

A Multi-aspect Sustainability Assessment of Tourism Development in Berau Regency, East Kalimantan

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ABSTRACT

Tourism development in Berau Regency, East Kalimantan, plays a strategic role in driving post-extractive economic transformation by fostering marine and nature tourism. However, pressure on environmental carrying capacity, inequality in economic benefits, limited infrastructure and technology, and disparities in community social capacity pose serious challenges to the sustainability of regional tourism. This study aims to comprehensively analyze the sustainability level of Berau Regency's tourism development through a Multi-aspect Sustainability Analysis (MSA) approach that encompasses ecological, economic, infrastructure, and technology, and social aspects. The study used a quantitative-descriptive approach with 30 expert respondents selected through purposive sampling, including government officials, academics, tourism practitioners, and community representatives. The analysis was conducted using the Exsimpro tool to calculate the sustainability index, determine sustainability status, identify leverage factors, and simulate future conditions (leveraged condition). The results indicate that, in general, Berau Regency's tourism development falls into the less sustainable to borderline sustainable status category for all aspects studied. Ecological, infrastructure, and technology, and social aspects are at the limits of sustainability, while economic aspects show the greatest potential for improvement and are most responsive to strategic interventions. Key levers include environmental carrying capacity, tourism's economic contribution and growth, transportation accessibility, and human resource capacity and community empowerment. These findings underscore the need for an integrated, adaptive, and priority-based cross-sectoral tourism management strategy to drive the transformation toward competitive, inclusive, and sustainable tourism.

1. Introduction

Sustainable tourism has become a key paradigm in regional development, particularly for areas rich in natural and cultural resources but vulnerable to exploitation pressures. Berau Regency, East Kalimantan, is one of the regions with national strategic tourism potential, particularly in the marine ecotourism and nature tourism segments, supported by the presence of leading areas such as the Derawan and Maratua Islands and more than one hundred natural

tourist attractions in the form of islands, lakes, caves, and coastal ecosystems¹. Amid the post-extractive economic transformation agenda, the tourism sector is seen as a driver of non-mining economic growth, capable of increasing Regional Gross Product (PAD), job creation, and strengthening the local community-based economy². However, tourism development in Berau Regency faces complex and multidimensional structural challenges. Pressure on environmental carrying capacity, inequality in economic benefits, limited infrastructure and supporting technologies, and disparities in social capacity between regions indicate that unmanaged tourism growth has the potential to undermine long-term sustainability. The phenomenon of over-tourism in priority marine destinations, degradation of coastal ecosystems, dependence on domestic markets and seasonal patterns, and gaps in accessibility and basic facilities on the outermost islands are clear indications that tourism development achievements are still at the limit of sustainability (border status)³.

A sustainable approach to tourism is inextricably linked to the integration of four main pillars: ecology, economics, infrastructure, technology, and socio-culture⁴. These four aspects interact with each other and systematically determine a destination's competitiveness. Failure to manage one aspect can have a domino effect on others, such as environmental degradation that reduces the quality of tourist attractions or infrastructure limitations that hinder investment and the distribution of economic benefits to local communities⁵. Therefore, analytical instruments are needed that can simultaneously and evidence-basely capture the complex dynamics between these aspects. Sustainability analysis based on sensitivity indices and leverage is a relevant approach for identifying the sustainability position of tourism and the leverage factors that most determine changes in sustainability status. This approach not only describes existing conditions but also provides projections of future scenarios (leveraged conditions) as a basis for formulating more targeted, adaptive, and priority-based intervention strategies. In the context of Berau Regency, this kind of analysis is crucial, given the disparity in development between Tourism Development Areas (KPP) and Regional Tourism Strategic Areas (KSPD), as well as the strong interaction between the tourism sector and other sectors, such as mining, the environment, and transportation.

Based on this background, this article aims to comprehensively analyze the sustainability of tourism development in Berau Regency through a multidimensional approach encompassing ecological, economic, infrastructure, technological, and social aspects. Specifically, this study identifies the sustainability status of each aspect, determines the most influential key levers, and formulates a strategic transformation direction toward competitive, inclusive, and sustainable tourism. The results of this study are expected to provide a scientific basis for the formulation of integrated regional tourism development policies, while also contributing to the strengthening of the literature on sustainable tourism management in Indonesia's island regions and tropical ecotourism areas.

¹ Zahrotu A'yunin Basyir and others, 'Progress of Tourism Development in East Kalimantan Province, Indonesia: A Path to Realize the Sustainable Economic Sector', *KnE Social Sciences*, 2024 <<https://doi.org/10.18502/kss.v9i21.16682>>.

² Natasha Chassagne and Phoebe Everingham, 'Buen Vivir: Degrowing Extractivism and Growing Wellbeing through Tourism', in *Tourism and Degrowth*, 2020 <<https://doi.org/10.4324/9781003017257-10>>.

³ John Connell, 'Islands: Balancing Development and Sustainability?', *Environmental Conservation*, 2018 <<https://doi.org/10.1017/S0376892918000036>>.

⁴ I Gusti Bagus Rai Utama and others, 'Assessing the Impacts of Overtourism in Bali: Environmental, Socio-Cultural, and Economic Perspectives on Sustainable Tourism', *TourismSpectrum: Diversity & Dynamics*, 1.2 (2024) <<https://doi.org/10.56578/tsdd010202>>.

⁵ Paul Swuste and others, 'Domino Effects in Chemical Factories and Clusters: An Historical Perspective and Discussion', *Process Safety and Environmental Protection*, 2019 <<https://doi.org/10.1016/j.psep.2019.01.015>>.

2. Research Method

2.1. Research Approach and Design

This study uses a quantitative-descriptive approach with a Multi-aspect Sustainability Analysis (MSA) framework to comprehensively assess the sustainability level of tourism development in Berau Regency⁶. The MSA approach was chosen because it can simultaneously integrate various dimensions of sustainability and identify the most influential levers affecting changes in sustainability status. The analysis was conducted using the Exsimpro tool, which allows for structured, index-based simulations of existing conditions and future scenarios (leveraged conditions).

2.2. Research Location and Time

The research was conducted in Berau Regency, East Kalimantan, with a focus on tourism development areas (KPP) and regional tourism strategic areas (KSPD), which include marine, nature, and cultural tourism destinations. Data collection was conducted during the research year, subject to the availability and involvement of expert respondents.

2.3. Respondents and Sampling Techniques

The study involved 30 respondents, selected using purposive sampling. This technique was used to ensure that respondents possessed the competence, experience, and in-depth understanding of tourism development and management in Berau Regency. The respondent criteria included:

1. Officials or technical staff of local government agencies who handle tourism, the environment, and regional planning;
2. Academics and researchers with expertise in sustainable tourism, the environment, and regional economics;
3. Tourism practitioners, business actors, and destination managers; and
4. Representatives of communities or institutions actively involved in developing community-based tourism.

The number of respondents is considered adequate for MSA analysis because the assessment is based on expertise (expert judgment), not on statistical representation of the population⁷.

2.4. Research Variables and Indicators

Sustainability analysis is conducted on four main aspects:

1. Ecological aspects, including environmental carrying capacity and degradation, natural attractions and diversity, resource conservation, and sustainable tourism practices;
2. Economic aspects, including tourism contributions and growth, investment and local revenue (PAD), local community income, export potential, and downstream tourism product development;
3. Infrastructure and technology aspects, including transportation accessibility, basic facilities, public and tourist facilities, and supporting infrastructure development; and
4. Social aspects include community empowerment, cultural preservation, human resource capacity, and community partnerships.

⁶ Swuste and others.

⁷ Urbano Lorenzo-Seva and Pere J. Ferrando, 'MSA: The Forgotten Index for Identifying Inappropriate Items Before Computing Exploratory Item Factor Analysis', *Methodology*, 17.4 (2021) <<https://doi.org/10.5964/meth.7185>>.

Each indicator is assessed using an ordinal scale that reflects conditions ranging from very poor to very good, in accordance with the MSA guidelines.

2. 5. Data collection technique

Primary data was obtained through structured questionnaires and limited discussions with expert respondents. The questionnaires were designed to explore respondents' perceptions and assessments of the sustainability status of each indicator. Secondary data were collected from regional planning documents, statistical reports, tourism-related policies, and relevant scientific publications to support and validate the primary data⁸.

2. 6. Data Analysis Techniques

Data analysis was conducted using Exsimpro-based Multi-aspect Sustainability Analysis (MSA) with the following stages:

1. Compiling an indicator score matrix based on respondent assessments;
2. Calculating the sustainability index for each aspect and the entire tourism system;
3. Determining sustainability status into categories of unsustainable, less sustainable, borderline sustainable, and sustainable;
4. Leveraging sensitivity analysis to identify the indicators most influential on index changes, and
5. Simulating future conditions (leveraged conditions) to assess the potential for increased sustainability if interventions focus on key levers.

The analysis results are presented as indices, ordination graphs, and qualitative interpretations to strengthen the interpretation of the quantitative findings.

3. Results and Discussion

3.1. Ecological Aspects

The ecological sustainability index for tourism in Berau Regency is 50%, indicating a borderline level of sustainability. Simulations of future (leveraged) conditions show an increase in the index value to around 75%, but this achievement still experiences fluctuations in status with a tendency to return to the border zone, reflecting structural vulnerability despite leverage interventions (Figure 1). These findings illustrate Berau's extraordinary potential as a marine ecotourism destination with a wealth of more than 100 natural attractions (lakes, caves, islands) and a flagship theme of KPP3 (Derawan/Maratua), but it is constrained by pressures from over tourism and ecosystem degradation that threaten its long-term competitiveness.

⁸ Daniele Mantegazzi, Maria Giulia Pezzi, and Gabriella Punziano, 'Tourism Planning and Tourism Development in the Italian Inner Areas: Assessing Coherence in Policy-Making Strategies', in *Advances in Spatial Science*, 2021 <https://doi.org/10.1007/978-3-030-61274-0_22>.

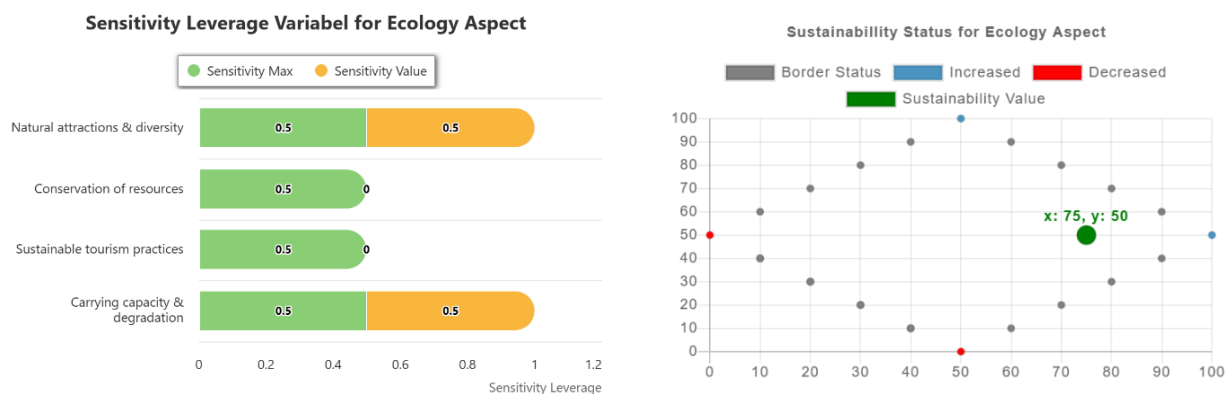


Figure 1. Sensitivity lever variables and sustainability status for ecological aspects

The results of the sensitivity leverage analysis show that carrying capacity & degradation and Natural attractions & diversity have the maximum leverage value (0.5), indicating that both dominantly influence overall ecological sustainability. This condition indicates that environmental capacity management and diversity preservation are strategic keys, while Resource Conservation and Sustainable Tourism Practices have a moderate influence that complements each other⁹. Carrying capacity in the KPP3 priority area is a critical factor, and accommodation consolidation on Derawan Island reflects adaptation to the pressure of marine ecosystem degradation, including coral reef sedimentation and coastal erosion driven by tourism intensity that exceeds carrying capacity.

Carrying capacity and degradation have become major bottlenecks due to the imbalance between capacity and the increasing number of tourist visits following the recovery of mobility. Derawan and Maratua experience clean water deficits during the peak season, while coral reef sedimentation increases due to accommodation waste, and erosion of the Biduk-Biduk coast threatens the coastline. Mangrove and marine wildlife conservation remains partial—only one-third of the KPP area is protected, and beach cleanup programs are limited to several sub-districts. Natural attractions and diversity, despite their rich quantity and potential, have not been optimally managed; 60% of natural destinations are vulnerable to conversion to coal mining, eroding annual ecotourism potential.

Sustainable tourism practices (index 2.8/5) are hampered by the suboptimal implementation of the 2016-2031 RIPARDA: the mangrove planting program is not yet balanced with the impact of deforestation due to tourism development, monitoring of carrying capacity still relies on manual methods without real-time technology, and the zoning of DPD/KSPD has not been fully ratified¹⁰. Resource conservation faces double pressure from resort expansion in KPP1-4, which clashes with the mining moratorium, whose implementation is weak, and from the absence of specific regulations on environmental carrying capacity despite the existence of the RIPARDA Regional Regulation. Cross-sectoral coordination among mining, environmental, and tourism agencies remains minimal, resulting in the current ecological sustainability index stagnating in the border zone.

Overall, the transformation of Berau's tourism ecological sustainability requires an integrated approach prioritizing carrying capacity through: 1) Real-time IoT digital monitoring

⁹ Adrienne B. Nicotra and others, 'Assessing the Components of Adaptive Capacity to Improve Conservation and Management Efforts under Global Change', *Conservation Biology*, 2015
<<https://doi.org/10.1111/cobi.12522>>.

¹⁰ Dede Aprylasari and Siti Azizah, 'Coastal Tourism's Impact on Local Livestock Farming at Bilik Sijile Beach, Baluran National Park', *Buletin Peternakan*, 49.1 (2025)
<<https://doi.org/10.21059/buletinpeternak.v49i1.99355>>.

for adaptive visitor quotas in marine destinations, 2) Green zoning KPP3 with 60% no-build zone areas to protect critical ecosystems, 3) Masterplan for conservation of natural attractions by accelerating the submission of the UNESCO Muhun Tunggal Geo Park. Integration of sustainable tourism practices through CHSE+Green Key international certification in resorts and homestays, along with resource conservation via a 500 ha/year mangrove eco-restoration corridor and an integrated marine wildlife program, will drive the ecological index towards >80% by 2028. This strategy will position Berau Regency as a premium ecotourism destination in East Kalimantan with a significant contribution to the non-mining sector's GRDP of +1.2%¹¹.

3.2. Economic Aspects

The sustainability index for Berau Regency's tourism economy is 60%, indicating borderline sustainability and a moderate recovery trend. Simulation results for future (leveraged) conditions indicate the potential for a significant jump to 100%, reaching the fully sustainable zone, albeit with minor fluctuations, reflecting the sector's high responsiveness to targeted interventions (Figure 2). These findings illustrate Berau's positive tourism momentum, supported by growth in accommodation and F&B and investment priorities in the Tourism Development Area (KPP), yet with limited market access for service exports and downstream tourism products.

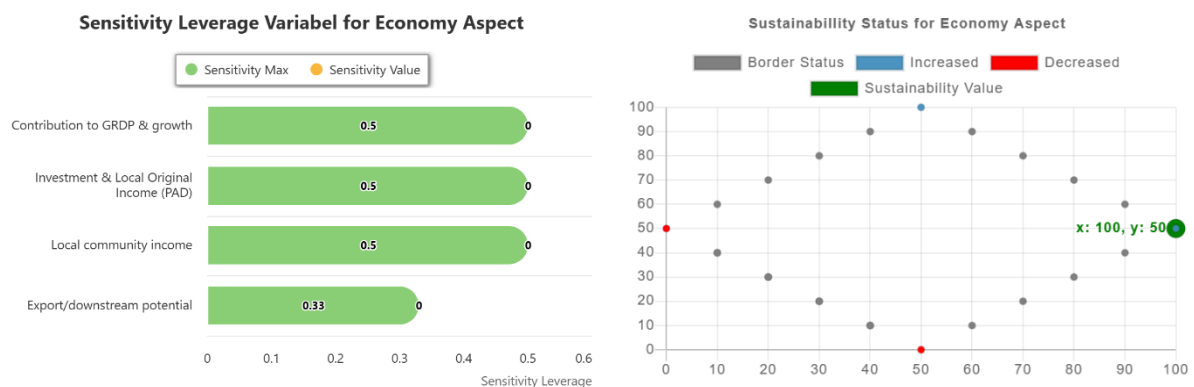


Figure 2. Sensitivity lever variables and sustainability status for economic aspects

Sensitivity leverage analysis identified Contribution & growth, Investment & PAD (Regional Original Income), and Local Community Income as the dominant variables (leverage 0.5), while Export/downstream Potential plays a supporting role (0.33). Contribution & growth are the main drivers through the recovery of tourist mobility and the expansion of culinary/accommodation businesses in priority KPP (Tourism Development Area) destinations such as KPP1 (urban Tanjung Redeb) and KPP2-3 (marine Derawan/Maratua), but still depend on seasonal patterns and the dominant domestic market. Investment & PAD have great potential in KPP2-3 ecotourism-themed resorts and KPP1 convention facilities, supported by the ease of one-stop digital licensing, although the realization of green investment is hampered by inter-regional logistics infrastructure.

¹¹ M. Nawawi and others, 'Community Potential Mapping for Activating and Developing of Social Entrepreneur Based on Local Commodity in Berau Regency, East Kalimantan', in *IOP Conference Series: Earth and Environmental Science*, 2020, CDXLIII <<https://doi.org/10.1088/1755-1315/443/1/012073>>.

Local community income from homestay/guide/souvenir MSMEs creates a significant multiplier effect on creative services, but is vulnerable to occupancy fluctuations, price competition among actors, and limited product diversification. Strong contribution & growth in priority KPP (Tourism Development Areas) but is depressed by dependence on basic services (room & board) versus premium experiences (dive packages/eco-tours); positive trends in Talisayan/Biduk-Biduk restaurants signal high demand, but the conversion of visits to stable income is not optimal due to weak local supply chains. Investment & PAD (Regional Original Income) is conducive through the PPP (Public-Private Partnership) scheme and tourism levies, but private ROI is hampered by KPP connectivity (Derawan-Tanjung Redeb logistics) and minimal special fiscal incentives for foreign investors.

Export/downstream potential has a moderate but strategic impact: KPP3's marine tourism packages and KPP1's cultural tourism packages have not yet reached international standards, the continuity of tour supply is disrupted by travel agent coordination, and the global branding of "Berau Ecotourism" is not yet mature. Berau's tourism economic transformation requires an integrated four-pillar approach: 1) KPP digital transformation through a cross-regional tour bundling marketplace (Derawan 3-day + Maratua diving + Tanjung Redeb heritage), 2) KPP2-3 green investment corridor with progressive tax incentives and tax holidays for sustainable resorts, 3) Premium downstream MSMEs via "Berau Wild" branding (mangrove-crafted souvenirs, organic Dayak cuisine), 4) Export of tourism services with international certification and global MICE (Meetings, Incentives, Conferences, Exhibitions) partners. Local income is stabilized through an integrated tourism cooperative and a 30:70 revenue-sharing model (investor: community). This holistic strategy projects a stable economic index of >90% over 3 years, positioning Berau as a growth pole for East Kalimantan tourism through an inclusive, sustainable non-mining service economy.

3.3. Infrastructure and Technology Aspects

The sustainability index for Berau Regency's tourism infrastructure and technology is 50%, indicating a borderline sustainability condition (border status) with a fluctuating trend, reflecting structural dependence on transportation accessibility as the main leverage (leverage 1.0) (Figure 3). The simulation results of future conditions (leveraged) show a potential increase to 75%, but still experience a partial decline in supporting indicators such as basic facilities and public facilities, illustrating the potential for connectivity between priority KPPs (Tourism Development Areas) that is constrained by disparities in basic facilities on the outermost islands and the digital divide in KSPDs (Regional Tourism Strategic Areas).

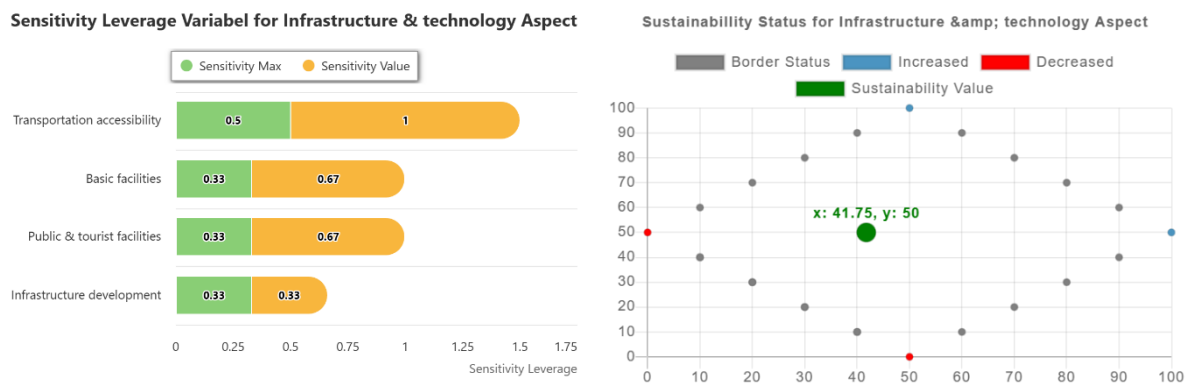


Figure 3. Sensitivity lever variables and sustainability status for infrastructure & technology aspects

Sensitivity leverage analysis places transportation accessibility as the dominant variable (leverage 1.0), followed by basic facilities and public & tourist facilities (0.67), while infrastructure development plays a supporting role (0.33). Transportation accessibility is the main driver connecting KPP1 (Tanjung Redeb urban) to KPP2-3 (Derawan/Maratua nautical) through a multimodal road/sea/air network and the Biduk-Biduk tourist pier, but the 2-3 hour lead time between Tanjung Redeb and Derawan, coupled with the volatility of sea crossings during strong winds, significantly reduces the competitiveness of the international MICE segment and budget-conscious backpackers. Basic facilities have high scalability potential through electricity/clean water/sanitation/telecommunications coverage of KSPD, but are constrained by network latency of the Maratua 4G signal (significant drop in peak season), a 40% clean water deficit in KPP3 at high occupancy, and limited PDAM pipe infrastructure (effective radius 300m from the beach) which hinders sustainable resorts.

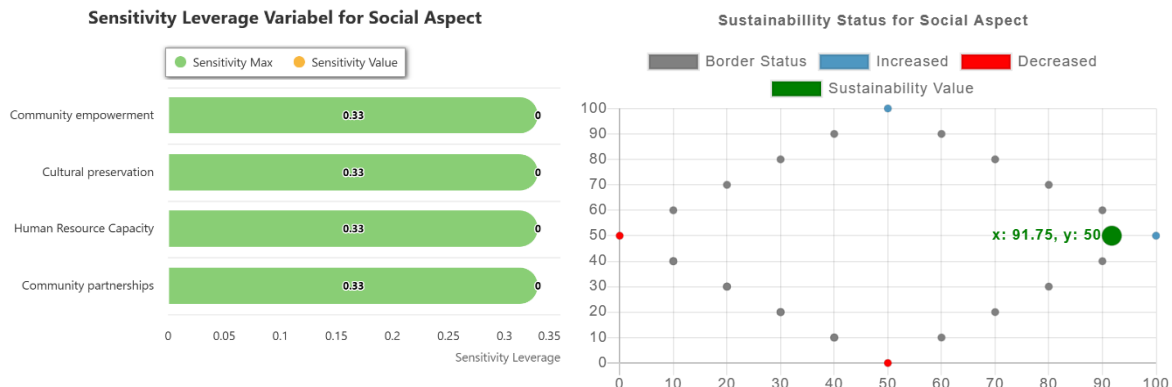
Public & tourism facilities achieved a partial compliance rate to parking/toilet/information standards per sub-district with strong spatial distribution of hotels in KPP3 Maratua/Biduk-Biduk, but experienced critical gaps in the multilingual information center of KPP4 (Segah/Kelay), rest areas on the Tanjung Redeb-Derawan main route that are not yet thematic, single-language directions for KPP2, and the absence of unisex prayer facilities for KPP3¹². Infrastructure development through the masterplan of DPD (Destination Development Area) RIPARDA 2016-2031 and DED (Detail Engineering Design) was hampered by cross-sector institutional fragmentation (mining-transportation-tourism), budget allocation disparity in the APBD between KPP1→KPP4 priorities, and minimal implementation of the one-gate policy accessibility pattern. The isolation of KPP4 ecotourism access via high-cost speedboat charters, the suboptimal scalability of the KPP3 resort solar power plant, and the absence of greywater treatment at the tourist pier further reduce the overall carrying capacity of the infrastructure.

The transformation of Berau tourism infrastructure & technology requires a systemically integrated Smart Island 4.0 approach (Mei, 2023): integrated mobility hub KPP with Tanjung Redeb-Derawan electric shuttle (30-minute lead time), hydrofoil speedboat KPP3 (50 pax capacity), smart utility grid IoT zero-waste water metering KPP3 with PLTS microgrid Maratua (5 MWp) and 5G blanket coverage KSPD, multilingual AR digital signage KPP1-4 with real-time KPP-linked navigation application, block chain smart contract green certification resort, and fast-track DED PPP eco-pier Biduk-Biduk carbon neutral (ship capacity 200 GT). This holistic strategy not only accelerates the implementation of the DED DPD through the Japanese Shinkansen tourism scheme but also realizes the "Kalimantan Digital Archipelago" - a tourism destination with the fastest seamless connectivity in East Kalimantan, KPP investment ROI +35%, KPP3 occupancy +25%, and a local economic multiplier effect +40% that supports the dual premium segments of international MICE as well as digital-native backpackers through integrated future-proof infrastructure.

3.4. Social Aspects

The social sustainability index for tourism in Berau Regency is 50%, indicating a borderline sustainability condition with a moderate upward trend (leveraged simulation: $x=41.75$; $y=50$) (Figure 4). This result reflects the dynamic balance between the potential for community empowerment through community-based tourism in priority Tourism Development Areas (KPP) and the structural constraints of human resource capacity and cultural preservation that are not evenly distributed across regions, particularly the disparity between marine destinations in KPP3 and remote ecotourism in KPP4.

¹² Diaz Pranita and others, 'Blockchain Technology to Enhance Integrated Blue Economy: A Case Study in Strengthening Sustainable Tourism on Smart Islands', *Sustainability (Switzerland)*, 15.6 (2023) <<https://doi.org/10.3390/su15065342>>.



Sensitivity leverage analysis revealed unique characteristics of the social aspect, with all four indicators (Community Empowerment, Cultural Preservation, Human Resource Capacity, Community Partnership) exerting equal influence (leverage 0.33), indicating a multidimensional nature that requires simultaneous, holistic intervention. Community empowerment through training programs for homestay management, local tour guides, and hospitality showed significant progress in KPP3 Derawan/Maratua with the activation of Pokdarwis and BUMDes tourism, but participation in destination management was still low in KPP4 Segah/Kelay due to the lack of tourism awareness education programs and access to market information. Cultural preservation was relatively strong in the heritage site KPP1 (Makam Raja Alam, Sambaliung Sultanate) with a consistent annual Erau festival, but the integration of Dayak Leleng traditions and local traditional ceremonies into KPP4 ecotourism packages was not optimal, resulting in fragmented cultural tourism potential.

Human resource capacity is reflected in the percentage of trained local guides/tourism SMEs (target 30%) and the quality of hospitality (survey scale ≥ 4.2), supported by national competency certification, but low foreign language proficiency (especially English/Mandarin) in KPP2-3 hinders premium foreign tourist services, while community partnerships through community-based tourism schemes and hotel CSR programs create progressive revenue sharing, but the level of local tourist satisfaction decreases due to immature coordination of tourism cooperatives and unequal distribution of benefits between community groups¹³. Community empowerment is effective in the maritime cluster of KPP3, with homestay revenue accounting for 25% of total local tourism business, but significant income disparities with large resorts in KPP1 create social tensions, and active Pokdarwis cover only 40% of identified tourist areas. Cultural preservation is strengthened by the Erau festival and the digital documentation of the Gunung Tabur Museum, but the lack of online accessibility and integration into an integrated cultural trail reduces the appeal to Generation Z.

The transformation of Berau's social tourism requires a systemically integrated 360° Human Capital approach: an integrated inter-KPP vocational program including digital marketing homestays (Google My Business integration), TOEIC 500+ certified tour guides with AR cultural storytelling, cross-regional cultural festivals with 70:30 revenue sharing (community:private sector), block chain-based CSR partnerships with transparent funding (resort CSR must allocate 25% to local human resources), digital tourism cooperatives for real-time revenue sharing via mobile wallet, and community dashboard-based Social Return on

¹³ Dede Aprylasari, Siti Azizah, and Norsida Man, 'Tourism Impact of on Beef Cattle Farmers Community in Bilik Sijile Beach, Baluran National Park', *Review of Urbanism and Architectural Studies*, 23.1 (2025) <<https://doi.org/10.21776/ub.ruas.2025.023.01.2>>.

Investment (SROI) monitoring. This holistic strategy not only increases the social index by >80% in 3 years but also positions Berau as a model for socially inclusive tourism in East Kalimantan with community participation in destination management reaching 60%, a social multiplier of +35% through a sustainable partnership ecosystem, and the creation of 5,000 new jobs in the creative services sector that are inclusive across generations.

4. Conclusion

Based on analysis using the Multi-aspect Sustainability Analysis (MSA) method with Exsimpro software, the system under study is generally still in the less sustainable category. This condition indicates that sustainability performance between aspects is not yet optimal, and there are still gaps in achievement between one aspect and another. Leverage analysis identified several sensitive attributes that have a dominant influence on the low sustainability index value, making them critical targets for improving sustainability. This finding confirms that improving sustainability cannot be done piecemeal, but rather requires an integrated, priority-based management approach. Therefore, strategic interventions are needed, including strengthening actors' capacity, improving governance, and optimizing resource utilization in line with regional characteristics. The implementation of this strategy is expected to gradually increase the sustainability index value towards the sustainable category in the medium- and long-term.

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