature reinforces spatial awareness and contextual learning. It transforms passive observation into active exploration, thereby increasing learner motivation and time-on-task, two critical factors linked to higher educational achievement (Alkhabra *et al*., 2023).

From a pedagogical standpoint, these AR features align well with constructivist learning theories, where learners build knowledge through active interaction with their environment. The combination of interactivity, realism, and personalization contributes to higher engagement levels, especially among digital-native learners who are more responsive to technology-enhanced learning tools. The application of AR technology in TOGA (Family Medicinal Plants)-based Edu-tourism can have a significant impact on the performance and development of the Edu-tourism

sector in a region, particularly in Tirta Jaya Village. The following are several aspects that may be influenced by the implementation of AR in the context of TOGA-based Edu-tourism:

1. Development of Tourist Visit Numbers

The use of AR to enhance the educational experience can attract more tourists to visit TOGA-based tourist destinations. With interactive elements, such as 3D models of medicinal plants and dynamic maps, AR provides a more immersive and engaging experience that can increase the number of visits. Tourists who are attracted to technological innovations are likely to become more frequent visitors. Therefore, the increase in visits to tourist destinations integrating AR could occur more rapidly compared to destinations relying solely on conventional approaches.

2. Development of TOGA Product Demand or Sales

With AR, visitors can more easily understand the benefits and processing methods of TOGA products in greater detail. For example, AR can visualize the process of making herbal products or processing spices directly, which enriches their understanding of these products. This not only raises awareness of the health benefits of TOGA products but also increases purchase interest. The sales of TOGA products, such as spice powders or herbal products, can increase as consumers gain a deeper understanding of their added value. Overall, AR can contribute to the growth of market demand, both locally and nationally.

3. Increase in Web and Digital Platform Visits

AR is beneficial not only at physical tourist locations but also in supporting the digital presence of a tourist destination. For instance, by utilizing AR, visitors can access TOGA educational experiences through apps or websites before or after their visit. This can affect the number of virtual visits and interactions on related digital platforms, such as websites that provide information and AR experiences. An increase in visits to digital platforms can raise awareness of the existence of the tourist destination and the TOGA products offered.

4. Increase in Visitor Engagement and Interaction

AR offers interactive features that can enhance visitor engagement during their visit. For instance, visitors can interact with 3D models of medicinal plants or participate in interactive tours that introduce them to TOGA products in more depth. The higher the level of engagement, the more likely visitors will recommend the destination to others, which could lead to increased visits and product sales. Additionally, this engaging experience also increases the likelihood that tourists will share their experiences on social media, further promoting the destination and TOGA products to a broader audience.

5. Impact on the Image of the Tourist Destination

The integration of AR in TOGA-based Edu-tourism can improve the image of a tourist destination as an innovative and attractive location. The use of cutting-edge technologies such as AR not only enhances the visitor experience but also positions the destination at the forefront of tourism innovation. This can potentially increase the destination's appeal to both domestic and international tourists, which could lead to increased visits, local economic sustainability, and higher demand for TOGA products.

6. Increase in Local Community Involvement

The use of AR in TOGA-based Edu-tourism can encourage the local community to become more actively involved in managing and developing TOGA products. For example, the community can participate in creating AR content that promotes their products or in providing information about medicinal plants to visitors. Additionally, the local community can play a role in supporting the marketing of products through applications and platforms that utilize AR technology. Each TOGA plant featured in the application is visualized in highly realistic 3D models. These models provide users with an opportunity to explore the structure, texture, and unique characteristics of the plants in a detailed and engaging way. This feature supports both educational and experiential learning by enhancing the visual quality of the AR application (Triatmaja & Aji, 2023).

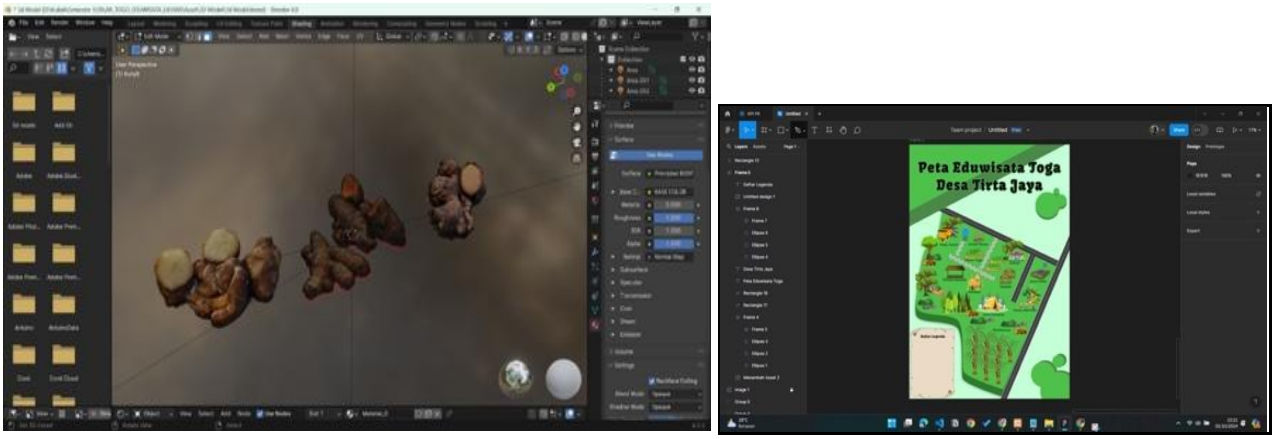

Figure 6. (a) TOGA 3D models, and (b) Interactive map of TOGA Edu-Tourism Tirta Jaya Village

The interactive map enables visitors to locate specific TOGA plants within the edu-tourism area of Tirta Jaya Village. Each point on the map provides additional details about the plant's characteristics, location, and usage. This feature is especially helpful for planning tours and ensuring an organized exploration of the site (Šoltésová *et al*., 2025). Markers are strategically placed on TOGA plants within the Edu-tourism area. Visitors can scan these markers using the AR application to view dynamic 3D visualizations of the plants along with relevant information. This feature bridges the physical and digital experience, providing an intuitive way to learn about TOGA plants (Kamińska *et al*., 2023). Despite the promising potential of the AR marker and audio features, the implementation of these technologies in rural edu-tourism contexts such as Tirta Jaya Village is not without challenges, including the following:

1. Digital Infrastructure Constraints

One of the main challenges is the limited availability and reliability of digital infrastructure in rural areas. Many parts of Tirta Jaya Village may lack stable internet connections, and mobile device penetration may be low or uneven. Since AR applications require real-time rendering, camera access, and data-intensive features (e.g., 3D model loading, audio streaming), poor connectivity or outdated smartphones can significantly hinder user experience and limit access to the full functionality of the application.

2. Low Digital Literacy in Rural Communities

While AR technology may seem intuitive to digital-native users, local community members—particularly older adults or individuals with limited education—may not be familiar with how to use smartphones for AR experiences. Understanding how to scan markers, navigate interactive menus, or troubleshoot app glitches requires a certain level of digital fluency. Without targeted digital literacy programs or community training sessions, the use of AR in Edu-tourism risks excluding some of the local population and limiting its educational impact.

3. Environmental Durability of Markers

Physical AR markers placed outdoors are vulnerable to environmental damage from rain, dust, direct sunlight, or physical tampering. Over time, these factors may cause the markers to fade, become illegible, or degrade in accuracy, leading to difficulties in marker detection and reduced app functionality. Regular maintenance and periodic replacement of the markers are necessary but may present logistical and financial challenges for community managers.

4. Limited Inclusivity and Accessibility

Although the integration of audio narration enhances the educational experience for auditory learners, it may not be inclusive for users with hearing impairments. Furthermore, the current version of the application may lack multilingual support or local dialect translations, limiting its reach to tourists or community members who do not speak Indonesian fluently. Likewise, visually impaired users may find it challenging to interact with 3D content, suggesting a need for broader accessibility features in future development.

Figure 8. AR marker and audio

5. User Fatigue and Technological Limitations

AR applications can quickly drain battery life and consume significant device resources, potentially leading to user fatigue or limited usage duration. Moreover, in an outdoor Edu-tourism setting, screen visibility can be hampered by sunlight, and holding up a smartphone for extended periods may reduce comfort and engagement. These factors should be considered in designing user experiences that are efficient, enjoyable, and practical for all ages. The application integrates audio narrations that complement the visual AR experience. These narrations cover topics such as the health benefits of each plant, processing techniques, and general plant characteristics. By combining audio and visual elements, the app provides a multi-sensory learning experience that caters to different user preferences (Sarwinda *et al*., 2020).

4. CONCLUSION

This study demonstrates that TOGA-based Edu-tourism supported by Augmented Reality (AR) technology has significant potential to enhance educational engagement in Tirta Jaya Village. The feasibility analysis yields an index exceeding 79%, indicating that the village is highly suitable for development as an eco-tourism-based Edu-tourism destination. Local TOGA products—particularly spice powders—have shown promising added value and profitability potential, supporting local economic empowerment. The integration of AR technology enriches visitor experiences using interactive 3D models, dynamic maps, and audio narratives, enabling a deeper understanding of the health and ecological benefits of family medicinal plants. This initiative not only supports public health awareness and environmental sustainability but also fosters rural community development and tourism diversification.

Looking ahead, this model could be enhanced by incorporating multilingual support, local dialect options, gamified learning features, and improved accessibility to ensure inclusivity for users of various ages and abilities. Furthermore, this approach shows strong potential for replication in other rural areas rich in biodiversity and cultural heritage, provided that adequate digital infrastructure and community training are in place.

For practical application, it is recommended that local governments and tourism stakeholders begin developing digital infrastructure and providing technology literacy training to the community to support the sustainability of this program. Future research should explore the effectiveness of AR-based learning experiences quantitatively, focusing on measurable learning outcomes and user engagement. Additionally, future studies should investigate the integration of inclusive design features to ensure accessibility for elderly users and individuals with disabilities.

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