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Multi-Disaster Risk Mitigation through Augmented Reality Conservation Map for Enhancing Cultural Heritage Attitude

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Abstract

Virtual conservation emphasizes access to information, user involvement, object preservation, and restoring the original ambiance of conserved or rebuilt things using technology during COVID-19. This study utilizes AR to create the City of Sawahlunto AR Conservation Map and then designs and tests the app's content and functionality using Media Richness Theory. The study involves R&D employing the Multimedia Development Life Circle model and an exploratory sequential mixed-methods. The City of Sawahlunto AR Conservation Map AR has augmentation, interaction, and registration. This study contributes to Media Richness Theory and Virtual Tourism and has practical implications for destination sustainability, carrying capacity, and over-tourism.

Keywords: Augmented Reality; Virtual Conservation; Media Richness Theory; Disaster Mitigation

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1.0 Introduction

The sole Dutch East Indies colonial town supporting coal mining was Sawahlunto in West Sumatra Province, backed by architecture, technology, and universal socio-cultural norms. Sawahlunto became a UNESCO World Heritage Site in 2019 as the Ombilin Coal Mining Heritage of Sawahlunto (OCMHS). The Netherlands East Indies government built this industrial complex in rural Sumatra to mine, process, and transport premium-grade coal during the vital period of global industrialization in the late 1800s and early 1900s. Contract workers from Java and China and prison laborers from Dutch-administered provinces supplemented the Minangkabau workforce. The rail network links the mining facility, company town, and coal storage facilities at Emmahaven to the seaside facilities. The OCMHS was designed to mine, process, transport, and export coal from deep underground sources. It also shows how indigenous knowledge and traditions merged with European technology.

An innovative technological complex conceived and built by European engineers in their colonies, the OCMHS is exceptional. This facility was designed to effectively extract important coal resources. The technological advances combine European engineering competence with indigenous environmental awareness and traditional labor methods. This example also shows how European

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colonial powers' social relations of production changed in their colonies and had lasting effects. These improvements enabled global industrialization in the second half of the 19th and early 20th century by providing resources and labor.

To exploit West Sumatra's inaccessible highlands' enormous Ombilin coal seams, the OCMHS was built. Twelve technological components are deliberately placed in three linked zones at this UNESCO monument. Area A features coal processing facilities, including the Ombilin Coal Mining Company's Main Office in Sawahlunto. A purpose-built mining village at Sawahlunto supports these mining facilities. In Table 1, the trialism of Sawahlunto's role and complexity as an operating city, world heritage site, and tourist attraction creates medium-high multi-disaster risks.

Table 1. Multi-Disaster Events in the City of Sawahlunto in 2018-2020

Year	Multi-Disaster Incident									
	Number of Natural Disasters*				Number of Non-Natural Disasters*			Social Disaster Projection**		
	Flood	Earthquake	Landslide	Tornado	Building Fire	Forest & Land Fires	Other Non-Natural	Population Activity Problems	Tourist Behavior Issues	Management Issues
2018	4	3	123	47	10	14	6	**High**	**Mid-High**	Middle
2019	12	1	136	63	7	16	1			
2020	3	-	55	63	4	7	303			
Disaster Risk	**High**				**Mid-High**			**Mid-High**		

(Sources: BPS Kota Sawahlunto, 2019, 2020, 2021*; Kemendikbud RI, 2017**)

Natural disasters and degradation, non-natural disasters like fires and building age, and social disasters like building function changes, vandalism, and poor visitor flow management, notably during the COVID-19 pandemic. UNESCO has devised indicators for evaluating world heritage cultural sites in the "State of Conservancy" status list with risky circumstances (UNESCO, 2023), including Ascertained Danger, where the property faces particular and confirmed threats over time. An imminent and prospective threat to the property's intrinsic features. Attitude is a set of long-term beliefs that explain favorable or negative assessments of specific tendencies, according to Cottam et al. (2012). This research measures users' attitudes toward cultural heritage preservation after utilizing virtual conservation AR material using the Attitude Cultural Heritage Scale from Akbaba (2014) and Koo et al. (2019). The assessment measures attitudes on cultural heritage's relevance to the community, concern, and sustainable transfer. Table 2 shows content R&D using an old city virtual tourism strategy using AR/VR technology by many academics.

Table 2. Mapping of Previous Research and Research Update

No.	Site Name	Location	Causes	R&D		Destination	Sources
1	The Ancient City of Surat	India	Social Disaster (Demolition due to Population Density)	*Technology*	*Digital Repository*	Information Management	Udeaja et al. (2020)
				Platform	*Mobile application*		
				Content	*Digital Map*		
				Access	*Online*		
2	Vesuvian Ancient City	Istanbul City, Turkiye	Non-Natural Disaster (Age Factor)	*Technology*	*VR Desktop*	Edutainment	Saborido et al. (2018)
				Platform	*Website*		
				Content	*Virtual tour panoramic 360°*		
				Access	*Online*		
3	The Ancient City of Palmyra	Syria	Social Disaster (Terrorist Attack)	*Technology*	*VR Desktop*	Edutainment	Denker (2017)
				Platform	*Virtual Map*		
				Content	*Virtual tour 3D models*		
				Access	*Online*		
				Access	*Online*		
4	Castellon Smart City	Spain	City Planning	*Technology*	*AR*	Information Management	Yagol et al. (2018)
				Platform	*Mobile application*		
				Content	*Virtual tour 3D Model*		
				Access	*Online*		
5	UNESCO World Heritage City of Malacca	Malaysia	Non-Natural Disaster (Age Factor)	*Technology*	*AR & VR*	Information Management	Aziz & Siang (2014)
				Platform	*Website*		
				Content	*Virtual tour panoramic 360°*		
				Access	*Online*		
				User Test	Experimental Survey of User Acceptance of Technology		
6	UNESCO World Heritage City of Sawahlunto	West Sumatera Province, Indonesia	Multi-Disaster	*Technology*	*AR*	Virtual Conservation	The originality of this research
				Platform	*Mobile Application*		
				Content	*3D AR Virtual Conservation*		
				Access	*On-site & Online*		
				User Test	Comparison of the effectiveness of AR with other media in influencing the attitude of concern for community conservation		

This research aims to address the risks associated with multiple disasters in OCMHS and AR-based virtual conservation research and development. This is done to reduce the impact of multiple disasters at OCMHS. The research also compares community cultural heritage views before and after utilizing the OCMHS AR map. The study's goal is to provide up-to-date research on multi-disaster risk mitigation using an AR-based virtual conservation approach that can be accessed remotely or on-site and includes a test of AR's effectiveness in influencing the user's conservation concern, which has not been found in previous studies.

2.0 Literature Review

2.1 Virtual Conservation

Virtual conservation is a conservation concept model that prioritizes easy access to data and information, user interactivity, and object preservation, as well as reviving the original atmosphere of objects that are preserved or reconstructed by utilizing reality technology, for example, 3D Augmented Reality (AR) (Napolitano et al., 2017; McMillan et al., 2017; Morrison et al., 2022). AR technology may improve people's perception of cultural heritage by offering virtual reconstructions and safeguarding endangered historical structures from many calamities. AR technology may replicate historical buildings' architectural and structural features without damaging their integrity or when resources are limited (Süvari et al., 2023). Digitizing UNESCO World Heritage Sites using AR-VR technology may

increase their exposure and help preserve cultural heritage (Ortiz-Zamora et al., 2023). Augmented reality (AR) technology enhances visitors' understanding of a site's history, architecture, and culture (Suyuti & Setyanto, 2023). Sohn et al. (2023) and Shadiq (2022) suggest using historical maps to make cultural heritage more disaster-resistant, preserving and highlighting its value. AR stores reliable data, information, and photos to monitor deterioration and repair designs (Guttentag, 2010) and enhance COVID-19 prevention (Asadzadeh et al., 2021). Virtual reality increases user knowledge of catastrophe dangers and encourages conservation behavior, according to Nelson et al. (2029 and 2020). Thus, AR-based virtual conservation may stabilize and maintain the world heritage site by mitigating multi-disaster risk. Virtual conservation may also reduce multi-disaster risk by creating a conservation map that improves OCMHS cultural heritage attitudes.

2.2 Augmented Reality

AR has been called a "middle ground" between totally synthetic (VE) and fully real (telepresence) (Milgram & Kishino, 1994). AR adds 2D and 3D virtual items to the actual environment in real-time, according to Azuma (1997), Werner (2019), and Morrison et al. (2022). Jacko (2003) defines AR as merging two- and three-dimensional virtual items into a three-dimensional actual world and projecting them in real-time. According to Basha et al. (2021), augmented reality blends the actual world with the computer-generated virtual world to blur the line between them. AR technology is employed in many industries, including cultural heritage protection. AR may improve tourists' comprehension of cultural heritage places' history, architecture, and culture (Sohn et al., 2023). As shown above, Augmented Reality is a computer system that integrates virtual worlds in real-time. Azuma (1997) lists three Augmented Reality indicators:

1) Augmented Reality enriches the physical world with virtual information. AR's biggest advantage over the Internet and TV is this. Text, location data, photos, video, and music may be projected into the actual environment to augment it.
2) Interactivation refers to real-time customer engagement with virtual and real-world media. Augmented Reality users may move virtual material into real space.
3) Registration involves registering virtual items for real-world use. This might make people believe that the virtual environment is genuine.

AR can also improve tourist engagement and preserve cultural resources (Suyuti & Setyanto, 2023). AR may also be utilized for disaster mitigation and education, especially multi-disaster risk mitigation (Fortuna et al., 2023). AR-based learning media like conservation maps may teach kids about disaster preparation and mitigation (Jiang et al., 2023). Historical maps also strengthen cultural heritage against calamities (Sohn et al., 2023). Cultural heritage resilience in disasters depends on this integration process. AR technology might help safeguard and conserve cultural heritage in this research.

2.3 Virtual Reality

Nelson et al. (2020) discovered that VR regarding marine biodiversity increases environmental awareness and encourages real-life donations to marine conservation. Nelson et al. (2019) also found that underwater VR movies increased student coral reef conservation behavior. Aziz et al. (2014) and Ahn et al. (2016) discovered that VR was more successful than traditional films in encouraging conservation. VR can help preserve cultural treasures and reduce multi-disaster risks. VR can generate virtual repair models of damaged ancient structures like the Virgin Mary Church (Sohn et al., 2023). VR can communicate the architectural and tectonic qualities of a historical structure without damaging it (Le, 2021 & Süvari, 2023). VR may also educate and teach society during disasters (Sadiq, 2022). VR helps preserve human identity and history (Jadhav et al., 2022). These technologies can also lower the cost of cultural exploration and study, especially for remote locations with high transportation costs. VR and AR conservation maps may also improve attitudes toward cultural heritage and aid multi-disaster risk mitigation.

3.0 Methodology

3.1 Research Design

This type of research is R&D with an exploratory sequential mixed methods approach consisting of observation techniques, literature studies, audio-visual materials, and experimental surveys using the Multimedia Development Life Circle (MDLC) model. Gall et al. (2003) stated, "Research and development have two main objectives: to develop a product and to test the product's effectiveness." Furthermore, the MDLC method is a method for developing multimedia applications. The MDLC method has six stages: concept, design, collecting material, assembly, testing, and distribution (Luther, 1994).

3.2 Data Collection

This study uses several data collection techniques, both qualitative and quantitative, including non-participatory observation techniques, which require researchers to directly visit the location of the object of observation so that they can make observations now without being involved in activities that take place at the observation location—followed by a literature study where this research is a collection of information from various sources of academic and non-academic literature about the City of Sawahlunto to compile legends and storylines of the City of Sawahlunto conservation maps using literature study mapping. Furthermore, the audio-visual material of this research is pictured by researchers to strengthen the results of this study obtained from audio-visual related to leading tourist destinations in the City of Sawahlunto and the preparation of AR marker content on conservation maps prepared in the

previous stage. In the final step, this study uses a direct experimental survey using a questionnaire to the City of Sawahlunto tourists who are willing to use the AR-based City of Sawahlunto Conservation Map with a one-shot case study treatment method.

3.3 Experimental Procedure

For the experimental group, the experiment begins when tourists use the City of Sawahlunto AR Conservation Maps. Tourists can access the virtual version of the destination through a link that has been developed in maps. On the link, travelers are equipped with Android smartphones to explore the City of Sawahlunto Destination's virtual goals interactively. Then, tourists are instructed to fill out questionnaires to confirm the possibility of a virtual experience that is felt while visiting the City of Sawahlunto AR Conservation Maps. The total sample involved in this research experiment consisted of 20 tourists who were visiting The City of Sawahlunto, aged ≥17 years, and had never seen the City of Sawahlunto before. Sampling was done purposively in the City of Sawahlunto.

3.4 Experimental Validation

An experiment is declared valid if the results obtained are only caused by manipulated independent variables or internal validity and if the results can be generalized to situations outside the experimental setting called external validity (Sekaran, 2010; Emzir, 2013). This study used internal and external validity through treatment control based on Campbell & Stanley (1966).

3.5 Measurement

According to Azuma (1997), three characteristics of AR can be used as indicators, namely: 1) Augmentation relates to the fact that AR enhances the physical environment with virtual information; 2) Interactivity is a characteristic related to consumer interaction with virtual media and the real world in real-time; 3) Registration is a characteristic related to the registration of virtual objects that can appear in the real world.

3.6 Data Analyzes

To analyze the results of observations, literature studies, and audio-visual material in the form of text, video, audio, and photos, this research uses content analysis, which emphasizes how researchers see the constancy of the content of communication qualitatively, how researchers interpret the content of communication, read symbols, make meaning—the content of symbolic interactions that occur in communication. Furthermore, for the results of the experimental survey, researchers use descriptive statistical analysis. These statistics include collecting, compiling, organizing, processing, presenting (usually in tables or graphs), and analyzing numerical data to provide an overview. That is organized, concise, and clear about a symptom, event, or situation so that specific meanings or meanings can be drawn without intending to generalize.

4.0 Results and Discussion

4.1 Concept Stages

The concept stage is the stage to determine the purpose of multimedia development and user identification and description of the multimedia concept to be built. The purpose and identification of multimedia users affect the nuances and adjustments of the complexity of the concept and multimedia needs. The drafting stage is the stage for determining the objectives of multimedia development, identifying users, and describing the multimedia concept to be made. The purpose and identification of multimedia users influence the nuances and adjustments to the complexity of the concepts and multimedia needs.

The concept stage in this study was carried out using the online observation method, namely by observing and studying the potential and impact of disasters that occurred in the City of Sawahlunto as an object of observation by relying on information from the Google search engine. This observation is also known as the study of online interaction only with no participation, where the researcher does not show his role as an observer and is not involved in activities; the researcher conducts remote observations. The points in this observation are contained in the observation logbook.

This research focuses on developing virtual conservation media and destinations for one heritage object in the City of Sawahlunto, The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto. At this stage, the researcher identified the current condition of the cultural heritage site in the City of Sawahlunto due to the harmful excesses of tourism and multi-disaster events using observation guidelines by adopting the "State of Conservancy" assessment indicator (UNESCO, 2023), namely 1) Ascertained Danger) where the property is exposed to a specific and proven hazard shortly 2) Potential Danger (Potential Danger), where the property is faced with a threat that may indirectly harm its inherent characteristics.

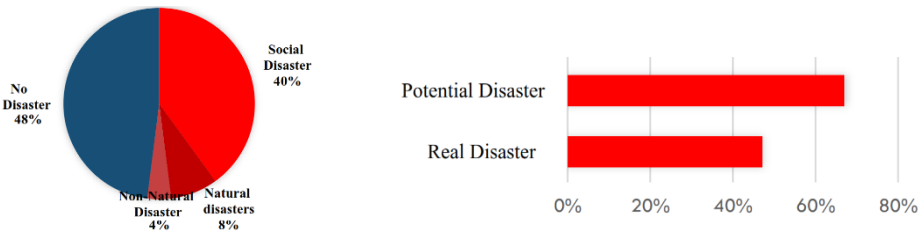

Fig. 1 Percentage of Potential Multi-Disasters in the City of Sawahlunto

Based on the results of the researchers' observations, it can be determined that the City of Sawahlunto has received threats from real and potential hazards whose urgency is quite high and, in the future, can threaten the sustainability of the site and the tourist destination itself. In Figure 1, from a total of 19 observation items for real hazards, 9 question items indicated that evidence of real hazards could threaten sites and destinations in the City of Sawahlunto with a percentage of 47%. In addition, from a total of 6 question items for potential hazards, it was found that the site and destination of the City of Sawahlunto experienced potential hazards in 4 question items with a percentage of 67%. In addition, the City of Sawahlunto experienced social disasters in a major way, as much as 40%, followed by natural disasters at 8% and non-natural disasters at 4%. Even though as much as 48% is considered not to have occurred a disaster, this value is considered worrying according to UNESCO's State of Conservancy standards and could become an "endangered site" status and could have the status of a UNESCO World Heritage Site revoked if it is not handled properly.

4.2 Design Stages

In this stage, the system design uses the storyboard design method because the media has a storyline. The storyboard and flow chart is a basic description of the built multimedia product and a design guide for the content. The flow chart of this research is depicted in Figure 2 as follows.

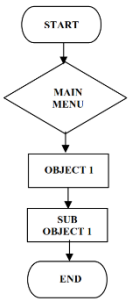

Fig. 2. Flow Chart The City of Sawahlunto AR Conservation Maps

4.3 Material Collecting Stages

This stage is carried out using the audio-visual method. The audio-visual material for this research is a picture the researcher took to strengthen the results obtained from the Blender 3D and Assemblr software on The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto is a cultural heritage building that is part of the OCMHS and old photos from the Leiden University Library digital collections, which is a research institute with a collection of millions of photographs, maps and historical evidence of Indonesia during the Dutch colonial period.

4.4 Assembly Stage

The assembly stage is the stage of making all multimedia objects or materials. Application development is based on the design stage, such as storyboards and flowcharts. Content creation requires hardware such as a PC with Windows OS and an Android Smartphone and software in Adobe, Blender, Assemblr Studio, and Assemblr Viewer. Assemblr is a content creation platform that allows users to create 3D visualizes of one sample object of Augmented Reality for the AR Markers and Web-AR Links named The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto. We can see the development of this building chronologically through photos, as shown in Figures 3 and 4, and the results of content development at this stage can be shown in Figures 5 to 7.

Fig. 3 The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto in [ca] 1920
(Source: Leiden University Libraries Digital Collections)

Figure 3 is the Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto or Hoofdkantoor van de steenkolenmijn Ombilin te Sawahloento built in 1916. In this building, all policies regarding coal mining are decided and now function as the office of the State Ombilin Coal Mining Company PT. Bukit Asam (Persero) Tbk. Unit Pertambangan Ombilin (PT. BA-UPO). Its address is at Jalan Diponegoro Village/Kelurahan/Nagari Sarringan, Barangin District, the City of Sawahlunto, West Sumatra Province. During the Japanese occupation in 1942, this building was also occupied by the company Hokkaido and Steamship Co. Ltd., a Mitsui Company subsidiary as the Ombilin coal mine operator in the City of Sawahlunto, with permission from the Japanese government (Saputra, 2012; Asoka et al., 2016).

During the period of independence and the founding of the Republic of Indonesia, the Ombilin coal mine was taken over by the Government of Indonesia. During the Republic of Indonesia, the Ombilin Mining Administration building was the place to organize activities by PT. Bukit Asam (Persero) Tbk. Unit Pertambangan Ombilin (PT. BA-UPO) until the status of a government shareholder in 1980. It was then changed to Ombilin Coal Mining General Company (PERUM) in 1984. The Coal Mining General Company was again merged with Bukit Asam Mine under the 1990 Regulations PT. Bukit Asam (Persero) Tbk. Unit Pertambangan Ombilin (PT. BA-UPO) has been ongoing until now (Asoka et al., 2016).

In terms of architecture, this building is thick with colonial style. This can be seen from the structure of thick brick and concrete walls. The windows and doors are relatively large/in width and height. On the front side, in the center of the building, a tower-like structure stands quite high. In this section, there is also a clock that marks the time. Roman numeral writing is typical of Dutch writing to indicate four hours, unlike the usual Roman numeral IV (Lindayanti et al., 2016; Lindayanti et al., 2017). The building has undergone renovation, the roof of the building is made of tiles, and the floor is white tile. Old photo documentation of the building depicts a dormer typical of Dutch colonial buildings on the roof, especially in the City of Sawahlunto. Dormer as an air vent is no longer visible. However, the changes that have occurred are not many and are not significant to the characteristics and identity of this building. The building has undergone renovation, the roof of the building is made of tiles, and the floor is white tile. Old photo documentation of the building depicts a dormer typical of Dutch colonial buildings on the roof, especially in the City of Sawahlunto (Saputra, 2012). Dormer as an air vent is no longer visible. However, the changes that have taken place are not many and are not significant to the characteristics and identity of this building.

Fig. 4 The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto in 2019
(Source: PT. Bukit Asam (Persero) Tbk. Unit Pertambangan Ombilin (PT. BA-UPO)

In Figure 4, in terms of architecture, this building is thick with a colonial style. This can be seen from the structure of thick brick and concrete walls. The windows and doors are relatively large/in width and height. On the front side, in the center of the building, a tower-like structure stands quite high. On the front, there is also a clock marking the time. The building has undergone several renovations. Initially, the roof contained a dormer typical of Dutch colonial buildings. Currently, the dormer as an air vent is no longer visible.

Fig. 5 The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto Slide 1
(Sources: http://asblr.com/XjFft)

Fig. 6 The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto Slide 2
(Sources: http://asblr.com/XjFft)

Fig. 7 AR Marker for The Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto

4.5 Testing Stages

After completing the assembly stage, the testing stage is carried out by testing the content using a virtual user experience assessment, namely the prospective City of Sawahlunto tourists (Williams et al., 2017; Yagol et al., 2018), while using an AR-based tourist directory map for the City of Sawahlunto destinations. The evaluation is carried out by conducting experiments using virtual products on potential tourists remotely and confirming the effectiveness of virtual AR. According to Azuma (1997), AR has three characteristics, i.e., Augmentation, Interactivity, and Registration. Table 3 shows the results of the frequency tabulation of the experimental survey results on the City of Sawahlunto AR Conservation Map content. This study uses the Attitude Cultural Heritage Scale from Akbaba (2014) to measure users' attitudes toward the City of Sawahlunto's virtual conservation AR content towards the preservation of cultural heritage after using this content. The measurement consists of attitude indicators for the importance of cultural heritage community, attitude of concern regarding cultural heritage, and attitude of transfer of cultural heritage sustainability.

4.5.1 Descriptive Statistical Results

The results of descriptive statistical calculations that can describe the data condition in this study can be seen in Table 3. The following is the research hypothesis to be further tested for its validity:

H1: There is an average difference in the variation of cultural heritage for the society's attitudes towards preserving the UNESCO World Heritage Sites cultural heritage in the City of Sawahlunto between before and after users obtain information from the AR the City of Sawahlunto Interactive Map.

H2: There is an average difference in the variation in the attitude of awareness of cultural heritage towards the preservation of the UNESCO World Heritage Sites cultural heritage in the City of Sawahlunto between before and after users get information from the AR the City of Sawahlunto Interactive Map.

H3: There is an average difference in the variation in the attitude toward the transfer of cultural heritage towards preserving the cultural heritage of UNESCO World Heritage Sites in the City of Sawahlunto between before and after users get information from the AR the City of Sawahlunto Interactive Map.

Table 3. Descriptive Statistics

Statistic							
		Cultural heritage for the society		*Consciousness of cultural heritage*		*The transfer of cultural heritage*	
		Before Usage AR Map	After Usage AR Map	Before Usage AR Map	After Usage AR Map	Before Usage AR Map	After Usage AR Map
N	*Valid*	65	65	65	65	65	65
	Missing	0	0	0	0	0	0
Mean		10,57	10,78	17,54	21,65	9,28	8,86
Std. Error of Mean		0,27	0,29	0,71	0,57	0,27	0,31
Std. Deviation		2,17	2,35	5,75	4,58	2,21	2,49
Minimum		6,00	6,00	7,00	9,00	5,00	3,00
Maximum		15,00	15,00	34,00	29,00	15,00	13,00

Table 3 shows that of the three variables studied, there is an average difference in awareness of cultural heritage between the period before using the AR Map of the City of Sawahlunto and after using the AR Map of the City of Sawahlunto. It can be seen in Table 3 that for the variable Cultural heritage of the society, the average before using the AR Map of the City of Sawahlunto was 10.57 and increased to 10.78 after using the AR Map of the City of Sawahlunto. Furthermore, in the Consciousness of Cultural Heritage variable, there is an average increase of 17.54 before the AR Map of the City of Sawahlunto and 21.65 after using the AR Map of the City of Sawahlunto. However, the opposite happened for the transfer of cultural heritage variable; that is, there was an average decrease from 9.28 before using the AR Map of the City of Sawahlunto to 8.86 after using the AR Map of the City of Sawahlunto.

4.6 Distribution Stages

The application is stored in a storage medium in the distribution stage, such as a physical map previously used as an autoplay file. This is the final stage, where the media is ready to be operated and used by the destination management team and used by the Department of Culture, Historical Heritage and Museums of the City of Sawahlunto to be distributed at various points in the City of Sawahlunto.

5.0 Conclusion

This study found that the City of Sawahlunto AR Conservation Map meets the characteristics of Augmented Reality—augmentation, interactivity, and registration—and that users rate its interactivity ability highest. Interactivity lets users move virtual media and explore actual-size virtual items' information. Five respondents, or 25%, strongly agree about the City of Sawahlunto AR Conservation Map for the Main Office of the Ombilin Coal Mining Company in the City of Sawahlunto or Hoofdkantoor van de steenkolenmijn Ombilin te Sawahloento. AR-based maps vary from Media Richness Theory-aligned printed maps in their interactivity. Video, music, photos, text, 3D objects, linkages to official tourist locations, and social media are possible with AR map media. AR-based virtual conservation may stabilize and maintain the world heritage site after several disasters. The City of Sawahlunto AR Conservation Map AR's augmentation, interactivity, and registration capabilities enable navigation, influence route preferences and duration, and spread/break tourist concentration at one point in the tourist destination, reducing overtourism. The study assesses the OCMHS AR app's technology.

This study has various drawbacks. The tiny sample of 20 respondents may not adequately represent user experiences, and COVID-19 pandemic results may not reflect usual AR application usage. Approaches like non-participatory observation and literature research restrict user interaction insights. Additionally, the City of Sawahlunto-specific results may not apply to other situations. Long-term user involvement and AR technological issues are understudied, exposing research gaps. Future studies may overcome these constraints better to comprehend the AR application's potential in heritage conservation, advancing the field, and improving cultural heritage experiences. The last recommendation is that post-pandemic studies are essential to evaluating standard tourist behaviors and interactions with AR technology for virtual tourism.

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Paper Contribution to Related Field of Study

This research paper contributes to the field of Cultural Heritage Information Management and Virtual Tourism.

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