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Development of a Web-Based 360-Degree Virtual Tour for AEWO Mulyaharja Tourism Village Using the MDLC

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Abstract

Digital tourism increasingly requires interactive and immersive media, yet virtual tour development in rural and community-based settings often lacks methodological rigor, structured usability evaluation, and user-centered design. To address this gap, this study develops a web-based 360-degree Virtual Tour for AEWO Mulyaharja using the Multimedia Development Life Cycle (MDLC) framework. Introductory Augmented Reality (AR) elements were included to enrich visual presentation, although these features were not the primary focus of evaluation. The system was developed through the six MDLC stages and assessed using an adapted usability instrument derived from the principles of the System Usability Scale (SUS), simplified to accommodate respondents with varying levels of digital literacy. Thirty participants tested the system and rated five aspects: attractiveness, ease of use, information completeness, intention to visit, and cross-device accessibility. The Virtual Tour achieved an average usability score of 81.68 percent, categorized as "very good," indicating that the platform is engaging, clear, and accessible for potential users. Scientifically, the study contributes to digital tourism literature by integrating MDLC with Human–Computer Interaction considerations and demonstrating the contextual application of an adapted usability measure for community-based environments. Practically, the Virtual Tour enhances AEWO Mulyaharja's digital visibility and offers a replicable model for rural tourism digitalization. Future research may explore deeper evaluation of AR functionality, broader respondent groups, and additional usability metrics.

Keywords: 360-Degree Virtual Tour, MDLC, HCI, Digital Tourism

Introduction

Tourism is one of the most dynamic sectors contributing to economic development and community empowerment. However, many local destinations, including AEWO Mulyaharja, still lack structured, engaging, and interactive digital media needed to compete in today's digital tourism environment. Previous studies have noted that limited access to compelling digital content weakens destination branding, reduces visitor interest, and restricts promotional effectiveness

(Dwi Intan Af'idah, 2023; Fatma et al., 2019). Meanwhile, advancements in immersive technologies such as virtual reality, augmented reality, and web-based 360-degree platforms offer opportunities to enhance destination communication and strengthen pre-visit experiences (Talwar et al., 2023; Wang et al., 2024).

Although 360-degree virtual tours have been shown to improve user engagement and familiarity with tourist destinations (Flavián et al., 2019; Gelter et al., 2021), many existing implementations rely only on basic panoramic visualization. Studies in the Indonesian context rarely document complete multimedia development workflows, provide structured usability testing, or adapt interface design for rural community users (Jung et al., 2017; Nasir & Suheri, 2016; Sari & Rasio Henim, 2022). This indicates a research gap in developing virtual tours that combine systematic multimedia development, user-centered interaction design, and empirical usability evaluation, especially in community-based tourism settings.

To address this gap, this study develops an immersive 360-degree Virtual Tour for AEWO Mulyaharja using the Multimedia Development Life Cycle (MDLC) from conceptualisation to public deployment (Latifah & Amelia, 2025; Luther, 1994). Introductory augmented reality elements are included to enrich the visual experience, although they are not the primary focus of the evaluation. Usability is assessed using an adapted version of the System Usability Scale tailored for non-expert users and cross-device access (Lestari et al., 2021; Sari & Rasio Henim, 2022). This combined approach strengthens methodological consistency and supports inclusivity for community stakeholders.

The scientific objective of this study is to analyse the application of MDLC in producing an interactive web-based Virtual Tour and to evaluate its usability using an adapted usability instrument grounded in Human–Computer Interaction principles. The practical objective is to provide a functional digital tourism platform for AEWO Mulyaharja and offer a replicable model for rural destinations seeking to adopt immersive digital media. This research is expected to contribute to scientific development in community-based smart tourism and to support the digital capacity of tourism village managers.

Research Methodology

This study was conducted at AEWO Mulyaharja Tourism Village, located in South Bogor District, Bogor City, from April to October 2025. The research is applied in nature and aims to develop a web-based 360-degree Virtual Tour that supports tourism promotion and digital empowerment within the local community. AEWO Mulyaharja was purposefully selected due to its strong potential in ecotourism, agricultural education, and community-based microenterprise development, which requires accessible and engaging digital communication media (Dwi Intan Af'idah, 2023; Fatma et al., 2019).

The study employed the Multimedia Development Life Cycle (MDLC) as described by Luther (1994) and further applied in technological and tourism studies in Indonesia (Nasir & Suheri, 2016; Satria et al., 2022). MDLC consists of six sequential stages, concept, design, material collecting, assembly, testing, and distribution, that together provide a rational, empirical, and systematic workflow for multimedia development.

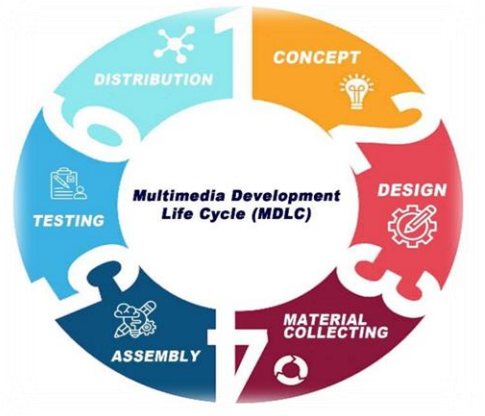

Figure 1. MDLC Method/Approach

Concept

The concept stage involved identifying user needs, establishing development objectives, and understanding the contextual characteristics of AEWO Mulyaharja as a rural tourism destination. Activities included reviewing literature on digital tourism and multimedia design, conducting interviews with tourism managers and local community members, and performing direct field observations. These steps ensured alignment between system requirements, user expectations, and community-based tourism characteristics (Fatma et al., 2019; Satria et al., 2022).

Design

At this stage, technical specifications were formulated, including the interface layout, navigation structure, information hierarchy, and multimedia integration plan. Storyboards and mockups were developed to visualise interactions and scene transitions. Human–Computer Interaction principles guided the design process to ensure clarity, intuitive navigation, and minimal cognitive load for users with diverse digital backgrounds (Flavián et al., 2019; Luther, 1994).

Material Collecting

In this stage, all multimedia components required for the Virtual Tour were gathered. The collected assets consisted of 360-degree panoramic images, descriptive text, audio narration, maps, short video clips, and markers for introductory AR elements. Materials were obtained directly from key tourism points such as organic farming areas, cultural zones, community gathering spaces, and local craft centers (Fatma et al., 2019; Latifah & Amelia, 2025). The collection followed the needs and thematic structure identified during the concept and design stages.

Assembly

All collected assets were integrated into a unified Virtual Tour system using the 3DVista software platform. The assembly process included embedding panoramic scenes, navigation hotspots, informational overlays, audio narration, and introductory AR elements. Interactive features were configured to support immersive and user-driven exploration. The virtual tour was

exported in HTML format to ensure compatibility with web deployment, following established practices in virtual tourism implementations (Kurniadi et al., 2023).

Testing

The testing stage assessed the system's functionality, clarity, stability, and cross-device accessibility. Thirty respondents participated, including tourism managers, residents, district staff, and visitors. The system was demonstrated using laptops and smartphones to ensure respondents could assess cross-device interaction.

Respondent characteristics were collected through the questionnaire, including age range, duration of technology use, and whether participants had previously visited AEWO Mulyaharja. Respondents ranged from young to older adults and represented varying levels of digital literacy, from basic to advanced experience with digital devices. These characteristics are essential because age, digital familiarity, and destination familiarity influence perceived usability and interaction comfort.

Usability was evaluated using an adapted questionnaire derived from the principles of the System Usability Scale (SUS) proposed by Brooke (1996) and commonly used in tourism and multimedia studies (Lestari et al., 2021; Sari & Rasio Henim, 2022). Due to the wide variation in digital literacy among community-based respondents, the original ten-item SUS was simplified into five key statements assessing attractiveness, ease of use, completeness of information, intention to visit, and accessibility across devices. This adaptation aligns with Human Computer Interaction research practices that allow instrument simplification in non-expert community contexts.

Because the adapted instrument does not follow the original SUS structure or scoring formula, the results are not interpreted as formal SUS scores. Instead, all responses were analysed descriptively, converted into percentage categories ("very poor" to "very good"), and used to reflect the perceived usability of the virtual tour transparently and contextually.

Distribution

The final Virtual Tour was deployed via the official AEWO Mulyaharja website and introduced to tourism managers and community members through workshops and training sessions. Documentation, user guides, and technical notes were provided to ensure sustainable system use and future development capacity within the community (Kurniadi et al., 2023).

Data Sources and Instruments

Primary data were obtained from field observations, semi-structured interviews with stakeholders, and post-experience user surveys. Secondary data included literature on digital tourism, multimedia design, and virtual tour development (Flavián et al., 2019; Jung et al., 2017; Tu et al., 2022). Instruments used included the Insta360 camera, VR headsets, smartphones, interview guides, and the adapted usability questionnaire.

Scientific Characteristics and Research Outcomes

The study demonstrates rational characteristics through its strong theoretical foundation and methodological alignment; empirical characteristics through real user testing under field conditions; and systematic characteristics through the structured application of MDLC stages.

The main outcome is a fully operational Virtual Tour with introductory AR elements that showcases AEWO Mulyaharja's tourism assets and provides a replicable model for rural digital tourism development (Flavián et al., 2019; Nasir & Suheri, 2016).

Results and Discussion

The development of the Virtual Tour for AEWO Mulyaharja Tourism Destination was carried out using the Multimedia Development Life Cycle (MDLC) model proposed by Luther(1994), which provides a systematic framework for designing and implementing multimedia-based applications. This model was selected because it emphasizes both the creative and technical dimensions of multimedia development, ensuring that each stage, from conceptualization to distribution, is aligned with user needs and project objectives. The MDLC process consists of six stages: concept, design, material collecting, assembly, testing, and distribution. Each stage was implemented sequentially while maintaining iterative feedback to refine the product's functionality and user experience. The results of each stage are described in the following subsections, beginning with the concept stage.

Concept

The concept stage served as the foundation for developing the AEWO Mulyaharja 360-degree Virtual Tour and established the strategic direction of the project. Based on interviews, field observations, and literature review, several key needs were identified: limited availability of interactive digital media, low accessibility of tourism information, and varying levels of digital literacy among local stakeholders. These findings aligned with the research gap identified in the introduction, namely the absence of systematically developed virtual tours supported by usability evaluation in community-based rural settings.

The main objectives formulated during this stage were (1) to develop an immersive 360-degree Virtual Tour that presents AEWO Mulyaharja's agro-edu-ecotourism potential in a structured and engaging format, (2) to increase information accessibility for potential visitors through web-based interactive media, and (3) to support digital empowerment by introducing a replicable multimedia development model for rural tourism destinations. Introductory Augmented Reality (AR) elements were included as optional enhancements to support educational content, although they were not positioned as primary features for evaluation.

A preliminary user analysis was conducted to understand expectations and interaction preferences. Stakeholder groups included tourism managers, local residents, MSME actors, district staff, and visiting tourists. Across groups, users indicated the need for simple navigation, clear visual cues, concise information, and cross-device compatibility. These insights guided the selection of panoramic viewpoints, narrative content, and interface elements used in subsequent stages.

The output of the concept stage was a structured development blueprint that defined the Virtual Tour's purpose, target users, required multimedia components, and initial content hierarchy. This blueprint ensured methodological alignment with the six-stage Multimedia Development Life Cycle (MDLC) and provided a coherent foundation for the design, material collecting, assembly, testing, and distribution stages that followed.

Table 1. Concept Stage Summary

Element	Description
Project Title	Development of Virtual Tour for AEWO Mulyaharja Tourism Destination Using the MDLC Approach
Project Objectives	○ Develop a web-based Virtual Tour 360° as an interactive medium for tourism promotion. ○ Enhance information accessibility and visitor engagement through immersive visualization. ○ Support digital transformation for AEWO Mulyaharja as a model of community-based smart tourism.
Problems Identified	○ Limited use of digital technology for tourism promotion. ○ Lack of digital infrastructure and online marketing tools. ○ Low digital literacy among local tourism managers and MSME actors. ○ Under-optimized branding and online visibility of AEWO Mulyaharja.
Target Users/Audience	Local community members, tourism managers, MSME entrepreneurs, students, and local government officials of Mulyaharja Village.
Needs Analysis	Field surveys and interviews revealed the need for a user-friendly, visually engaging digital platform that can showcase tourism attractions virtually and integrate AR-based informational content.
Proposed Solution	Integration of Virtual Tour 360° and Augmented Reality (AR) into the official village website (wisatamulyaharja.com) to create immersive tourism experiences and improve digital accessibility.
Multimedia Elements Identified	○ Text: Informational content and on-screen descriptions within the website. ○ Images/Visuals: 360° panoramic views, interactive maps, and AR markers. ○ Video: Tourism video teasers and promotional content for dissemination. ○ Interactivity: User-controlled navigation and AR object interaction.
Expected Outcomes	○ Increased digital tourism visibility of AEWO Mulyaharja. ○ Enhanced community capacity in managing digital content. ○ Strengthened collaboration between academia, local government, and community under the pentahelix partnership model.
Alignment with SDGs	SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 17 (Partnerships for the Goals).

Design

The design stage transformed the conceptual foundation into a structured multimedia experience by developing the interaction flow, storyboard architecture, visual hierarchy, and multimedia layout for the AEWO Mulyaharja 360° Virtual Tour. Following the MDLC framework (Luther, 1994; Nasir & Suheri, 2016), this stage positioned user needs, information structure, and interaction patterns as the core elements of system design. The design process emphasized clarity, accessibility, and ease of navigation, particularly because the target users

consisted of community members, visitors, and tourism managers with varied levels of digital literacy.

The first design activity involved establishing an overall workflow that mapped the logical sequence of AEWO Mulyaharja's agro-edu-ecotourism points. The workflow connected key sites such as the Entrance Gate, Ticketing Area, Fish Pond, Goat Pen, Organic Rice Field, Trekking Path, Saung Jaga Bersama, Gardu Café, and the Lambang Cinta AEWO photo spot. The arrangement was based on spatial coherence and thematic storytelling, a principle supported by multimedia communication theory stating that users comprehend visual narratives more effectively when presented in a linear yet flexible sequence (Rahmatika et al., 2023). This ensured that the virtual tour mirrored an authentic visitor pathway and supported intuitive exploration.

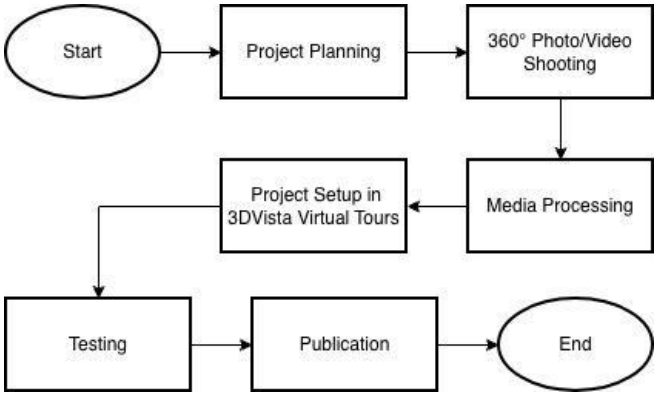

Figure 2. The Workflow of AEWO Mulyaharja Virtual Tour

To operationalize this sequence, a distribution map was prepared to determine the exact panoramic capture locations and their directional relationships. This map served as a spatial guide for 360-degree image acquisition and ensured coverage of AEWO's essential visual elements while maintaining consistent orientation for user navigation. Such mapping aligns with recommendations in immersive media studies that emphasize spatial legibility as a determinant of user comfort in virtual tours (Mardainis et al., 2020; Prathama et al., 2023).

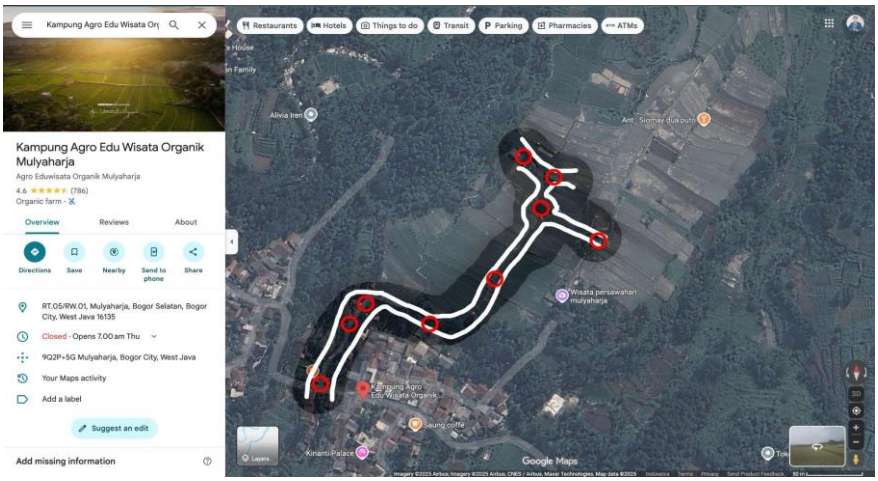

Figure 3. Distribution map of 360° Virtual Tour shooting locations at AEWO Mulyaharja

The next component of the design stage involved the construction of a detailed storyboard that translated the workflow into scene-by-scene specifications. The storyboard outlined each location's narrative description, hotspot connections, audio cues, information panels, and supporting multimedia components. According to Luther(1994), storyboard development is a critical step in multimedia production because it functions as a bridge between conceptual planning and technical assembly, enabling designers to anticipate user interactions and multimedia synchronization. In this study, the storyboard addressed the need for simple navigation, minimal text load, and content segmentation suitable for users unfamiliar with complex digital interfaces.

Table 2. Storyboard/Content Flow

No	Scene / Location	Description (Narrative)	Hotspots / Navigation	Interactive Elements
1	Entrance Gate	The starting point of the tour showing AEWO's main entrance, signage, and panoramic view of the village. The voice-over welcomes visitors to AEWO Mulyaharja and introduces its concept as an Agro Edu-Ecotourism destination.	Navigation arrows to: Ticketing Area, Fish Pond	Background music (Sundanese theme), voice-over intro, text info "About AEWO", photo gallery
2	Ticketing Area	Depicts the ticket booth and visitor registration point. The narration explains ticket types and AEWO facilities.	To: Entrance Gate, Organic Rice Field	Info pop-up "Visitor Information", short video on AEWO overview
3	Fish Pond (Kolam Ikan)	A calm area showcasing organic fish farming. The narration highlights eco-friendly aquaculture practices and local fish varieties.	To: Organic Rice Field, Goat Pen	Video "Fish Feeding", photo gallery, text info "Organic Aquaculture"
4	Goat Pen (Kandang Kambing)	The goat pen area where visitors can see livestock feeding and waste management practices integrated with organic farming.	To: Fish Pond, Trekking Path	Voice-over explanation, text "Livestock Integration System", short video clip
5	Organic Rice Field (Area Sawah Organik)	Expansive view of the rice fields with narration about AEWO's organic farming philosophy and crop rotation	To: Fish Pond, Trekking Path, Saung Jaga Bersama	Info hotspot "Organic Rice Process", photo gallery

No	Scene / Location	Description (Narrative)	Hotspots / Navigation	Interactive Elements
		system.		
6	Trekking Path (Jalur Trekking)	Pathway surrounded by natural scenery, connecting AEWO's main educational and eco-tourism spots.	To: Goat Pen, Saung Jaga Bersama, Gardu Café	Ambient nature sound, directional arrows, pop-up map
7	Saung Jaga Bersama	A traditional resting hut serving as a community gathering space. Narration explains local collaboration and education activities held here.	To: Trekking Path, Organic Rice Field, Gardu Café	Voice-over, text info "Community Activities", photo gallery
8	Gardu Café	A cozy café offering local products and AEWO organic food. Narration promotes community-based entrepreneurship.	To: Saung Jaga Bersama, Lambang Cinta Photo Spot	Video "Coffee Processing", product gallery, button "Local Menu"
9	Lambang Cinta Photo Spot	Iconic heart-shaped landmark symbolizing AEWO's spirit of love for nature and togetherness. Narration concludes the tour and invites visitors to experience AEWO in person.	To: Gardu Café, End	Share button, background music fade-out

To complement the tabular storyboard, a visual storyboard illustration was created showing the hierarchical structure of scenes and the branching navigation paths. Such visualization not only facilitated the design team's development process but also helped local tourism managers understand how content elements were connected, reflecting the project's orientation toward community empowerment and knowledge transfer (Latifah & Amelia, 2025).

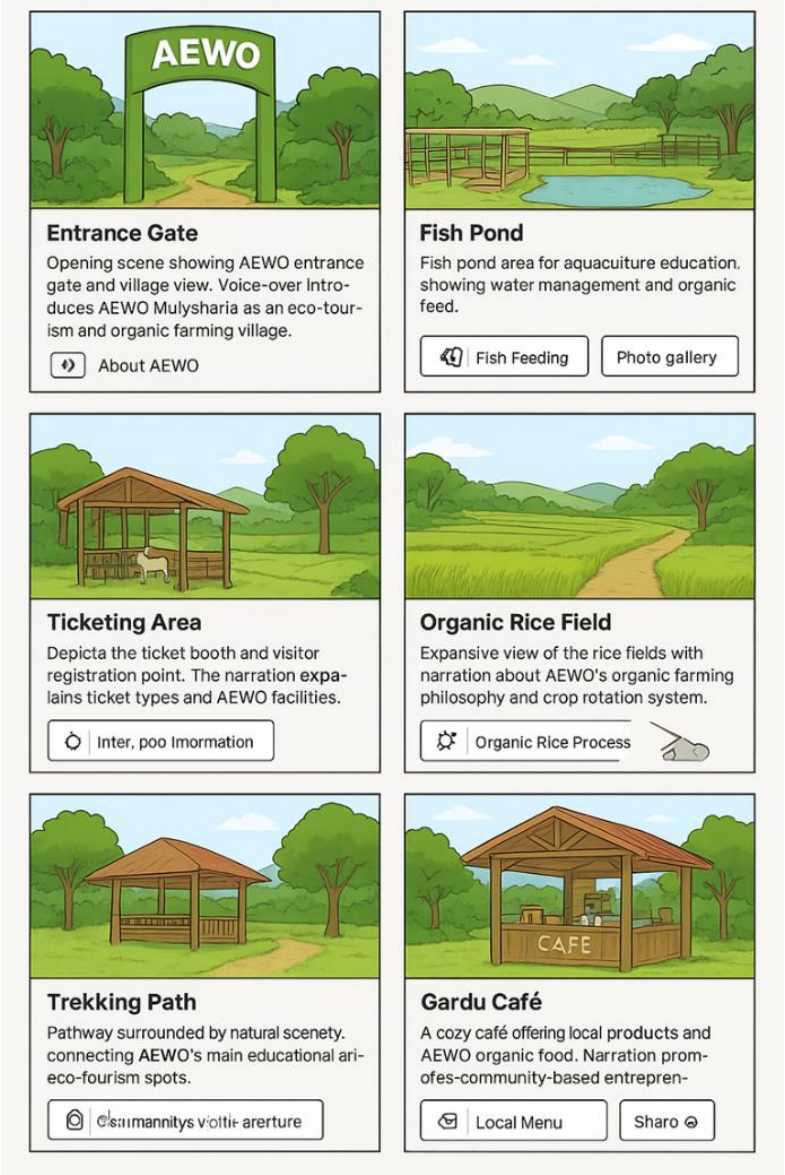

Figure 4. Storyboard illustration of the AEWO Mulyaharja Virtual Tour

Human–Computer Interaction (HCI) principles were embedded throughout the design process to ensure usability and meaningful engagement. Key considerations included: Cognitive Load Reduction, limiting the amount of text and presenting information through layered hotspots to prevent user overload (Flavián et al., 2019); Visual Hierarchy, using consistent hotspot icons, FPV orientation markers, and clear transitions to support spatial awareness; Accessibility Across Devices, designing interface elements that function seamlessly on laptops, smartphones, and VR headsets, prioritizing universal design for diverse user groups; Immersive Signaling, incorporating visual cues that guide users through scenes without overwhelming them, consistent with multimedia learning principles (Mardainis et al., 2020).

The design stage also included determining the placement of multimedia assets collected from the field, such as panoramic images, local soundscapes, short videos, and informational text, by aligning them with the storyboard and user experience goals. Careful consideration was given

to maintaining scene consistency, avoiding abrupt transitions, and ensuring that each hotspot delivered clear value to users. These decisions reflect the findings from prior virtual tourism research, which indicates that narrative coherence and intuitive interactivity are critical to sustaining user engagement (Prathama et al., 2023; Sari & Rasio Henim, 2022).

Overall, the deliverables of the design stage consisted of a complete workflow diagram, shooting map, textual storyboard, visual storyboard illustration, and multimedia layout plan. These outputs provided a comprehensive blueprint for the subsequent MDLC stages, particularly material collecting and assembly, while ensuring that the system design remained aligned with user needs, community characteristics, and technical considerations identified earlier in the study. This structured design approach reinforces the novelty of the research by demonstrating how MDLC combined with HCI principles can produce a user-centered virtual tour model for rural digital tourism contexts.

Material Collecting

The material collecting stage focused on gathering, organizing, and preparing the multimedia assets required for constructing the AEWO Mulyaharja 360° Virtual Tour. Consistent with the MDLC framework (Luther, 1994; Nasir & Suheri, 2016), this stage emphasized technical accuracy, content authenticity, and alignment with the storyboard and user needs identified during the concept and design phases.

Primary visual materials were obtained during field observations at AEWO Mulyaharja's main agro-edu-ecotourism locations. Using an Insta360 X2 camera, 360-degree panoramic photographs and short immersive video clips were captured at all predetermined shooting points outlined in the design workflow. These included organic farming areas, trekking routes, livestock pens, community gathering spaces, and café environments. To ensure consistency across scenes, each panoramic image underwent stitching, color balancing, cropping, and optimization. The final outputs were rendered in 4096×2048 resolution to balance high-quality visuals with efficient web loading performance, following recommended practices in immersive media production (Mardainis et al., 2020; Prathama et al., 2023).

Textual materials were developed from interview notes, field documentation, and official information provided by AEWO tourism managers. These texts were refined into concise descriptions and hotspot content for integration into the Virtual Tour interface. In accordance with multimedia learning principles, information was segmented into short, focused units to reduce cognitive load and enhance user comprehension during scene exploration (Flavián et al., 2019).

Supplementary assets, including ambient environmental audio, promotional videos, maps, icons, and introductory Augmented Reality (AR) markers, were also collected to enhance narrative richness and visitor engagement. While AR markers were prepared as complementary elements, they were intentionally positioned as optional features rather than primary components, aligning with the methodological clarification provided in this study.

All multimedia assets were systematically catalogued and renamed based on the scene hierarchy and navigation flow produced during the design stage. This organizational structure ensured efficient integration during assembly and minimized errors in linking multimedia components within the virtual environment. Such structured asset management is considered essential in multimedia development workflows (Latifah & Amelia, 2025).

By the end of the material collecting stage, a complete and well-organized multimedia asset library had been prepared, forming a robust foundation for the assembly stage and ensuring coherence between the conceptual, visual, and interactive elements of the AEWO Mulyaharja Virtual Tour.

Assembly

The assembly stage integrated all multimedia components, panoramic images, textual descriptions, audio elements, and supplementary videos, into a functional 360° Virtual Tour system using 3DVista Virtual Tour Pro. This stage operationalized the outputs of the design and material collecting phases, translating the storyboard and navigation workflow into an interactive digital environment. Consistent with MDLC principles (Luther, 1994; Nasir & Suheri, 2016), assembly emphasized accuracy, consistency, and user-centered presentation.

Panoramic scenes captured during fieldwork were imported into 3DVista and arranged according to the navigation structure established in the design stage. Each scene represented a key AEWO Mulyaharja location, organic agriculture areas, ecotourism landscapes, community activity spaces, and café environments. Interactive hotspots were strategically positioned to simulate real visitor movement through the site, allowing users to transition smoothly between viewpoints. These hotspots also included informational text, buttons linking to supplementary media, and FPV orientation markers for spatial clarity.

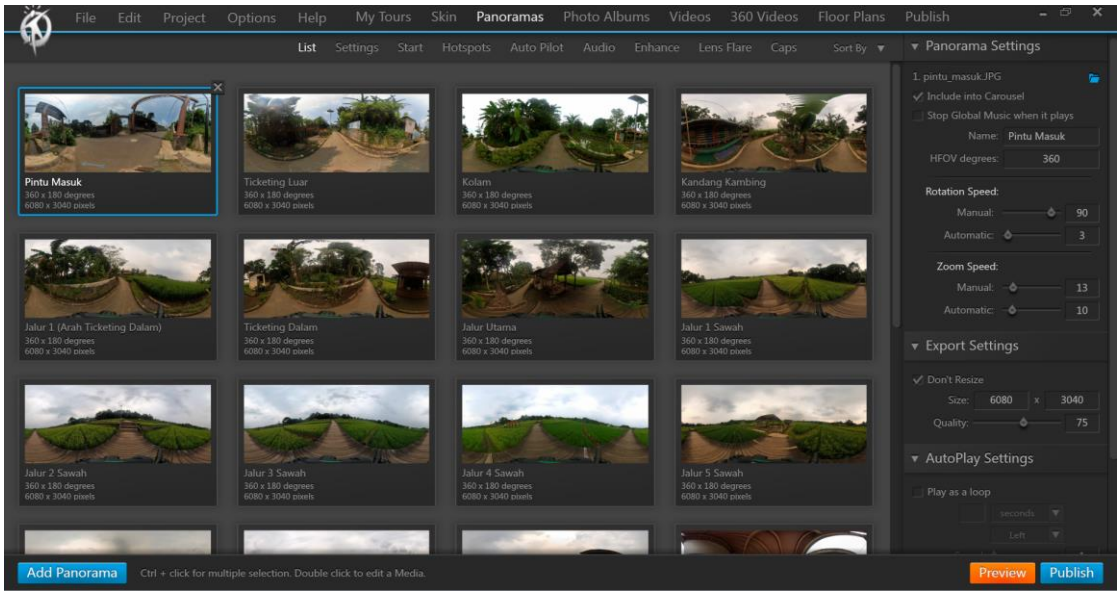

Figure 6. Assembly of AEWO Mulyaharja Virtual Tour scenes in 3DVista software

The interface layout was then configured, incorporating icons, menus, and informational layers in alignment with HCI principles such as visual hierarchy, consistency, and ease of interaction. This ensured that users could access content intuitively across devices with varying screen sizes and input methods.

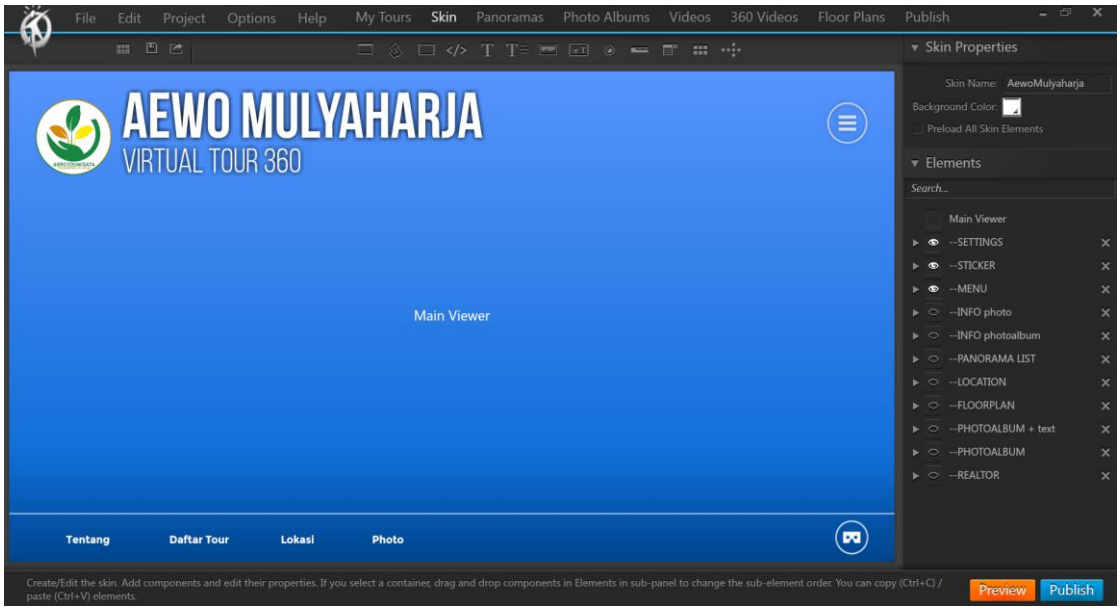

Figure 7. Main interface layout of AEWO Mulyaharja Virtual Tour 360 in 3DVista

Figure 8. Hotspots and FPV Icons of AEWO Mulyaharja Virtual Tour 360

Audio elements,including short voice-over explanations and ambient environmental sound, were synchronized with relevant scenes to enhance immersion. Multimedia overlays such as galleries and short videos were embedded into hotspots to support narrative depth, consistent with recommendations in immersive tourism experience design (Prathama et al., 2023; Sari & Rasio Henim, 2022).

A preview build of the virtual tour was generated and reviewed internally to ensure functional stability, consistent transitions, and optimal rendering quality. Following this internal evaluation, the prototype was shared with the AEWO Mulyaharja tourism management team for feedback related to content accuracy, clarity, and ease of use. Feedback-informed revisions were applied to refine hotspot placements, adjust text readability, and correct minor synchronization issues.

Upon finalization, the HTML5 version of the Virtual Tour was published at virtualtour.wisatamulyaharja.com and embedded into the official AEWO Mulyaharja website. The assembled system provided a fully operational virtual tour ready for formal user testing and usability evaluation in the subsequent MDLC stage.

Testing

The testing stage aimed to evaluate the functional performance and usability of the AEWO Mulyaharja 360° Virtual Tour across multiple devices and user groups. A total of 30

purposively selected respondents, including AEWO tourism managers, local residents, subdistrict staff, visiting tourists, and other stakeholders, participated in direct hands-on trials. Participants accessed the Virtual Tour via laptops, smartphones (Google Chrome and Safari), and VR headsets to assess navigation flow, content clarity, visual quality, and overall ease of use.

Usability evaluation employed a five-item adapted questionnaire derived from the conceptual principles of the System Usability Scale (SUS) (Brooke, 1996). As described in the methodology section, the instrument was simplified to accommodate respondents with varying levels of technological literacy. The five items measured are (1) attractiveness; (2) perceived ease of use; (3) completeness of information; (4) intention to visit, and (5) cross-device accessibility.

Responses were recorded on a five-point Likert scale and analyzed descriptively using percentage categories rather than the standard SUS scoring formula, in accordance with the methodological justification presented earlier. Before interpreting the usability results, Table 3 presents the distribution of raw responses across each scale category.

Table 3. Respondent Answers for AEWO Mulyaharja Virtual Tour Testing

No	Statement	Strongly Disagree	Disagree	Fair	Agree	Strongly Agree
1	The virtual tour application attracts your attention to use it.	0	1	6	17	6
2	You prefer using a 360° virtual tour compared to 2D images or photos.	0	0	8	12	10
3	The 360° virtual tour gives you a more complete impression of the tourist location than images or videos.	0	0	5	16	9
4	You feel interested in visiting the location after viewing this virtual tour.	0	1	7	13	9
5	The virtual tour application is easy to use on laptops, smartphones, and VR headsets.	0	0	4	18	8

To provide clearer insight into the relative strength of each usability dimension, each item's total score was converted into a percentage and categorized into five interpretive ranges ("Very Poor" to "Very Good"), as shown in Table 4.

Table 4. Questionnaire Score Calculation Results

No	Total Score	Maximum Score	Percentage	Category
1	(0×1) +(1×2) +(6×3) +(17×4) +(6×5) =119	30×5=150	79.3%	Good
2	(0×1) +(0×2) +(8×3) +(12×4) +(10×5) =124	150	82.6%	Very Good
3	(0×1) +(0×2) +(5×3) +(16×4) +(9×5) =124	150	82.6%	Very Good
4	(0×1) +(1×2) +(7×3) +(13×4) +(9×5) =122	150	81.3%	Very Good
5	(0×1) +(0×2) +(4×3) +(18×4) +(8×5) =124	150	82.6%	Very Good

$$\frac{79.3 + 82.6 + 82.6 + 81.3 + 82.6}{5} = 81.68\%$$

The results indicate that all usability dimensions fall within the "Good" to "Very Good" categories, with an overall mean score of 81.68%, classifying the Virtual Tour as "Very Good." Respondents consistently reported that the system was engaging, intuitive, and easy to navigate across devices. Many users expressed that the 360° panoramic scenes provided a more complete understanding of AEWO Mulyaharja compared with static photographs or standard video tours. Additionally, most participants stated that the Virtual Tour increased their interest in visiting the location in person.

Qualitative feedback gathered during the trials supported these findings. Users highlighted smooth hotspot transitions, clear spatial orientation, and informative scene descriptions, while also suggesting minor improvements to text readability and scene-to-scene pacing. Observations further showed that local residents—after brief instruction—were able to navigate the Virtual Tour independently, demonstrating the accessibility and long-term usability of the system for community-based digital tourism promotion. Overall, the testing stage verified that the AEWO Mulyaharja Virtual Tour performs reliably, provides a positive user experience, and effectively supports the village's digital tourism objectives.

Distribution

The distribution stage represents the final phase of the MDLC process, focusing on deploying the completed AEWO Mulyaharja Virtual Tour and ensuring that it becomes accessible, functional, and beneficial for the intended user community. After the system passed functionality and usability testing, the Virtual Tour was published on the official AEWO Mulyaharja website (wisatamulyaharja.com) to provide public access through both desktop and mobile browsers. This deployment aimed to enhance the visibility of AEWO's digital tourism initiatives and support wider engagement from visitors, stakeholders, and the general public.

To ensure effective dissemination, the Virtual Tour was introduced to AEWO tourism managers, local community groups, and institutional partners through workshops and short training sessions. These sessions were designed to build local capacity in operating, maintaining, and promoting the platform. Emphasis was placed on familiarizing users with the system's navigation structure, scene-based storytelling features, and cross-device accessibility, ensuring that the community could independently manage the platform after project completion.

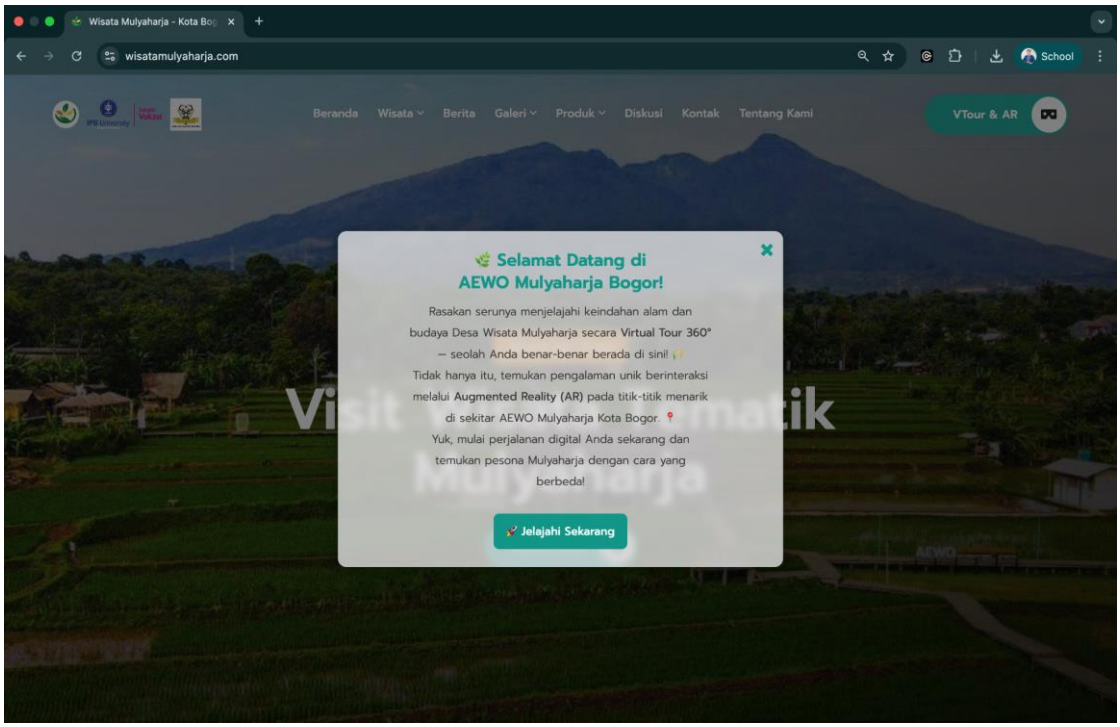

Figure 9. Welcome screen of the AEWO Mulyaharja Virtual Tour website

In addition to direct training, supporting documentation, including usage guides, maintenance instructions, and technical notes, was provided to the village tourism management team. These resources were intended to promote long-term sustainability and encourage future adaptation or expansion of the system. Public outreach activities, such as announcements on village social media channels and coverage by local media partners, further contributed to the visibility of the Virtual Tour and encouraged its adoption as a tool for digital tourism promotion.

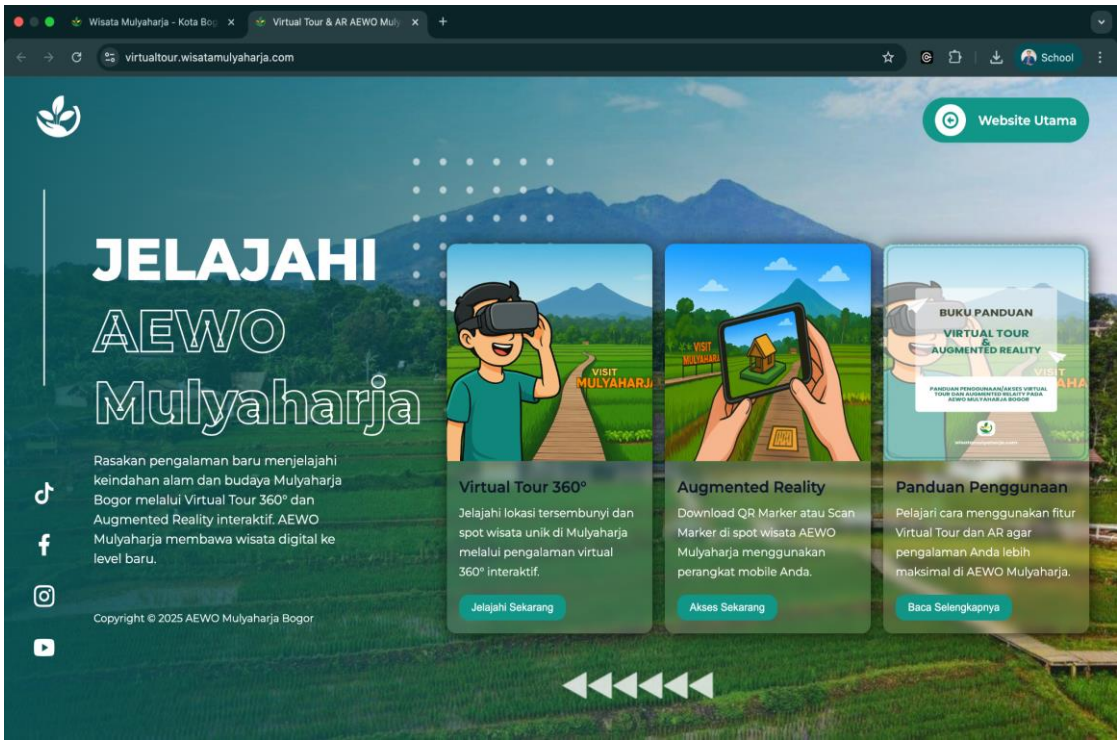

Figure 10. Landing page of the AEWO Mulyaharja Virtual Tour 360 website

Figures 9 to 13 illustrate the accessible interface and deployment outputs, including the welcome page, landing page, splash screen, 360-degree entry view, and VR display mode. These visual elements demonstrate that the final Virtual Tour system offers both ease of access and a dynamic user experience suitable for diverse audiences.

Figure 11. Splash screen of the AEWO Mulyaharja Virtual Tour application

Immersing users in a panoramic perspective, the AEWO Mulyaharja Virtual Tour delivers an interactive 360-degree view of the village entrance, welcoming visitors as they begin their exploration of the site. The visual interface combines clear branding and intuitive navigation, allowing users to smoothly transition into different locations within the virtual environment. With its distinctive "tiny planet" effect, this entry scene immediately draws attention and sets the tone for a dynamic and engaging digital tourism experience.

Figure 12. Main interactive display of the AEWO Mulyaharja Virtual Tour 360 at the entrance gate

Experiencing the AEWO Mulyaharja Virtual Tour through a VR headset immerses users directly in the panoramic landscape, offering a lifelike exploration of key tourism sites such as the iconic rice fields and thematic village signage. The split-screen view is optimized for VR, allowing seamless navigation and interaction as users move through the virtual environment, enhancing presence and engagement beyond standard web-based access.

Figure 13. AEWO Mulyaharja Virtual Tour display as viewed with a VR headset

Overall, the distribution stage successfully established the AEWO Mulyaharja Virtual Tour as an operational, publicly accessible digital platform, while equipping local stakeholders with the skills and resources necessary to support its continued use and future development.

Discussion

The results of this study indicate that the AEWO Mulyaharja 360° Virtual Tour achieved a high level of usability, as reflected in an average score of 81.68%, classified as "Very Good." When interpreted using principles of Human Computer Interaction (HCI), these results affirm that the virtual tour fulfills the core usability components outlined in ISO 9241-11: effectiveness, efficiency, and user satisfaction(International Organization for Standardization, 2018). Effectiveness was demonstrated through users' ability to navigate the tour independently and access information without assistance, while efficiency was reflected in smooth interactions across laptops, smartphones, and VR devices. High satisfaction levels were shown through strong interest in using the virtual tour and increased intention to visit AEWO Mulyaharja in person.

When interpreted using principles of Human Computer Interaction (HCI), these results affirm that the virtual tour fulfills the core usability components outlined in ISO 9241-11: effectiveness, efficiency, and user satisfaction. Effectiveness was demonstrated through users' ability to navigate. The interface adhered to Nielsen's usability heuristics such as visibility of system status, consistency and standards, and user control and freedom (Nielsen, 1994).

The positive usability outcomes can be linked directly to several design decisions made during the earlier MDLC stages. First, the interface adhered to Nielsen's usability heuristics, particularly "visibility of system status," "consistency and standards," and "user control and

freedom." Clear navigation arrows, predictable hotspot placement, and consistent iconography helped users orient themselves within the virtual environment, reducing cognitive load and enabling intuitive exploration. These findings align with prior studies that emphasize the importance of interface clarity and spatial coherence in 360-degree or VR-based tourism media (Flavián et al., 2019; Gelter et al., 2021).

Second, the immersive 360° panoramic visuals contributed significantly to users' perceived presence and engagement. This is consistent with literature on immersive tourism technologies, which suggests that 360-degree environments can enhance destination image formation and emotional attachment through embodied exploration (Jung et al., 2017; Wang et al., 2024). Respondents' strong agreement with statements related to information completeness and interest in visiting supports this theoretical relationship, indicating that the virtual tour successfully conveyed AEWO's unique agro-edu-ecotourism identity.

The integration of multimedia elements, such as ambient audio, concise textual descriptions, and optional promotional videos, also contributed to a positive user experience. According to multimedia learning principles, segmenting information into manageable units and combining visuals with short explanatory text can improve comprehension while minimizing extraneous cognitive load. The descriptive content embedded within hotspots followed this guideline, which likely influenced the high usability ratings related to ease of use and information clarity.

Although Augmented Reality (AR) markers were included in the system, their role in the user experience was intentionally limited to introductory features. This approach aligns with HCI recommendations to avoid overloading users with advanced interaction modes during initial exposure, especially when targeting a community with varied levels of technological literacy. The decision also reflects findings from previous research on rural digital tourism, which suggests that gradual integration of advanced interactive elements can support better community adoption and long-term sustainability (Kurniadi et al., 2023).

Compared with earlier virtual tour studies in Indonesian tourism contexts, which often emphasize product demonstration rather than user experience evaluation (Nasir & Suheri, 2016; Sari & Rasio Henim, 2022), this research contributes a more structured, theory-driven analysis of usability. The adapted SUS evaluation, supported by methodological justification, offers insight into user perceptions across five key dimensions relevant to immersive web-based media. While the instrument does not replicate the original ten-item SUS structure, its contextual adaptation enabled practical assessment among respondents with diverse technological backgrounds and aligns with simplified usability testing approaches used in community-centered digital projects.

Nevertheless, several limitations emerged from the analysis. The virtual tour's reliance on high-resolution panoramas may pose loading delays on low-bandwidth connections, reflecting broader infrastructural challenges faced by rural communities. Additionally, while VR headset compatibility was tested, the sample size for VR users remained limited, suggesting the need for more extensive evaluation of immersive interaction patterns. Finally, although introductory AR elements were included, the absence of dedicated AR usability testing represents an opportunity for more comprehensive multimodal evaluation in future development cycles.

Overall, the discussion demonstrates that the AEWO Mulyaharja Virtual Tour fulfills key HCI and UX principles, aligns with findings from international research on 360° tourism media, and offers methodological contributions to community-based digital tourism development. The results highlight the importance of combining immersive design, clear navigation structures, multimedia learning principles, and usability-centered evaluation to support effective and sustainable digital tourism platforms in rural destinations.

Conclusions

This study successfully developed the AEWO Mulyaharja 360° Virtual Tour using the Multimedia Development Life Cycle (MDLC) and demonstrated that the platform performs effectively as an immersive digital tourism medium. The usability evaluation, conducted with an adapted and contextually justified instrument, resulted in an average score of 81.68%, indicating that the system is considered "Very Good" in terms of attractiveness, ease of use, information clarity, intention to visit, and cross-device accessibility. These findings affirm that the virtual tour is technically reliable, accessible to diverse users, and capable of enhancing the visibility and appeal of AEWO Mulyaharja as a rural tourism destination.

Beyond its practical outcomes, this research contributes to the scientific development of community-based digital tourism and interactive multimedia evaluation. The integration of immersive 360-degree visualization, structured scene-based storytelling, and usability testing grounded in Human Computer Interaction (HCI) principles extend current practices in virtual tour development, which often lack systematic methodological justification. The study also provides an applicable model for combining MDLC with usability-focused design strategies in rural settings where digital literacy varies widely.

Practically, the project strengthens local capacity for managing digital tourism tools and supports broader efforts toward sustainable tourism village digitalization. The platform enables stakeholders to promote AEWO Mulyaharja more effectively and encourages potential visitors to develop interest before their onsite experience. Future work may expand the scope of evaluation by incorporating full-scale assessments of Augmented Reality features, conducting device-specific usability testing, especially for VR headsets and exploring long-term community adoption patterns to ensure the continued growth and sustainability of rural digital tourism initiatives.

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