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ASSESSING THE SOCIO-ECOLOGICAL FEASIBILITY OF DAM CONSTRUCTION PROJECTS ON CRITICAL LANDS: A STUDY ON THE ANALYSIS OF THE BENEFITS AND DESIGN CONCEPT OF RIVERSCAPE AS A TOURIST DESTINATION

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Abstract: The construction of dams on critical lands presents a strategic solution to water scarcity, agricultural degradation, and land productivity decline. However, such infrastructure projects often trigger adverse socio-ecological impacts, including forced displacement, cultural disruption, and ecosystem imbalances. In response, there is growing interest in integrating riverscape-based tourism concepts into dam projects to enhance environmental sustainability and community welfare. This study aims to assess the socio-ecological feasibility of developing riverscape tourism in the context of dam construction, focusing on the Mujur Dam project in Central Lombok, Indonesia—a region affected by drought and land degradation. The research adopts a qualitative case study approach, employing data collection methods such as in-depth interviews, focus group discussions (FGDs), document analysis, and participatory field observations. Informants include residents, farmers, policymakers, tourism actors, indigenous leaders, environmentalists, and project planners. The results reveal that riverscape-based landscape design fosters multifunctional land use, promotes local economic activities, and restores riparian ecosystems. It also facilitates inclusive public spaces, cultural preservation, and environmental education, crucial for sustainable tourism and disaster resilience. Moreover, integrating tourism elements into dam planning encourages participatory governance and strengthens social cohesion. The study highlights the importance of aligning infrastructure development with ecological sensitivity and local aspirations. Findings provide a framework for combining dam engineering, eco-tourism, and landscape design into a unified socio-ecological model. This research also provides practical implications for decision-makers, emphasizing that riverscape tourism can be a bridging concept to harmonize environmental, social, and economic goals. Future research should explore the longitudinal impacts of riverscape tourism on community resilience and biodiversity conservation. Such inquiry is essential to determine whether the observed socio-ecological benefits are sustainable and adaptable to changing environmental and social conditions. Comparative studies across different dam regions could further validate the transferability of this model. Understanding its scalability and context-specific outcomes would inform the development of flexible frameworks suitable for diverse ecological and cultural settings. Additionally, more empirical work is needed to sustain future integrated dam-tourism projects.

Keywords: tourist destinations, riverscape design, dam construction, critical land, socio-ecology

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INTRODUCTION

The water crisis is worsening in many parts of Indonesia, especially in areas prone to drought and agricultural land becoming unproductive. Coupled with anthropogenic pressures, increased pressure on water resources due to climate change, and land-use change have made water resource management difficult (Isukuru et al., 2024; Jahura et al., 2024; Kanownik et al., 2024; Madomguia et al., 2025; Snizhko et al., 2024). Certain areas with low rainfall intensity or uneven water distribution patterns face an increasing risk of water scarcity, ecosystem degradation, and social conflicts in water use (Naderi et al., 2024; Tan et al., 2024). Especially in areas that experience water deficits, such as the southern part of Lombok Island, water resources managers [Inf.3], when interviewed, revealed that on Lombok Island, the annual rainfall is limited to only around 1,087 mm (02/11/2022). As a result, critical land in this region needs quick and appropriate solutions to overcome serious threats to food security and the social life of the community (Fanta et al., 2024).

The government's efforts to build water infrastructure, such as the Mujur Dam in Central Lombok Regency, are one of the strategic options to overcome the water deficit. In addition, the construction of this dam is also targeted to provide raw water sources for developing areas, including the Mandalika Special Economic Zone, in order to support socio-ecological sustainability at the local and national levels (Bustami et al., 2023). In various countries, research on the socio-ecological feasibility of dam construction projects highlights the importance of a thorough analysis of social and ecological impacts. Studies in Zimbabwe show that small dams provide irrigation benefits but also trigger declining fish populations and land-use conflicts (Gwazani et al., 2012). In Thailand, the social impacts of small dams are uneven, including reduced fish populations

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and flood mitigation benefits (Fung et al., 2019). In addition, the design of river border landscapes as tourist destinations has also been applied to improve environmental quality and community welfare, such as riverbank restoration in Xining, China, which improves the city-river system (Shang, 2018). Including in France, where landscape transformation due to dam removal encourages stakeholder engagement (Germaine & Gonin, 2024). Despite numerous studies on dam construction, in-depth studies related to the socio-ecological feasibility, especially on critical lands, are still rare. Previous research has focused more on technical aspects, such as hydrological design and water use optimization, without exploring the balance between the needs of local communities, creative economy development, and tourism. This research offers innovations in the form of benefit analysis and design concepts of river border landscapes as tourist destinations, which provide policy recommendations for local governments to build water-based tourism. This study answers three main questions, namely: [RQ1] How does the concept of river border landscape support dam tourism? [RQ2] What are the socio-ecological benefits? and [RQ3] How does tourism development improve the sustainability of unproductive land? This study contributes to providing a new perspective on water resources management that focuses not only on technical aspects but also on socio-ecological integration and tourism. Its goal is to be a conceptual design model for similar infrastructure projects in other regions experiencing water deficits.

LITERATURE REVIEW

Socio-ecological feasibility of dam projects

Socio-ecological feasibility refers to the evaluation of the sustainability of a project based on the integration of social and ecological aspects. Studies on this feasibility are often used to assess impacts on local communities and ecosystems (Ujuagu et al., 2025). According to Tan et al., (2024), an effective socio-ecological system requires a balance between human needs and environmental conservation. In many countries, the development of large infrastructure such as dams indicates the need to consider social dimensions, such as community relocation and ecological dimensions. These include changes in river flow patterns and their impact on biodiversity (Burrier & Hultquist, 2019). In the Indonesian context, the integration of socio-ecological aspects is a challenge due to cultural diversity, traditional land tenure systems, and conflicts of interest between stakeholders (Kusters, 2015).

The urgency of dam construction in overcoming the water deficit

Dam construction projects are a strategic solution to overcome water deficits, improve irrigation, and support energy needs in many countries. However, the impact is often controversial. For example, in India, the Narmada Dam project succeeded in increasing agricultural productivity but also led to social conflicts related to evictions (Molden et al., 2010; Seijger et al., 2025). In Indonesia, the construction of large dams, such as the Jatigede Dam in West Java, shows the importance of a multidisciplinary approach, including social impact management and environmental protection (Amalia & Malihah, 2016). In the context of Lombok Island, the main challenge is to ensure equitable water distribution in downstream areas that often lack water, as well as to manage community protests due to environmental and social changes (Prasetyo, 2022; Akhmad et al., 2025)

Critical land of west nusa tenggara and other provinces in Indonesia

Critical lands in Indonesia, such as dry and less fertile areas, have great potential to be developed into strategic projects, including dam construction. According to BPS-Statistics Indonesia Data (Machdi et al., 2024), around 14% of Indonesian land is classified as critical, especially in eastern regions such as Nusa Tenggara.

Table 1. The province with the largest critical land area in Indonesia (Source: Indonesia's critical land (Machdi et al., 2024)

No	Province	Critical Land (ha)	Very Critical	Total
1	West Java	397.516	432.040	829.556
2	Central Kalimantan	734.524	85.159	819.682
3	North Sumatra	486.713	291.229	777.942
4	West Kalimantan	735.421	8.363	743.784
5	South Sumatra	509.126	198.043	707.169
6	West Sumatra	371.489	314.601	686.091
7	East Nusa Tenggara	471.395	109.336	580.731
8	West Nusa Tenggara	324.783	165.531	490.314
9	Maluku	260.013	227.235	487.248
10	North Maluku	83.607	399.660	483.268

From Table 1, the latest data from BPS-Statistics Indonesia Data (Machdi et al., 2024) shows that there are around 10 out of 38 provinces with the largest total critical land in Indonesia. These ten provinces include West Java (829.556 ha), Central Kalimantan (819,682 ha), and North Sumatra (777.942 ha). West Java, despite being one of the most populous provinces, has great challenges in managing critical land, especially in a very critical area of 432.040 ha. Central Kalimantan and West Kalimantan also have a total of 819,682 ha and 743.784 ha of critical land, respectively, with most of the land being degraded due to deforestation and unsustainable agricultural activities.

In the Sumatra region, North Sumatra (777.942 ha), South Sumatra (707.169 ha), and West Sumatra (686.091 ha) face similar challenges, with a combination of high critical and highly critical land, resulting in a decrease in soil fertility and agricultural productivity. Eastern Indonesia, such as East Nusa Tenggara (580.731 ha), West Nusa Tenggara (490.314 ha), Maluku (487.248 ha), and North Maluku (483.268 ha), also showed significant numbers for critical land. West Nusa Tenggara, for example, has 324.783 ha of critical land and 165.531 ha of critically ill land, most of which are in hilly

topographic areas with limited water access.According to Lv et al., (2023), critical land use requires an ecologically based approach and community participation to ensure long-term sustainability. Studies show that careful planning in maximizing the potential of critical land can provide economic benefits while minimizing environmental impacts (Alyani et al., 2024). To address these challenges, an integrative strategy that combines critical land rehabilitation, ecological design, and community-based economic development is urgently needed.

Analysis of the function and design of tourism concept

Function analysis is often used in infrastructure planning to evaluate the contribution of each element in supporting project objectives. In dam construction, functional analysis helps ensure that benefits such as raw water supply, irrigation, and electrical energy can be effectively achieved (Munyai et al., 2024; Park & Kim, 2014). In addition, the concept of tourism design is increasingly involved in increasing the added value of the project through the development of dam-based tourist areas. For example, the Jatiluhur Dam project in West Java, which successfully combines infrastructure functions with tourism, has resulted in a significant contribution to the local economy (Wulandari et al., 2021). For river border areas, a sustainability-based design approach involving local communities can provide long-term benefits (Lara-Valencia et al., 2023).

River landscape (riverscape) in the dam area

Riverscape, or river boundary view, refers to the transition area between the land and aquatic ecosystems that have important ecological, social, and economic functions of a dam (Dunham et al., 2018). The management of river boundary areas plays an important role in supporting the ecological functions of dams, including water quality management, erosion control, and natural habitat conservation (Bian et al., 2024; Lisetskii & Buryak, 2023). Studies show that effective management in this area can reduce sedimentation, improve water quality, and increase biodiversity around dams (Chukwuka et al., 2023). However, in Indonesia, river border areas are often not managed optimally, triggering environmental degradation and reducing their ecological benefits (Khairina et al., 2020).

RESEARCH METHODS

This study adopts a qualitative approach with a case study design to evaluate the socio-ecological viability of dam construction on essential land (Emmanuel et al., 2020; Creswell, 2018). Data were collected through field observations, in-depth interviews, document analysis, and focus group discussions (Akyıldız & Ahmed, 2021). The lead author directly participated as part of the environmental social survey team involved in the Mujur Dam pre-construction phase, contributing to data collection on environmental and social aspects, also aligned with the author's dissertation.

Observations focused on the physical and ecological characteristics of the dam site, including soil, vegetation, and hydrological conditions. Interviews were conducted with key stakeholders - affected communities, planners, and ecologists—to explore perspectives and concerns. The document analysis encompasses thorough design studies, project planning documents, and water governance policies. Certain data, represented as maps derived from Landsat imagery and geographic information systems, were obtained from the regional planning report with authorization from the consultant - PT. Massuka Pratama. FGDs captured community needs and aspirations for ecological tourism design in the riparian buffer zones.

Participants were purposively selected based on relevance to the study, including indigenous leaders and technical experts (Table 2 for detailed participants). Data were analyzed thematically to identify patterns related to social-ecological dynamics and tourism design (Gates et al., 2023; Johnson et al., 2022). Methodological triangulation and researcher reflection were employed to ensure data credibility and reduce bias (Donkoh, 2023). The findings support recommendations for sustainable, community-based tourism development in the dam border region, contributing both practically and theoretically to water resource planning and inclusive infrastructure development (Woldu, 2018).

Table 2. Informant categories and data obtained (Source: survey results, 2023)

Informant code	Position/ Profession	Number of participants	Field	Data obtained
Inf.1	Affected communities	15	Socio-economic	Perception of the impact of dam construction, community needs, and aspirations related to ecotourism design.
Inf.2	Project planner	3	Tourism development	Technical plans for tourism development, dam design, and potential tourism impacts.
Inf.3	Water resource managers	2	Water management	Water management policies, river discharge data, and dam water distribution plans.
Inf.4	Ecologist	2	Ecological tourism	Analysis of border Riverscape ecosystems, biodiversity, and potential environmental impacts.
Inf.5	Traditional leaders and local leaders	4	Culture and Social	Local wisdom in the management of resources, community traditions, and cultural values that need to be maintained.
Inf.6	Academy	3	Geography and Social Education	Academic perspectives related to ecotourism site design and socio-ecological integration of the project.

RESULT

Administrative and land characteristics of the dam project location

This research was carried out around the border area of the Mujur Watershed which is the location of the Mujur Dam project. Administratively, the Mujur dam project is located between Prako Village and Lelong Village, Janepria District,

Central Lombok Regency-West Nusa Tenggara Province. This area is in strategic coordinates in the central part of Lombok Island, with quite good accessibility from the sub-district city and the district capital. The Mujur Dam project is part of the strategic project for the arrangement of the Eastern Indonesia region, which is handled directly by the Nusa Tenggara I River Regional Center, based on the Regulation of the Minister of Public Works and Public Housing No. 04/PRT/M/2015 concerning the determination of the governance status of the river area.

The catchment area that supports this dam has diverse land use characteristics. Land cover conditions in this area are dominated by critical land, shrubs, and a small number of rainfed rice fields that depend on seasonal rainfall. In addition, there is the potential for land cover in the form of mixed garden areas managed by local communities for palm oil and tobacco crops. Table 3 presents further information about the distribution of land use in the catchment area.

Table 3. Land use in catchment areas supporting the Mujur Dam project (Source: Landscape image analysis, 2021)

Land use	**Areas (Km^2)**	**Percentage (%)**
Forest	13.85	17.91
Garden	27.94	36.13
Settlement	13.86	17.92
Rice Fields	13.09	16.93
Fields	8.6	11.12
Total	77	100

Based on Table 3, it shows that the land use pattern reflects the balance between agrarian activities, environmental protection, and the need for space for settlements. Structuring and managing dominant land uses, such as plantations, forests, and settlements, is essential to ensure the sustainability of the hydrological function of dams and minimize potential negative impacts such as erosion, sedimentation, and uncontrolled land conversion. An analysis of land use reveals that plantations dominate the catchment area, with a coverage of approximately 27 km².

The coverage of all land use from the catchment area is presented in Figure 1. This presents the spatial distribution of land use in the Mujur watershed catchment area, expressed in square kilometres (km²). Garden land constitutes the dominant land use type, accounting for approximately 27.94 km² or 36% of the total catchment area. Forest land occupies an area of approximately 13.85 km², contributing around 18% to the total water catchment area. Similarly, settlement areas cover about 13.86 km², nearly equivalent to the forest land.

Meanwhile, rice fields and dryland farms (fields) span approximately 13.09 km² and 8.6 km², respectively. Overall, the total area of the water catchment region amounts to 77 km².

Figure 1. Distribution of Land Use in the Mujur Catchment Area (Source: Landscape Image Analysis, 2023)

In terms of soil characteristics, the area is predominantly composed of sandy clay textured soils, with relatively poor drainage conditions in several locations, rendering it susceptible to erosion. Geologically, the region is dominated by old volcanic rock formations with thin surface soil layers, posing significant challenges for water retention and vegetation growth. The topography ranges from flat to gently sloping, with gradients between 0–15%, offering opportunities for the development of ecotourism sites and dryland agriculture initiatives.

Social characteristics of communities at the dam project site

Based on survey and mapping results, three sub-districts are located in close proximity to the projected inundation area, namely Central Praya, East Praya, and Janapria. The population affected by the dam construction is primarily concentrated in these three sub-districts. According to the recapitulated statistical data, both the total population and the population density of each village within these sub-districts have been identified and analyzed. The spatial distribution of population density in the villages surrounding the dam site is illustrated in Figure 2.

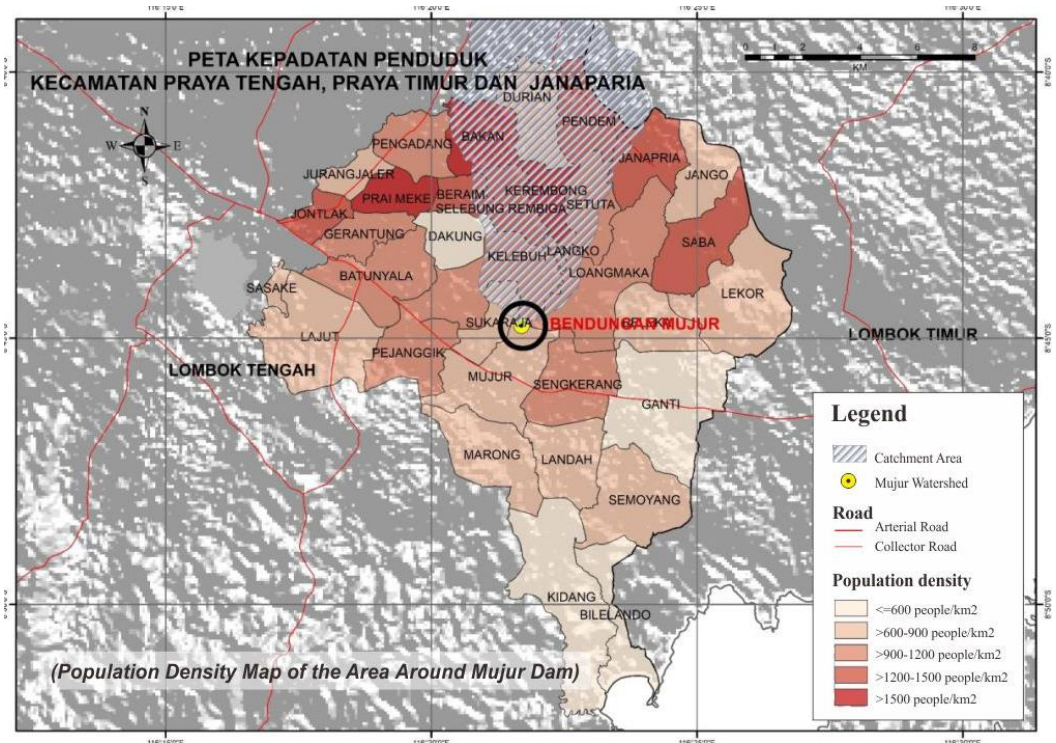

Figure 2. Map of population density levels around the dam (Source: BPS Data Processing, 2024)

In terms of population, the villages around the study site have populations that mostly work as farmers and farm laborers, with income levels dependent on the growing season. The tradition of mutual cooperation and the use of local resources is still strong, and they are important social capital in the management of the dam border area. Village infrastructure, such as access roads and public facilities, is still developing and needs to be upgraded to support economic and tourism activities. The source of population data in the Catchment Area comes from statistical data in numbers (BPS-Statistics Indonesia); the number of people per village in the Catchment Area is calculated based on the proportion of the area of each village that enters the Catchment Area. The results of the analysis show that the total population in the Catchment Area area is estimated to be 114 people spread across 3 sub-districts. Residents can play a role as subjects or objects of planning. The characteristics of the community in the study area show social and cultural characteristics that are important factors in supporting development activities. The values of kinship and togetherness still dominate the social character of the community. The principle of strong cooperation makes people tend to be more collaborative than individualists, creating a solid foundation for community-based development. The role of community leaders and government officials is very significant in social life. These figures function as role models, provide direction, and become a bridge between the community and the government in various development programs. Trust in community leaders strengthens social ties and motivates community participation in various development activities.

Ecological feasibility analysis of dam project sites

Morphometry and coverage of catchment areas of dam project sites

Based on the results of manual digitization using the Geographic Information System with basic data in the form of a map of the Indonesian Terrain (RBI) of Lombok Island on a scale of 1:25,000, information was obtained that the total area of the Catchment Area planned for the Mujur dam reached 77.39 km². This Catchment Area covers the area that serves as the primary source of water supply for the dam, which includes various types of land use, such as agricultural land, shrubs, residential areas, and secondary forests. The process of delimitation of the catchment area is carried out by considering topography, surface water flow patterns, and natural boundaries such as ridges.

A complete visualization of the scope and boundaries of the Catchment Area can be seen in Figure 3, which provides a comprehensive spatial overview to support the planning and management of this area.

The Catchment Area morphometry shows that the region has relatively varied topographic characteristics, ranging from flat areas to sloping and steep slopes, which affect the pattern of water flow towards the dam. Morphometry indices such as the length of the main flow, the density of the flow, and the elongation ratio indicate the potential of this area to hold and drain surface water optimally. The analysis also shows that this catchment area plays an important role in controlling sedimentation entering dams, especially from areas with high erosion levels due to suboptimal land cover.

In addition, the scope of this catchment area also shows great potential to support the hydrological function of the dam, both as a source of water supply for irrigation, domestic needs, and planned water tourism activities. Thus, catchment area management based on sustainability principles is very important to maintain the capacity and quality of water resources in the Mujur Dam area. Based on the results of GIS analysis with the basic data of the RBI Map of Lombok Island on a scale of 1:25,000, the catchment area of the Mujur Dam has the following morphometry.

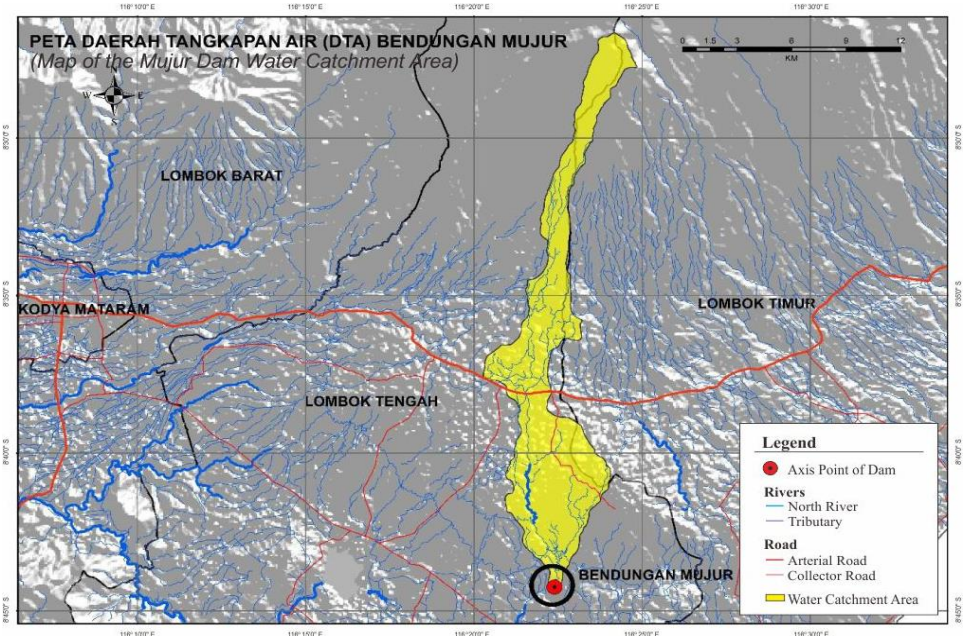

Figure 3. Catchment Area of the Mujur Dam (Source: consultant analysis, 2022)

Table 4 provides detailed information about the physical characteristics of the catchment area of the Mujur Dam. The area of the catchment area reaches 77.39 km² with the length of the main river as far as 43.76 km, and the total length of the river network reaches 204.81 km. The elevation of the catchment area varies significantly, from 122 meters above sea level (masl) at the lowest point to 2937.50 meters above sea level at the highest point, resulting in a height difference of 2815.50 meters. The length of the watershed reaches 33.60 km with an average width of 0.99 km, and the circumference of the watershed reaches 78.34 km. The density of the river in the catchment area is quite high, namely 2.65 km/km², indicating a dense river network and potentially supporting surface water collection. A meandering index value of 0.77 indicates that rivers in this region tend to turn or wind, which can affect flow patterns and erosion. This data is an important basis for understanding the hydrological capacity, flow patterns, and potential for sustainable management of the water catchment area.

Table 4. WCA Morphometry of the Mujur Dam (Source: Consultant Analysis 2022)

Information	Value	Unit
Water Catchment Area	77.39	Km^2
Length of the main river	43.76	Km
Total river length	204.81	Mdpl
Highest elevation	2937.50	Mdpl
Lowest elevation	122.00	Mdpl
Elevation difference	2815.50	Meter
Watershed length	33.60	Km
River density	2.65	Km/ km^2

Table 5. Data on the slope of the water catchment area (Source: Consultant Analysis in 2023)

Slope Gradient	Areas (Km^2)	Percentage (%)
0-8%	59.86	77.35
8-15%	8.29	10.71
>15-25%	2.43	3.14
>25-45%	3.06	3.95
>45%	3.75	4.85
Sum	77.39	100.00

Study of the slope of the catchment area of the dam project location

The slope conditions in the catchment area of the Mujur Dam show significant variations, ranging from areas with a flat slope (<8%) to areas with a very steep slope (>45%). Land that has a relatively flat slope is generally located in the downstream part of the water catchment, which is adjacent to the dam inundation area and is more suitable for land use such as settlements, agriculture, and plantations. In contrast, lands with steep slopes are in the upstream part of the catchment area, which has greater challenges in terms of land management and conservation and is vulnerable to soil erosion and degradation. This slope distribution pattern is important for designing and implementing appropriate area management policies to minimize negative impacts on ecosystem sustainability and dam function. More detailed information about the condition of the slope in the water catchment area can be seen in Table 5.

Based on the presentation of Table 5, the distribution of slopes in the Water Catchment Area (DTA) of the Mujur Dam is shown based on the slope class. Most of the water catchment area, which is 77.35% or 59.86 km², has a slope between 0-

8%, which generally covers flat and slightly sloping areas suitable for land use such as plantations and settlements. The 8-15% slope class covers an area of 8.29 km² (10.71%), which is often used for agriculture and gardens. Areas with steeper slopes, between 15-25% and 25-45%, cover 2.43 km² (3.14%) and 3.06 km² (3.95%), respectively. Areas with very steep slopes of more than 45% cover 3.75 km² (4.85%) of the total catchment area, which usually have greater management challenges and are prone to erosion. Overall, the total area of the catchment area is 77.39 km².

Table 6. Recapitulation of average rainfall at 4 Nearby Stations (Source: DD Mujur Dam in 2023)

Station	Average monthly rainfall (mm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kopang	279	231	293	211	63	74	31	8	59	123	231	256
Pengadang	265	213	201	143	58	28	12	8	32	67	222	251
Loang Maka	194	160	125	77	37	23	16	4	19	32	129	185
Perian	310	256	306	182	91	57	36	22	63	177	303	284
Average	262	215	231.3	153.3	62	46	24	11	43	100	221.3	244

Climatology and water supply study on critical lands around dam areas

Based on an interview with a geology expert from the consulting firm PT Massuka, it was explained that the location of the site plan of the Mujur Dam is located in the Kalibabak Formation with lithology in the form of breccia and lava. This Kalibabak formation covers the Kalipalung Formation, where the strategic positions of the formation are mutually exclusive. The climatological condition in the area around the location of the Mujur Dam is influenced by two tropical climates, namely the rainy season and the dry season. The rainy season starts from November to April, while the dry season is from May to October. The data that affect the climate in the Renggung watershed are 1). The average monthly temperature is around 26°C, 2). The average annual relative air humidity at Keruang and Kopak Climatology Stations is 75%, 3). Average evaporation of 4.5 mm/day, 4). The average solar irradiation is 55%. 5). The average daily wind speed is 60 km/day. Based on the results of previous investigations, the bedrock at the dam location is lava deposits and lake sediments. Lahars are in the form of coarse soil deposits or breccia, while silt and sand matrices dominate lake deposits of fine-sized rocks. The sediments found are not uniform, with both vertical and horizontal spreads. Generally, the spread changes only a few meters. Changes occur in grain size, composition, and degree of consolidation. Generally, it is in the form of sandwich lens interspersed hoses. Because the deposits mentioned above are young and not layers of weathered rock cover all, the process of consolidation and cementation is not perfect. As for the rainfall aspect, based on the monthly average rainfall of Kopang, Pengadang Loang Make and perian rain stations, an average rainfall recapitulation was obtained (Table 6). Meanwhile, judging from the water supply at the location of the Mujur Dam located in the Renggung watershed on the eastern island of Lombok, where the rainfall conditions in this area are relatively smaller when compared to the western island of Lombok. The Renggung watershed itself is a small watershed whose discharge is very minimal, even non-existent during the dry season (Figure 5). Based on these data, the source of irrigation for this dam is planned to utilize the existing interconnection system from the High-Level Diversion Babak system, Jurang State Canal, and excess water from the Jangkok—Babak system with the construction plan of the Meninting dam.

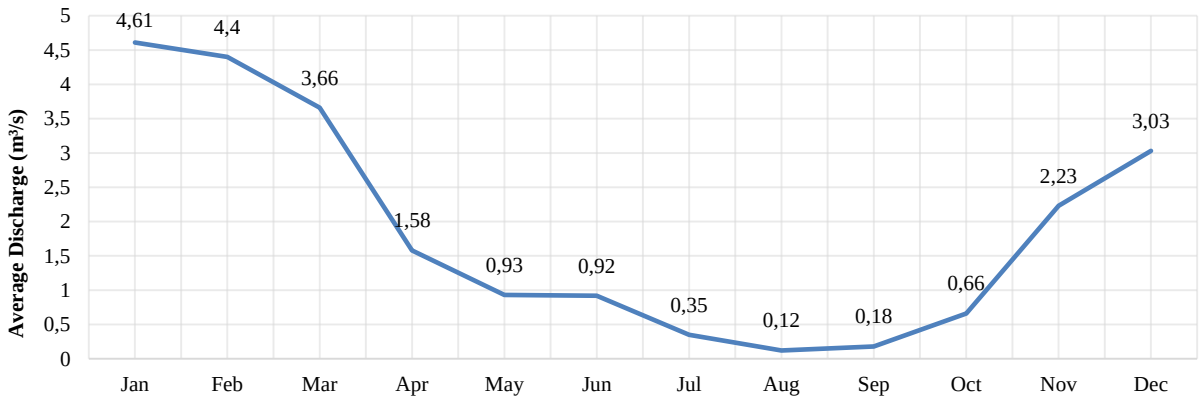

Figure 5. Average Monthly Discharge of Sungai Renggung (Source: FS DAM of Mujur, 2021)

Concept design of dam reverscape as a tourist destination

The Catchment Area of the Mujur Dam has great potential to be developed into a border landscape-based tourist destination that combines environmental conservation with tourism activities. Based on data, land use in this area is dominated by gardens (36.13%) and forests (17.91%), which provide opportunities to create green spaces as well as nature-based tourist attractions (Figure 7). With an area of 77.39 km² water catchment, the site planning of the river border area integrates natural elements such as local vegetation (teak trees, mahogany, and shrubs) with contour arrangements that support the ecological and aesthetic functions of the area. Border landscape design prioritizes adaptation to natural conditions. For example, areas with a flat land slope (<8%) covering 77.35% of the total the Catchment Area are used for the location of public facilities such as bicycle paths, picnic areas, and water tourism rides around the dam inundation (Figure 6). This approach aims to minimize the cut-and-fill process that can damage soil structures and disrupt local ecosystems.

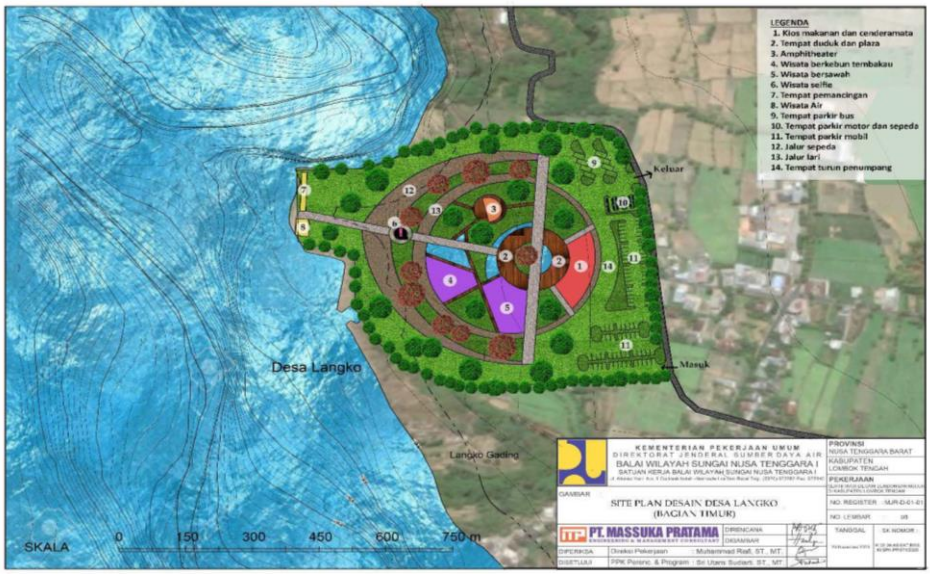

Figure 6. Map of the site plan of the eastern dam boundary area (Source: mapping report document for Mujur Dam Project Consultants, 2024)

Figure 7. Riverscape design concept for the Mujur dam area: (A) Fishing spot and jogging track landscape, (B) Children's playground landscape, (C) Education and souvenir center, (D) Recreation and sports area (Source: designed by a consultant, with the concept and layout developed by the author)

The main concept of the design of this area is "Building as Nature Tourism," which emphasizes the optimization of nature as an integral part of the design. The structures and facilities in the river border area are designed in harmony with the environment, both in terms of spatial planning and building shape. This aims to maintain a balance between environmental conservation and land use for tourism. For example, the vegetation at the site is still maintained as part of the design, thus creating a beautiful atmosphere that supports nature-based tourist attractions. In addition to ecological functions, this design also pays attention to social and economic sustainability aspects. By integrating tourism activities with the empowerment of local communities, the river border area is expected to create new economic opportunities for local residents. For example, the concept of agrotourism that utilizes gardens and fields in the Catchment Area can provide an educational experience for visitors while increasing community income through the marketing of local agricultural products such as tobacco and crops. Overall, the concept of designing the Mujur Dam border area site not only supports the sustainability of the ecosystem but also serves as a model for multifunctional tourist destinations that contribute to improving the quality of life of local communities. With this approach, river border areas can catalyze sustainable environmental conservation-based development in Indonesia. In addition, the site planning in the boundary area of the Mujur Dam is designed to take advantage of the natural conditions of the area, such as the contours and vegetation that already exist.

The main building is planned on low-slope land to minimize the cut-and-fill process that can damage the soil structure and reduce ecological stability. This is in line with the sustainability principles that are the basis for the management of this area, where adaptive design is used to preserve existing natural elements. Local vegetation, such as teak and mahogany trees, is

utilized as part of the design elements to create a natural and beautiful atmosphere that supports the tourist attraction. Figure 7 shows that the circulation of the parking area around the dam is specially designed for pedestrians, with a parking area placed near the main gate. This ensures that the parking area becomes a vehicle-free zone, providing a safe and comfortable recreational experience for visitors. The circulation concept applied is circular circulation, which connects each main activity area in the park, such as water tourism spots, agro-tourism, and sports spots. This approach not only makes it easier for visitors to access various facilities but also supports efficient space management. Adaptation to the contours of the land is also applied to maintain soil stability, especially in areas with higher slopes. This circulation pattern supports connectivity between areas while paying attention to the safety and comfort of visitors. In addition, this concept allows for the development of flexible public spaces to support various recreational activities, ranging from educational activities to commercial activities. With a sustainability-focused approach, this border landscape planning is expected to provide social, economic, and ecological benefits for the local community. This strategic circulation arrangement also supports the optimization of the area's function as a multifunctional tourist destination that combines environmental conservation with local community empowerment.

Target groups and economic impacts of riverscape tourism objects

The groups of users and visitors of the tourist area around the Mujur Dam can be categorized into three main groups: visitors, tenants/ retail fillers, and cleaning and security officers. Visitors include people from various walks of life and ages, both from the area around the dam and from urban areas. This group is a key element in utilizing tourist facilities such as culinary areas, selfie spots, and water tourism. In addition to making an economic contribution through entrance tickets and purchasing local products, the presence of visitors also strengthens awareness of the importance of environmental sustainability through direct interaction with education-based tourism and nature. Tenants or retail fillers play a central role in supporting economic activities in tourist areas. They manage various commercial facilities, including culinary establishments, souvenir shops, tourist attractions, and the sale of locally cultivated products. These tenants can come from local communities or outside investors who want to contribute to the development of the area. Tenant activities not only open up business opportunities but also help create an inclusive economic ecosystem. Renting stalls, selling crops, and managing tourist attractions provide additional opportunities for local communities to increase their income.

In addition, collaboration with tenants from outside the area expands the marketing network and increases the attractiveness of tourist areas at the regional level. Cleaning and security officers, including parking attendants, have an important role in maintaining the comfort and safety of tourist areas. They are tasked with ensuring environmental cleanliness, maintaining public facilities, and maintaining order during area operations. With working hours set before and after operational hours, this group plays a strategic role in maintaining the sustainability and comfort of the tourist area. The involvement of local communities as officers not only reduces the unemployment rate but also strengthens the sense of ownership of the area, which ultimately supports sustainable management of the area. The existence of these three groups creates synergies that support the ecological, social, and economic functions of tourist areas. Visitors benefit from recreation and education, tenants gain economic opportunities, and local officers gain jobs that support their livelihoods. This combination supports the development of the border area of the Mujur Dam as a tourist destination that not only has a positive impact on visitors but also empowers people affected by inundation. This cross-sectoral collaboration strategy is aligned with the region's sustainability goals through the integration of social, economic, and ecological functions.

DISCUSSION

Socio-ecological feasibility analysis of dam projects

The existence of the Mujur Dam project and the surrounding river border area provide significant benefits for the local community and the surrounding environment. Socially, the development of this area can improve the quality of life of the community by opening new economic opportunities, such as tourism management, culinary services, and the provision of local products. Activities such as renting fishing equipment, managing water tourism spots, and selling handicrafts or agricultural products are additional sources of income for the community. Social values rooted in cooperation and kinship are strong social capital to encourage active community participation in the management of this tourist area. On the other hand, the role of strong and respected community leaders can be used to motivate local communities to be involved in environmental conservation programs and sustainable management of the area. Ecologically, the border area has an important role in maintaining environmental stability and hydrological functions in the DTA of the Mujur Dam. With an area of 77.39 km², this area has a high river density (2.65 km/km²), which supports the capacity of surface water management and sedimentation control. Local vegetation in the river border area helps stabilize the slopes, especially in areas with a slope of more than 45%, which are prone to erosion. Efforts to organize the area by minimizing the cut-and-fill process and maintaining natural vegetation at the site also contribute to maintaining biodiversity in this area. In addition, the border landscape also has the potential as an environmental education area. The arrangement of the area that combines tourism and conservation functions provides a direct experience for visitors regarding the importance of maintaining river ecosystems and water resources. This eco-friendly design concept supports sustainability not only from an ecological but also a social perspective by involving the community in the management and preservation of the area. This creates a synergy between social and ecological benefits, making the border area of the Mujur Dam a model of sustainable development.

Evaluation of riverscape potential for tourism

The riverscape area or border landscape around the Mujur Dam has great potential to be developed as an ecological-based tourist destination. The results of the analysis show that the dam catchment area covers an area of 77.39 km², covering various types of land use, such as agricultural land, shrubs, residential areas, and secondary forests. This diversity

of land use provides opportunities to create diverse tourist attractions, including nature tourism, environmental education, and community-based ecotourism. In addition, the existence of natural elements such as streams, hills, and native vegetation can be leveraged to create a unique and immersive tourist experience. However, this potential must be evaluated based on a sociocultural and ecological approach. The development of tourism in the riverscape area requires a design that is not only aesthetic but also adaptive to the needs of local communities and environmental conditions.

In this study, a community participation-based approach through FGD has shown that the surrounding community aspires to utilize the border area as a tourist destination while still protecting its ecological function. This aspiration can be realized by integrating ecological landscape design, such as eco-friendly walking trails, habitat conservation zones, and recreational areas that support local activities such as fishing and picnics. In addition, the evaluation of the potential of the riverscape for tourism needs to consider economic and environmental sustainability. For example, secondary forest areas and shrubs can be preserved as conservation zones that are also tourist attractions. With proper planning, this riverscape area can function as the main support for water-based ecotourism, increase people's economic income, and support the conservation of local ecosystems. Efforts like this have proven effective in several countries, such as China and Thailand, where river border landscapes have been successfully developed into environmentally friendly tourist destinations (Fung et al., 2019; Shang, 2018).

Comparative study with other case studies

In evaluating the potential for dam construction on critical land around Das Mujur, case studies from various countries provide valuable insights into the challenges and opportunities in the management of riverscape areas. Research in Zimbabwe, for example, shows that small dams can provide significant benefits for irrigation and food security. However, negative impacts on ecosystems, such as declining fish populations and land-use conflicts, are often consequences that must be managed properly (Gwazani et al., 2012). This condition is relevant to the potential for conflicts between users in the Mujur Dam area, especially related to the use of borderland for tourism and conservation activities. In Thailand, research on the impact of small dams shows that although this infrastructure contributes to flood mitigation, its impact on the socio-economy of communities is not always even (Fung et al., 2019). This is an important lesson for the development of the Mujur Dam border area so that the benefits produced can be felt inclusively by all community groups, including local farmers, tourism actors, and vulnerable groups. Compared to other experiences in managing river border areas for tourism, it can also inspire the Mujur Dam project. A river restoration project in Xining, China, has succeeded in improving the quality of the urban environment and socio-ecological system by utilizing the river border as a public space and nature-based tourist destination (Shang, 2018). This approach is relevant to the Mujur Dam, where the border area can be designed as a multi-functional space that supports tourism, conservation, and local community activities. In addition, in France, landscape transformation due to the removal of dams shows that stakeholder engagement is essential in managing new landscape configurations that emerge. The project has succeeded in increasing the involvement of local communities in redesigning the function of the border area, ultimately strengthening the social and environmental sustainability of the area (Germaine & Gonin, 2024). This concept can be adapted in the Mujur Dam through a participatory approach that involves the community in every stage of planning and management of the border area. From this comparative study, the success of riverscape management is highly dependent on the integration of ecological, social, and economic aspects. The Mujur Dam has a great opportunity to adopt best practices from various case studies, such as ecological restoration, environmental quality improvement, and community empowerment. Thus, the development of this area is expected not only to increase tourism potential but also to become a model for sustainable dam management at the local and national levels.

Challenges and opportunities for sustainable development of Dam Tourism Areas

The critical land use in the Water Catchment Area (DTA) of the Mujur Dam, which is dominated by fields, has great potential to be optimized through the integration of tourism and agricultural functions. The concept of education-based tourism is the main foundation in the development of this area, aiming to increase public awareness about the importance of maintaining the balance of nature for the sustainability of the ecosystem. One approach that can be done is through the development of agrotourism, which takes advantage of the potential of local agriculture such as tobacco cultivation and harvesting—the main commodity in Lombok. This not only increases farmers' income but also strengthens local identity as an agrarian tourism destination. The park area around the dam is designed to support a variety of tourist activities, including nature tourism, culinary, sports, performing arts, and commercial activities. Various planned tourist spots provide economic, social, and ecological benefits. Fishing spots, for example, offer opportunities for local communities to provide services such as fishing tackle rentals, which can increase local income. Selfie spots and water tourism, such as duck boats, canoes, or speedboats, not only add to tourist attraction but also expand the earning potential of the nature-based tourism sector.

In addition, this area is equipped with culinary spots and souvenir spots that support micro and small businesses in the surrounding community. This facility provides a platform for the community to market regional products, such as traditional foods, garden products, and handicrafts. This approach not only strengthens the local economy but also increases community involvement in the management of tourist areas. In an effort to improve the quality of life of the local community, sports and recreation spots, such as running tracks and bicycle paths, are also designed, which create healthy and inclusive public spaces. Meanwhile, the performing arts spot provides a space to display Lombok's typical art and culture, as well as opening opportunities for collaboration with artists from outside the region. The successful development of this river border area requires a multidisciplinary approach that integrates landscape design, environmental conservation, and local community empowerment. The arrangement of this area not only provides recreational benefits for visitors but also supports environmental conservation, increases social interaction, and creates new jobs. By combining ecological, social, and economic functions, the management of this area is able to answer the economic needs of communities affected by inundation, strengthen Lombok's tourist attraction, and become an important model for sustainable management of critical land in Indonesia.

CONCLUSION

The construction of dams on vital land, particularly in river border regions, necessitates a more efficient and sustainable strategy to address the water crisis. The development of the river border area as a water-resource-based tourist attraction is a pertinent solution that can yield immediate economic advantages for the local community. This research significantly enhances the comprehension of the configuration of dam boundary areas, emphasizing the advancement of recreational and ecotourism purposes. The analytical results indicate that leveraging the river border area as a tourist destination can significantly enhance the welfare of individuals impacted by flooding. Utilizing boundary space for sustainability-oriented tourism activities can enhance the revenue of the local population and bolster the socio-ecological sustainability of dam construction initiatives.

This strategy anticipates that dam management will evolve from only supplying water services to stimulating the local economy. This is crucial for fostering synergy among the technical requirements, environmental conservation, and social welfare of the community, particularly for those residing near the dam. This study underscores the necessity of reconciling social and ecological advantages in significant infrastructure development projects, such as dams, to achieve a balance among technical considerations, environmental sustainability, and the economic welfare of impacted populations.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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