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-RESEARCH ARTICLE-

PREDICTING THE IMPACTS OF TOURISM DEVELOPMENT ON LAND USE DYNAMICS IN MALINO, GOWA REGENCY: PRIORITY ZONING STRATEGY BASED ON SPATIAL CONFLICTS, SWOT, AND AHP ANALYSIS

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─Abstract─

Tourism expansion in environmentally sensitive regions, such as Malino in Gowa Regency, Indonesia, has intensified over the last ten years, generating economic benefits while simultaneously increasing land use conflicts and governance challenges. Rapid, often unregulated spatial development has converted forests, agricultural lands, and conservation zones into settlements and tourism infrastructure, frequently diverging from the regional spatial plans (RTRW). To forecast future land use changes and support sustainable tourism-oriented planning, this research employed Markov Chain and Cellular Automata–Markov (CA–Markov) modelling to simulate land use scenarios for 2034 and 2044, using data from 2015 to 2024. The findings indicate a persistent

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reduction in forest cover alongside the growth of settlements and dryland agriculture, particularly concentrated along primary access routes and tourism clusters. Analysis of transition probability matrices highlighted prevailing land conversion trends, whereas CA–Markov simulations incorporated key drivers (settlements and road networks) and constraints (protected forests, slope, and water bodies) to improve spatial realism. Projections suggest that around 19% of land within protected zones is vulnerable to utilisation inconsistent with zoning regulations, reflecting ongoing spatial conflicts. Overlay and conflict mapping highlight governance challenges, including overlapping institutional mandates, weak enforcement, and limited community participation, revealing a gap between planning and implementation. To address these issues, this study integrates SWOT analysis with the Analytical Hierarchy Process (AHP) to prioritise zoning strategies. A total of twenty strategic alternatives were evaluated, with strict land-use control to prevent illegal conversion identified as the highest priority, followed by eco-tourism development based on landscape potential, participatory zoning control, and climate-adaptive spatial planning. This study proposes a replicable framework that integrates spatial forecasting, conflict analysis, and multi-criteria decision-making to support adaptive, participatory, and sustainability-oriented land-use governance in highland protected tourism areas.

Keywords: Predicting Use Change, Spatial Conflict, Strategic Zoning Policy.

INTRODUCTION

Tourism has emerged as a key driver of regional economic growth in Indonesia, particularly within ecologically sensitive highland zones such as Malino in Gowa Regency. The increasing demand for tourism has accelerated investments in supportive infrastructure including hotels, restaurants, recreational facilities, and access roads resulting in substantial land-use transformation, often at the expense of agricultural and forested landscapes (Ai et al., 2025). While these changes provide economic gains, they simultaneously pose ecological risks such as deforestation, habitat fragmentation, and heightened susceptibility to environmental hazards. This tension between economic expansion and environmental degradation reflects broader patterns in tourism-intensive regions across Indonesia, including Java, and presents persistent challenges for spatial planners and policy developers.

Previous research highlights that tourism can enhance land-use efficiency when integrated within sustainable planning frameworks; however, unregulated expansion frequently triggers ecosystem degradation and biodiversity loss. (Hall, 2010) emphasises the necessity of conservation-oriented tourism development to alleviate environmental pressures, especially in ecologically fragile locations. In Malino, land-cover assessments over the past decade reveal notable reductions in secondary forest areas, complicating conservation within designated strategic zones (Chen et al., 2021). These trends underline the escalating conflict between tourism growth and ecological

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sustainability. Spatial assessments demonstrate that the development of tourism infrastructure substantially reshapes land-use patterns. Sentinel-2 imagery for Malino from 2015 to 2024 indicates a decline in forested areas from 5,334.64 ha in 2019 to 4,938.59 ha in 2024, accompanied by the expansion of settlements and horticultural plantations (Hjalager, 2020). These transformations diminish ecological stability and elevate the risk of hazards such as landslides, particularly in steep terrains where vegetation serves a protective function (Morea, 2021). Comparable patterns are observed in other tourism-dense regions, where economic priorities gradually supplant traditional agricultural and ecological land functions (Ai et al., 2025).

Beyond physical land conversion, Malino faces critical spatial governance challenges. Discrepancies between actual land use and legally designated zoning under the RTRW are increasingly apparent. Despite large areas being formally classified as conservation and agroforestry zones at both provincial and regency levels, unauthorized tourism facilities and residential developments have proliferated. Overlay analysis indicates that roughly 19% of land within the Malino Nature Tourism Park is currently utilised in ways inconsistent with spatial regulations, including settlements, agricultural expansion, and infrastructure encroachment in protected zones (Hjalager, 2020). These inconsistencies reflect weak policy enforcement and misalignment between planning objectives and field implementation, undermining the efficacy of RTRW as a regulatory instrument (Katsanevakis et al., 2011).

Such spatial misalignments generate multidimensional land-use conflicts encompassing institutional, operational, and value-based dimensions. Institutional conflicts arise from overlapping mandates among the Ministry of Environment and Forestry, tourism authorities, and regional planning agencies, producing fragmented governance and policy inconsistencies. Operational conflicts emerge through zoning violations, inadequate monitoring, and contradictory land-use practices. Value-based tensions occur between local communities, government bodies, and private investors, as residents often perceive land as a cultural and livelihood resource, whereas external actors treat it as a commercial asset, resulting in disputes over land rights, exclusion from decision-making, and inequitable benefit distribution (Ai et al., 2025). The absence of participatory spatial planning mechanisms further exacerbates these conflicts and diminishes social legitimacy.

The environmental and social consequences of unregulated tourism-induced land transformation underscore the need for spatially informed planning approaches. Rapid land-use change in tourism hotspots can reduce ecological value, disrupt biodiversity corridors, and compromise ecosystem functions (Katsanevakis et al., 2011). In Malino, satellite-based monitoring from 2015 to 2024 records a 3.65% decline in forest cover and increasing pressures on conservation zones due to uncoordinated development (Baja, 2012). These dynamics indicate the importance of integrated spatial planning frameworks capable of balancing tourism growth with ecological thresholds and long-

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term sustainability (Ai et al., 2025). Land-use conflicts in Malino also produce substantial social repercussions, including restricted access for communities to traditional lands, limited engagement in spatial decision-making, and uneven distribution of tourism benefits. Evidence suggests that land transformation processes excluding local participation exacerbate socio-economic inequality and impede inclusive development (Katsanevakis et al., 2011). Similarly, zoning policies implemented without participatory mechanisms can intensify tenure disputes and erode social trust (Morea, 2021). Accordingly, participatory and data-driven spatial planning is essential to reconcile conservation objectives with local livelihoods and tourism-driven economic development.

Despite growing literature on tourism-related land-use change and spatial governance, integrative research frameworks remain scarce. Most studies either focus on land-cover change using GIS and remote sensing (Ai et al., 2025) or examine policy and institutional dimensions of land management (Morea, 2021). with few bridging predictive spatial modelling, conflict analysis, and strategic policy prioritisation. For example, Katsanevakis et al., (2011) analyses tourism-induced land-use impacts from a planning perspective but does not incorporate predictive modelling or conflict resolution tools. (Morea, 2021) examine spatial mismatches and conflicts in Malino's ecotourism area through SWOT analysis but lack a structured prioritisation mechanism such as the AHP for decision support. This fragmentation limits the capacity of spatial planning frameworks to address land-use conflicts comprehensively and proactively.

Research Novelty and Contribution

This study addresses the identified gaps by presenting an integrated analytical framework that combines spatial forecasting, conflict mapping, and strategic zoning prioritisation to support sustainable governance in ecotourism regions. The contribution of this research is novel in three principal ways. First, it employs CA–Markov spatio-temporal modelling to anticipate future land-use trajectories under tourism expansion, facilitating early detection of potential pressures on conservation zones. Second, it systematically identifies spatial conflicts by overlaying projected land-use changes with RTRW, offering empirical insights into governance discrepancies and regulatory shortcomings. Third, it extends policy-oriented analyses by combining SWOT assessment with the AHP, enabling the prioritisation of zoning strategies grounded in expert evaluation and multi-criteria decision-making.

From a theoretical standpoint, the study enriches the literature on tourism-induced land-use transformation by linking geospatial modelling with spatial governance and decision-support frameworks. Practically, it provides actionable guidance through prioritised zoning strategies that reconcile conservation objectives with tourism-driven economic growth. By positioning Malino as a representative highland ecotourism destination experiencing rapid development pressures, the framework developed here

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offers a replicable approach applicable to other environmentally sensitive tourism areas in Indonesia and comparable global contexts.

Research Objectives

This study seeks to investigate the spatial consequences of tourism development in Malino, Gowa Regency, employing an integrated geospatial and policy-oriented methodology. The specific objectives are:

1. To forecast land-use changes driven by tourism expansion using spatial modelling techniques, thereby identifying patterns of land-cover transformation between 2015 and 2024.
2. To detect and map spatial conflicts arising between conservation functions and tourism-related development by examining discrepancies between actual land use and RTRW.
3. To develop priority zoning strategies through the combination of SWOT analysis and AHP, facilitating policy alignment between conservation objectives and economic development within protected areas.

LITERATURE REVIEW

Tourism Development and Land-Use Transformation

Tourism development is widely acknowledged as a major catalyst for land-use transformation, particularly in ecologically sensitive regions. The expansion of tourism infrastructure often converts land previously used for agriculture, forestry, or conservation into built-up areas, altering spatial configurations and ecological functions. Wu et al., (2020) contends that tourism-driven land-use changes frequently prioritise short-term economic benefits over long-term spatial sustainability, especially in rapidly growing destinations. Although tourism can enhance land-use efficiency within well-regulated planning frameworks, unregulated expansion tends to accelerate deforestation, habitat fragmentation, and broader ecological degradation. Empirical research in developing countries indicates that tourism-induced land transformation is rarely linear or environmentally neutral. Chen et al., (2021) show that land-cover changes associated with tourism expansion often led to the reduction of secondary forests, which are critical for sustaining ecological resilience. Likewise, (Agustí, 2019) demonstrate that GIS and remote sensing techniques can effectively track spatial patterns of land conversion, though these analyses often lack integration with governance and policy considerations. In Indonesia, tourism growth in highland and rural areas has intensified pressure on forested and agricultural lands, reflecting global patterns in which economic priorities progressively displace traditional land uses (Tan & Wang, 2025).

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Zoning Conflicts and Institutional Overlap in Tourism Areas

Land-use changes in tourism destinations frequently give rise to zoning conflicts caused by inconsistencies between planned and actual land use. These conflicts are particularly evident in areas where conservation objectives coincide with tourism-driven development. Baja, (2012) notes that spatial plans often fail as effective regulatory tools when enforcement is weak or institutional mandates overlap. In many instances, zoning regulations exist formally but are applied inconsistently, permitting unauthorized land conversion within protected or conservation zones. Research in Indonesia indicates that institutional fragmentation further intensifies zoning conflicts. Suprianto & Dhafir, (2020) demonstrate that overlapping responsibilities among environmental agencies, tourism authorities, and regional planning institutions generate governance gaps that weaken spatial control. Similarly, Bussard & Reynard, (2022) report spatial mismatches in Malino's ecotourism area, where tourism infrastructure and settlements encroach on areas officially designated for conservation and agroforestry. These observations illustrate a wider governance challenge in tourism destinations, in which economic development priorities frequently take precedence over spatial planning regulations.

Spatial Governance and Spatial Justice in Land-Use Planning

Spatial governance encompasses more than the technical allocation of land, extending to issues of participation, equity, and social legitimacy. Research indicates that land-use planning processes excluding local communities often exacerbate spatial injustices, particularly in tourism-driven regions experiencing rapid increases in land value. Garvey et al., (2022) highlight that land transformation conducted without community involvement frequently marginalises residents and channels economic benefits predominantly to external investors. Likewise, Hanna et al., (2025) stress that zoning policies applied without inclusive mechanisms may intensify land tenure disputes and weaken trust among stakeholders. From a governance standpoint, spatial justice is closely tied to the distribution of environmental risks and economic benefits arising from land-use decisions. Al hothaufi et al., (2025) show that land conversion on steep or ecologically sensitive slopes disproportionately exposes local communities to hazards such as landslides and soil erosion. In tourism-intensive areas, these risks are typically borne by residents, whereas economic gains accrue largely to private developers. These imbalances underscore the critical need to incorporate social considerations into spatial planning frameworks.

Research Gaps and Positioning of This Study

The reviewed literature highlights several notable gaps. First, research on tourism-driven land-use change has largely concentrated on historical land-cover transformations using GIS and remote sensing, with relatively few studies employing predictive spatial modelling to anticipate future land-use pressures (Popovici et al.,

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2013; Wagistina, 2025). Second, although zoning conflicts and overlapping institutional responsibilities are well documented (Baja, 2012) into spatial decision-support systems capable of guiding policy prioritisation. Third, investigations into governance and spatial justice stress participation and equity but frequently lack spatially explicit analyses that link governance shortcomings to tangible land-use outcomes. This study addresses these gaps by integrating spatio-temporal land-use forecasting, spatial conflict analysis, and multi-criteria decision-making. By combining CA–Markov modelling with conflict overlay mapping and SWOT–AHP-based zoning prioritisation, the research advances current knowledge in three principal ways: (1) it moves beyond descriptive land-use assessments toward predictive and policy-relevant spatial planning; (2) it operationalises governance and zoning conflicts through spatially explicit mapping; and (3) it provides a structured framework to prioritise zoning strategies that reconcile tourism development with conservation and spatial justice objectives. In doing so, the study delivers an integrative and replicable approach for sustainable land-use planning in ecotourism destinations.

METHOD

Study Area

The study area is situated in Malino, Gowa Regency, South Sulawesi, Indonesia, a highland ecotourism destination distinguished by a cool climate, mountainous terrain, and extensive tropical forest cover. The region comprises a diverse mosaic of land uses, including agricultural fields, horticultural plantations, settlements, and conservation zones that serve as critical habitats for local biodiversity. Traditionally, Malino's economy has relied on agriculture and plantation-based livelihoods; however, rapid tourism development over the past decade has accelerated land-use changes and intensified pressures on ecologically sensitive areas. Malino's tourism appeal stems from both natural attractions, such as waterfalls, tea plantations, forest trails, and scenic highland landscapes, and cultural and artificial tourism sites. This growth has driven the expansion of tourism-related infrastructure, including accommodations, restaurants, parking areas, and recreational facilities. According to data from the Gowa Regency Tourism and Culture Office, international tourist arrivals increased from zero in 2015 to 859 in 2024, while domestic visits surged from 13,360 to 467,596 over the same period. Such rapid increases in visitor numbers signal an expanding tourism footprint, with substantial implications for land-use dynamics, spatial conflicts, and socio-ecological sustainability.

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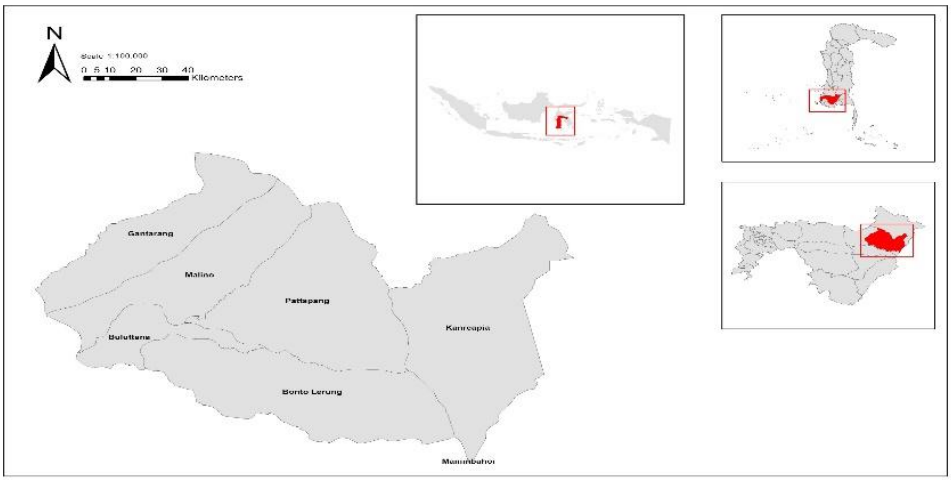

Figure 1: Study Area Location

Research Procedures

The study employed a sequential and integrated spatial analysis framework comprising six principal stages, as depicted in the research flowchart.

Preliminary Data Collection and Study Area Delineation

The initial stage involved defining the study boundary encompassing Malino and adjacent sub-districts within Gowa Regency. Both spatial and non-spatial baseline data were collected, including administrative boundaries, land-use maps, tourism zoning, road networks, topographic datasets, and RTRW. These datasets formed the foundational spatial database for subsequent modelling, conflict assessment, and strategic zoning formulation.

Remote Sensing and GIS-Based Land-Use Classification and Change Detection

To assess land-use dynamics from 2015 to 2024, Sentinel-2 multispectral satellite imagery was employed. Image pre-processing steps included geometric correction, atmospheric correction, and cloud masking to ensure radiometric and spatial consistency. Land-use classification utilised a supervised classification approach with the Maximum Likelihood algorithm, selected for its robustness and interpretability in land-cover studies. Six land-use categories were delineated based on regional land characteristics and planning classifications: (1) forest, (2) agriculture, (3) horticultural plantation, (4) settlement/built-up area, (5) tourism infrastructure, and (6) water bodies. Training samples were collected through stratified random sampling, with approximately 60–80 pixels per class, derived from high-resolution imagery and field verification. Classification accuracy was evaluated using an independent validation dataset, with metrics including Overall Accuracy (OA), User's Accuracy (UA),

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Producer's Accuracy (PA), and the Kappa coefficient obtained from a confusion matrix. Only maps achieving an overall accuracy above 80% were retained for further analysis. Post-classification comparison was subsequently applied in ArcGIS 10.8 to identify land-use transitions over the study period.

Spatial Conflict Identification and Mapping

Spatial conflict analysis was performed by overlaying classified land-use maps with zoning allocations specified in the RTRW. Areas where actual land use diverged from designated zoning functions were identified as spatial mismatches. These mismatches were categorised into three types: policy-based conflicts (regulatory inconsistencies), operational conflicts (implementation and enforcement deficiencies), and value-based conflicts (differences in stakeholder interests). Field observations were conducted to validate conflict locations, and qualitative insights were collected through stakeholder interviews to contextualise the causes and implications of the identified conflicts.

SWOT Analysis for Strategic Issue Identification

A SWOT analysis was conducted to synthesise internal and external factors influencing land-use governance in Malino. Internal factors (strengths and weaknesses) were derived from spatial analysis outcomes, ecological conditions, and institutional capacity assessments, while external factors (opportunities and threats) were identified based on tourism trends, policy frameworks, and environmental risks. The SWOT matrix served as the conceptual basis for subsequent strategy prioritisation using AHP.

Priority Zoning Formulation Using the Analytical Hierarchy Process (AHP)

The outcomes of the SWOT analysis were incorporated into an AHP framework to prioritise zoning strategies. A hierarchical decision structure was developed comprising three levels: (1) the overall goal (sustainable zoning for tourism and conservation), (2) evaluation criteria derived from SWOT factors, and (3) alternative zoning strategies. Expert respondents from the domains of spatial planning, forestry, and tourism participated in pairwise comparisons of criteria and alternatives.

Validation and Synthesis

The final stage involved validating spatial and strategic outputs through field verification and stakeholder feedback. Results from spatial modelling, conflict analysis, and AHP-based prioritisation were integrated to formulate policy recommendations emphasising participatory governance, ecological sustainability, and inter-sectoral coordination.

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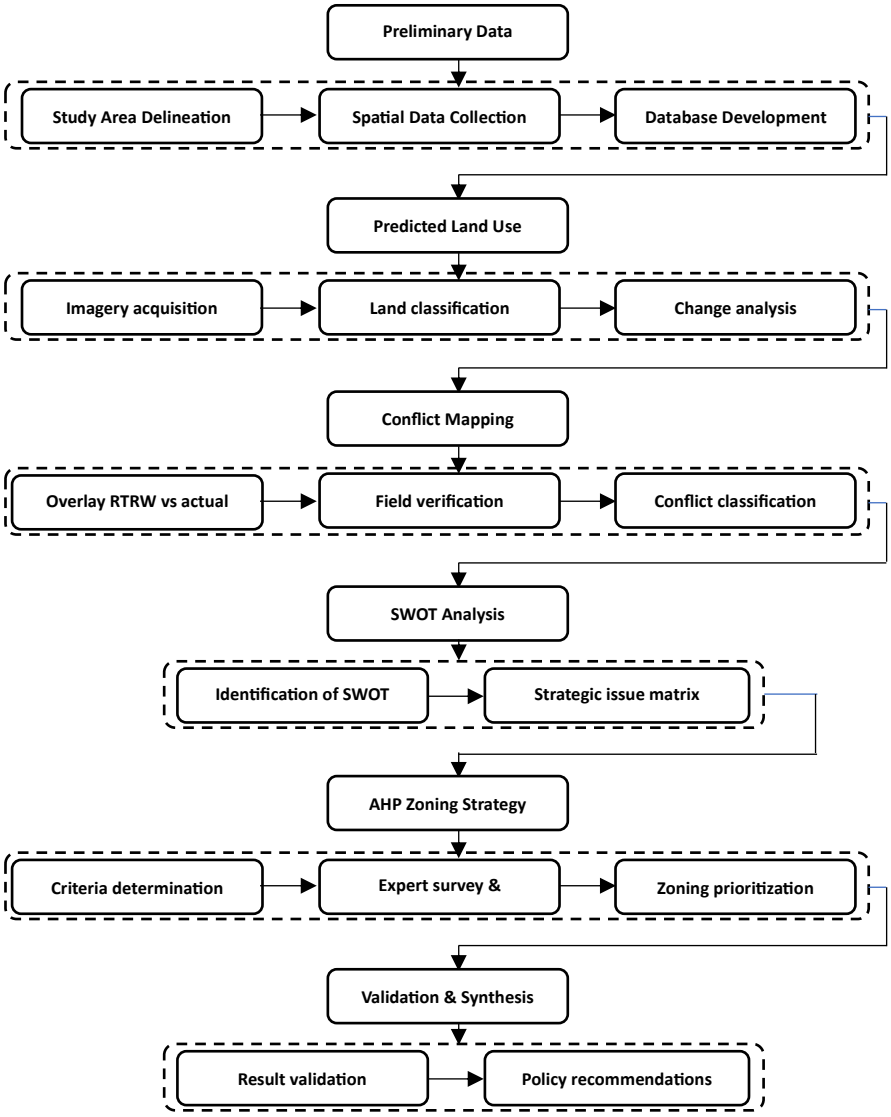

Figure 2: Research Procedure Flowchart

Data Analysis

Predicting Land-Use Change Using Markov Chain and CA–Markov Modelling

Land-use change prediction was performed for the Strategic Development Area (KSP) of Malino Nature Tourism Park and its surrounding regions using land-use maps from 2018, 2020, and 2022. A Markov Chain probability analysis was employed to quantify the likelihood of transitions between land-use classes over time. Key outputs included a Transition Probability Matrix and a Transition Area Matrix, generated by overlaying

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the 2018 and 2023 land-use maps. The year 2023 was chosen as the validation reference because it represents the most recent classified land-use map supported by reliable field verification. Model validation involved comparing the simulated 2023 land-use map with the observed 2023 map, utilising a confusion matrix to calculate OA, UA, PA, and the Kappa coefficient. Future land-use projections for 2042 were generated using the Cellular Automata–Markov (CA–Markov) model, which integrates temporal transition probabilities with spatial neighbourhood rules. Driving factors included proximity to existing settlements and transportation networks, reflecting their influence on urban and tourism-related expansion. Constraints encompassed slope, protected forest areas, and water bodies, which restrict land conversion. Suitability maps were standardised and weighted prior to integration into the CA–Markov model to ensure realistic spatial simulation.

Spatial Conflict Identification and Stakeholder Analysis

Potential future conflict areas were identified through spatial overlay analysis of simulated land-use maps and RTRW zoning plans. Semi-structured interviews were conducted with seven key stakeholders, comprising local community representatives, government officials, and tourism operators. Interview discussions focused on drivers of land-use change, zoning enforcement, institutional coordination, community participation, and perceived socio-environmental impacts. Thematic coding was applied to analyse the interview data, enabling qualitative insights to be systematically linked with spatial conflict patterns. This integration enhanced the interpretation of spatial mismatches by incorporating stakeholder perspectives into the analysis.

Strategic Zoning Prioritization Using SWOT and AHP

For strategic zoning prioritisation, SWOT factors were translated into AHP criteria and sub-criteria. Expert judgments were aggregated using the geometric mean method, commonly employed to synthesise multiple pairwise comparison matrices. Consistency of expert evaluations was assessed using the Consistency Ratio (CR), with $CR < 0.10$ considered acceptable. The final outcome of the SWOT–AHP analysis was a ranked list of zoning strategies aimed at balancing tourism development with conservation objectives. These strategies provide evidence-based guidance for spatial planning and policy harmonisation in Malino's ecotourism region.

RESULT

Predicting Land Use Change in Malino Ecotourism Strategic Area (2034–2044)

The projection of land-use changes in the Malino Ecotourism Strategic Area for 2034 and 2044 offers a forward-looking perspective on spatial dynamics under ongoing tourism development and regulatory measures. Using CA–Markov modelling calibrated with land-use data from 2015–2024, future scenarios were simulated by incorporating

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spatial drivers (proximity to roads and settlements) and constraint factors (slope, protected forest zones, and water bodies). The projected maps reveal a continued decline in forest cover, decreasing from 4,939.94 ha in 2023 to 4,880.97 ha by 2044. Although the decline is moderate, it indicates sustained anthropogenic pressure in peripheral conservation areas, particularly where tourism-related accessibility is increasing.

In contrast, rice field areas are anticipated to expand markedly from 1,002.13 ha to 1,672.01 ha over the same period. This growth is interpreted as the combined effect of agricultural intensification policies and the conversion of degraded drylands or abandoned plots into productive food-crop zones, reflecting a regional prioritisation of food security alongside tourism development. A distinctive pattern emerges in the settlement category, which rises sharply to 762.51 ha in 2034 before decreasing to 307.21 ha in 2044. This fluctuation does not indicate a modelling error; rather, it reflects a policy-driven zoning scenario embedded in the simulation. The initial increase corresponds to continued growth of tourism infrastructure under prevailing development trends, while the subsequent reduction represents the enforcement of stricter spatial zoning regulations, conservation restoration initiatives, and reclassification of certain built-up areas into mixed-use agroforestry or controlled tourism zones. This scenario aligns with planned spatial interventions aimed at mitigating uncontrolled settlement expansion within conservation-sensitive regions.

Table 1: Predicted Land Use in Malino Strategic Area (2023–2044)

No	Land Use Category	2023 (ha)	2024 (ha)	2034 (Predicted)	2044 (Predicted)
1	Forest	4,939.94	4,938.83	4,786.54	4,658.94
2	Shrubland	409.68	929.79	1,015.94	1,065.88
3	Plantation / Garden	1,978.94	1,978.88	2,032.00	2,085.77
4	Dryland Farming / Field	2,249.24	2,252.49	2,290.24	2,320.83
5	Rice Field	570.99	1,001.35	976.49	952.15
6	Settlement and Activity Areas	933.19	573.95	621.8	648.84
7	Vacant / Open Land	81.41	409.24	361.69	352.29
8	River	1,003.59	81.53	81.58	81.58

*Note: The classification in 2034 distinguishes between "Dry Land Agriculture" and "Mixed Agriculture", both approximating fields and plantation/garden functions.

Several productive land-use classes are projected to expand during the simulation period. Plantation areas increase from 1,929.45 ha in 2015 to 2,085.77 ha in 2044, while dryland farming areas increase from 2,207.83 ha to 2,320.83 ha. These increases indicate gradual agricultural intensification and the conversion of vacant or transitional land into productive land uses. Settlement and activity areas also expand steadily from 525.11 ha in 2015 to 648.84 ha in 2044, reflecting the growing demand for tourism-

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related infrastructure and supporting economic activities in the Malino highland tourism corridor.

Shrubland areas increase substantially from 791.56 ha in 2015 to 1,065.88 ha in 2044, indicating the emergence of transitional landscapes associated with forest degradation or land conversion processes. Meanwhile, rice field areas exhibit a gradual decline from 1,027.21 ha in 2015 to 952.15 ha in 2044, suggesting moderate pressure on irrigated agricultural land despite spatial restrictions applied within the model. Vacant or open land also declines significantly, indicating progressive land utilization for agricultural or settlement purposes.

Overall, the projected land-use dynamics indicate a gradual transformation of the Malino landscape from natural land cover toward more intensive agricultural and settlement uses. These changes reflect the combined influence of tourism development, agricultural expansion, and spatial accessibility within the highland ecotourism area. The spatial distribution of these projected changes is illustrated in Figure 3, which shows the progressive transformation of forest and open land into shrubland, agricultural land, and settlements across the study area.

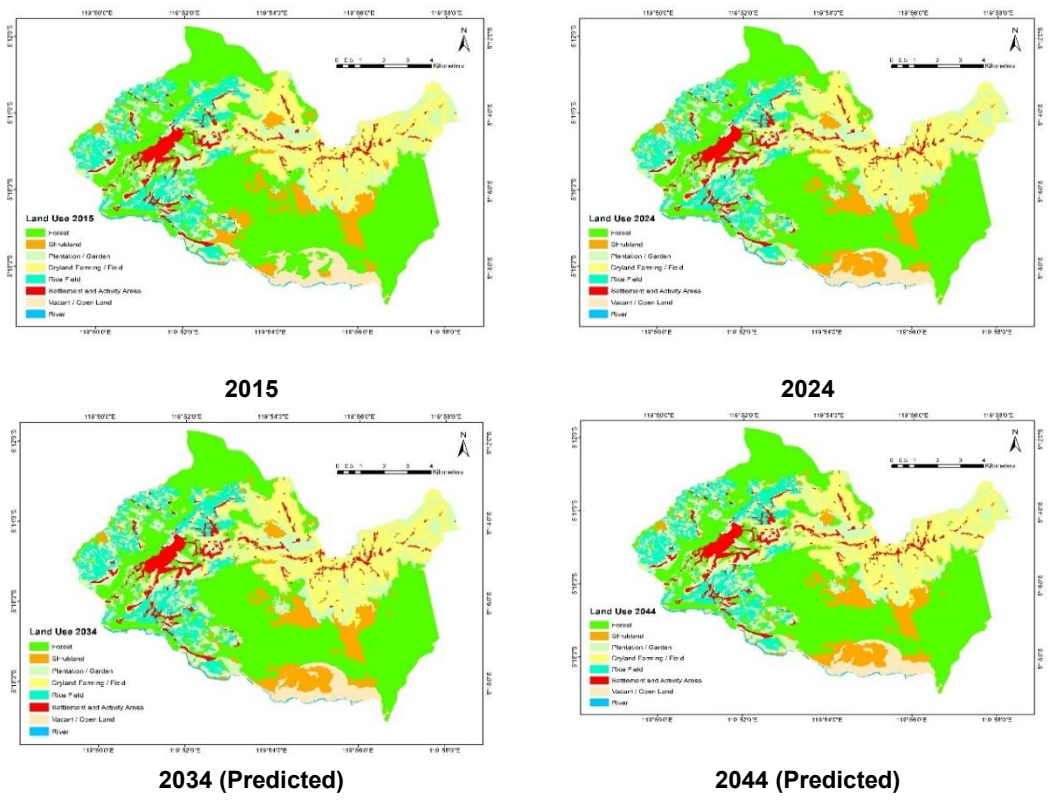

Figure 3: Predicting Land Use Change in Malino Ecotourism Strategic Area

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Spatial Conflict Analysis

Spatial Utilization Conflict in the Malino Ecotourism Strategic Area

Spatial utilization conflicts in the Malino Ecotourism Strategic Area primarily arise from discrepancies between designated land-use zoning (RTRW) and actual land-use practices. Overlay analysis indicates that conflicts are most acute in areas where conservation zones and limited production forests intersect with expanding settlements, agricultural activities, and tourism infrastructure. These mismatches generate tensions among tourism developers, local communities, and conservation authorities, particularly in locations where land-use restrictions constrain traditional livelihoods or economic opportunities. For analytical clarity, land-use conflicts were categorised into three suitability classes: Good (aligned), Medium (conditionally aligned), and Bad (misaligned). Rather than detailing extensive class-by-class data, Table 2 presents a summary of conflict intensity by category.

Table 2: Land Use Conflict Potential in KSP Malino

Spatial Zoning Category	Existing Land Use	Suitability	Area (ha)	Percentage (%)
Outside Delineation	Forest	Good	19.22	0.16
	Open Land	Good	0.37	0.00
Agroforestry Cultivation Area	Field	Good	114.94	0.94
	Forest	Good	169.25	1.39
	Open Land	Medium	9.68	0.08
	Plantation/Garden	Good	170.49	1.40
	Rice Field	Bad	30.65	0.25
	River	Good	3.53	0.03
	Settlements & Activity Areas	Bad	5.33	0.04
	Shrubs	Medium	23.71	0.19
Conservation Forest	Field	Medium	944.88	7.77
	Forest	Good	1,082.77	8.90
	Open Land	Bad	5.58	0.05
	Plantation/Garden	Medium	700.62	5.76
	Rice Field	Medium	270.42	2.22
	River	Medium	13.01	0.11
	Settlements & Activity Areas	Bad	217.31	1.79
	Shrubs	Medium	257.65	2.12
Horticultural Cultivation Area	Field	Medium	314.60	2.59
	Forest	Good	111.44	0.92
	Open Land	Bad	3.79	0.03
	Plantation/Garden	Good	250.74	2.06
	Rice Field	Good	126.66	1.04
	River	Good	20.01	0.16
	Settlements & Activity Areas	Bad	59.36	0.49
	Shrubs	Medium	16.76	0.14
	Field	Medium	739.09	6.07

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Limited Production Forest	Forest	Good	3,362.30	27.63
	Open Land	Medium	357.42	2.94
	Plantation/Garden	Medium	343.16	2.82
	Rice Field	Medium	80.69	0.66
	River	Good	13.28	0.11
	Settlements & Activity Areas	Bad	58.37	0.48
	Shrubs	Medium	571.10	4.69
Plantation Cultivation Area	Field	Good	61.90	0.51
	Forest	Good	119.00	0.98
	Open Land	Bad	4.82	0.04
	Plantation/Garden	Good	255.81	2.10
	Rice Field	Medium	33.99	0.28
	River	Medium	13.94	0.11
	Settlements & Activity Areas	Bad	139.12	1.14
	Shrubs	Medium	40.23	0.33
Protected Area of Regency	Field	Medium	0.19	0.00
	Forest	Good	0.23	0.00
	Plantation/Garden	Medium	0.23	0.00
	Rice Field	Medium	0.02	0.00
	Settlements & Activity Areas	Bad	0.07	0.00
	Shrubs	Medium	0.08	0.00
Protected Forest	Forest	Good	6.82	0.06
	Open Land	Bad	25.87	0.21
	River	Good	5.94	0.05
	Shrubs	Medium	1.10	0.01
Residential Area	Field	Medium	0.88	0.01
	Forest	Medium	1.34	0.01
	Plantation/Garden	Medium	4.97	0.04
	Rice Field	Medium	0.21	0.00
	Settlements & Activity Areas	Good	35.09	0.29
	Shrubs	Medium	0.01	0.00
Water Area	Field	Medium	2.72	0.02
	Forest	Medium	7.77	0.06
	Open Land	Bad	0.79	0.01
	Plantation/Garden	Medium	1.31	0.01
	Rice Field	Medium	0.45	0.00
	River	Good	6.75	0.06
	Settlements & Activity Areas	Bad	0.06	0.00
	Shrubs	Medium	2.58	0.02
Wetland Agricultural Area	Field	Medium	73.63	0.61
	Forest	Medium	58.46	0.48
	Open Land	Bad	1.36	0.01
	Plantation/Garden	Medium	251.53	2.07
	Rice Field	Good	459.03	3.77
	River	Good	4.95	0.04
	Settlements & Activity Areas	Bad	59.23	0.49
	Shrubs	Medium	16.33	0.13
Total			**12,166.98**	**100.00**

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Land uses categorised as good suitability are predominantly forested areas within Conservation Forest and Limited Production Forest zones, reflecting a relatively high level of compliance with spatial planning objectives. Medium suitability areas correspond to transitional zones where land uses such as shrublands, plantations, and mixed agriculture may either progress toward compliance or deteriorate, depending on the effectiveness of governance mechanisms. Conversely, Bad suitability areas highlight severe spatial conflicts, including settlements and intensive agricultural activities encroaching on conservation and protected forest zones. These areas are considered high-priority targets for enforcement, ecological restoration, and conflict mitigation interventions.

Governance Conflicts in Balancing Conservation and Tourism Policy in Malino

Beyond the physical discrepancies in land use, spatial conflicts in Malino are compounded by governance fragmentation. Multiple regulatory frameworks overseeing conservation, tourism, forestry, and regional development operate concurrently yet lack effective coordination. This situation leads to inconsistent interpretation of zoning regulations, overlapping institutional mandates, and weakened enforcement capacity.

Table 3: Types of Governance Conflict in Conservation-Tourism Policy and Their Causes

Conflict Domain	Conflict Type	Stakeholders Involved	Root Cause of Conflict
Institutional	Authority Overlap Conflict	Ministry of Environment vs Ministry of Tourism	Dual management of TWA without clear hierarchy
	Inter-Agency Coordination Conflict	DLH vs Local Tourism Office	Weak integration of planning and execution
	Policy Orientation Conflict	Provincial RTRW vs Regional Development Plan (RPJMD)	Focus mismatch: ecology vs economic growth
	Strategic Goal Conflict	Local Government vs Communities and NGOs	Tourism revenue targets vs conservation ethics
Operational	Zoning Conflict	Developers, Local Government	Tourism infrastructure encroaching protected zones
	Core Zone Misuse Conflict	Tourism Operators	Disregard for zoning restrictions
	Enforcement Conflict	DLH, Satpol PP	Inadequate field monitoring and sanctioning
	Carrying Capacity Conflict	Planning Authorities	Absence of environmental impact thresholds
	Ecological Impact Conflict	Tourists, Local Operators	Waste, habitat disturbance, infrastructure pressure
	Implementation Bias Conflict	Government Agencies	Emphasis on physical development over sustainability

Institutional conflicts arise from competing mandates between conservation-focused agencies and tourism development authorities, whereas operational conflicts emerge through zoning violations and the unregulated expansion of tourism infrastructure. Such

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governance deficiencies undermine the credibility of spatial planning and intensify ecological degradation, particularly within core conservation zones.

Stakeholder-Based Conflict Dynamics in the Governance of TWA Malino

Stakeholder analysis indicates that spatial conflicts are influenced by asymmetric power relations and contrasting priorities among government agencies, local communities, private investors, NGOs, and academic stakeholders. While governmental and private actors tend to prioritise, economic growth driven by tourism, local communities and civil society groups emphasise ecological conservation and the equitable distribution of benefits. Vertical conflicts, occurring between government and communities, are driven by restricted participation and unequal access to decision-making processes. Horizontal conflicts, involving community-to-community or private-to-conservation interactions, stem from divergent perceptions of land value and resource utilisation. These dynamics underscore the necessity of participatory and inclusive mechanisms in spatial governance.

Table 4: Mapping Stakeholder Conflicts and Their Underlying Causes in TWA Malino

Stakeholder Axis	Conflict Issue	Root Cause of Conflict
Government vs Local Communities	Access to Natural Resources	Restrictive zoning; exclusion of customary rights
	Distribution of Economic Benefits	Unequal revenue-sharing; lack of benefit guarantees
	Participation in Planning Processes	Top-down decision-making; limited consultation mechanisms
Private Sector vs Conservation Stakeholders	Infrastructure Expansion	Aggressive development; zoning violations
	Resource Overuse and Exploitation	Profit-driven land use; weak environmental safeguards
	Development Time Orientation	Short-term return focus vs long-term sustainability
Intra-Community Stakeholders	Unequal Business Opportunities	Capital access disparities; tourism domination by few actors
	Differing Environmental Values	Contrasting views on nature: sacred space vs economic asset

Perceptual and Cultural Value Conflicts

Value-based conflicts in TWA Malino stem from differing perspectives on land, nature, and governance. Authorities emphasise formal legal frameworks and conservation principles, whereas local communities perceive land as a cultural and livelihood resource closely tied to social identity. These divergent perceptions foster resistance to top-down conservation policies and undermine sustained cooperation. In the absence of culturally sensitive governance and co-management frameworks, spatial planning

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interventions are at risk of eliciting social backlash and failing to achieve intended policy outcomes.

Table 5: Value-Based Conflicts between Local Communities and Authorities in TWA Malino

No	Conflict Issue	Community Perspective	Authority Perspective	Impact of Conflict
1	Natural Resource Access	A right linked to tradition and daily subsistence	Restricted based on zoning and conservation laws	Exclusion from ancestral lands; erosion of trust
2	Meaning of Conservation	Should support local use with ecological safeguards	Defined as strict protection with minimal human activity	Resistance to conservation rules; lack of compliance
3	Land Ownership and Control	Based on communal or ancestral claims	State-managed under national forestry and conservation law	Disputes over legitimacy; unclear tenure security
4	Tourism Benefit Sharing	Expectation of direct and fair distribution	Prioritizes investor confidence and regional revenue	Feelings of injustice; reduced community support for tourism development
5	Role in Governance	Desire for participatory decision-making	Decisions made top-down at national or provincial level	Disempowerment; mistrust in government planning processes
6	Cultural Land Use Practices	Sacred and identity-linked practices on the landscape	Viewed as needing regulation under formal conservation	Loss of cultural expression; regulatory conflict

Priority Zoning Strategy Formulation SWOT-AHP

Internal Factor Evaluation for Land Use Conflict Mitigation and Conservation-Tourism Balance

The Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) indicate that TWA Malino benefits from substantial ecological assets and favourable external development opportunities but is constrained by moderate internal governance and capacity limitations. The IE Matrix position at coordinates (2.35; 3.60) situates the area in Quadrant II (Hold and Maintain), implying that strategic focus should be directed toward enhancing internal capabilities while preserving advantageous external conditions.

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Table 6: IFAS Matrix – Internal Strategic Factors of TWA Malino

IFAS	Component	No.	Statement	Average Value	Weight	Rating	Total Score
Strengths	Biodiversity	1	Malino is home to rich biodiversity, including endemic flora and fauna	4.2	0.10	4	0.40
	Landscape	2	Diverse topography and scenic landscapes support nature-based tourism	3.9	0.08	3	0.24
	Ecosystem Services	3	Provides water resources and air quality regulation	3.8	0.07	3	0.21
	Water Resources	4	Numerous rivers support irrigation for local agriculture	3.7	0.06	3	0.18
	Eco-Agro Tourism	5	Area supports development of sustainable eco/agro tourism	3.6	0.06	2	0.12
	Strategic Area Status	6	Designated as a Provincial Strategic Area (KSP)	3.5	0.05	2	0.10
Total Strengths					**0.42**		**1.25**
Weaknesses	Land Conversion	1	Rapid land conversion for tourism and farming pressure	4.1	0.10	2	0.20
	Sanitation & Waste	2	Waste and sanitation systems are underdeveloped	3.9	0.09	2	0.18
	Disaster Risk	3	Increasing landslide and erosion risks in hilly areas	3.8	0.08	2	0.16
	Deforestation	4	Ongoing forest degradation due to weak enforcement	3.7	0.07	2	0.14
	Land Use Conflict	5	Overlapping functions between conservation, agriculture, and tourism	3.9	0.07	2	0.14
	Pollution	6	Pollution from tourism and domestic sources remains a challenge	3.5	0.05	2	0.10

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	Low Community Capacity	7	Limited community skills and knowledge in managing tourism sustainably	3.6	0.04	2	0.08
	Water Supply Decline	8	Decline in water availability in dry seasons	3.4	0.03	1	0.03
	Monitoring Weakness	9	Weak spatial planning control and monitoring	3.6	0.03	1	0.03
	Land Degradation	10	Increasing degraded land around tourism development zones	3.5	0.02	1	0.02
	Unmanaged Waste	11	Accumulation of unmanaged solid waste in public and river areas	3.4	0.02	1	0.02
Total Weaknesses					**0.60**		**1.10**
TOTAL IFAS					**1.00**		**2.35**

Table 7: EFAS Matrix – External Strategic Factors of TWA Malino

EFAS	Component	No.	Statement	Average Value	Weight	Rating	Total Score
Opportunities	Nature-Based Tourism	1	High potential for nature- and culture-based tourism development	4.3	0.10	4	0.40
	Green Infrastructure	2	Potential to build environmentally friendly tourism infrastructure	4.0	0.09	4	0.36
	Community-Based Conservation	3	Opportunities for environmental education and local conservation participation	3.8	0.08	3	0.24
	Eco-Agro Economy	4	Ecotourism and agrotourism can increase jobs and income	3.9	0.08	4	0.32
	Green Technology	5	Application of green technologies for	3.7	0.07	3	0.21

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			waste, energy, and water management				
	Eco-Tourism Branding	6	Malino has potential to become a flagship ecotourism destination in South Sulawesi	3.9	0.07	4	0.28
	Sustainable Development Concept	7	Balance between ecological and economic functions is attainable through sustainability principles	3.6	0.06	3	0.18
	Natural & Cultural Attractions	8	Rich environmental and cultural features boost tourism sector potential	3.8	0.06	3	0.18
	Strategic Regional Planning	9	Malino is designated as a Provincial Strategic Area (KSP)	3.7	0.05	3	0.15
Total Opportunities					**0.66**		**2.32**
Threats	Deforestation & Illegal Logging	1	Ongoing deforestation and timber extraction threaten biodiversity and zoning compliance	4.1	0.08	2	0.16
	Land Conversion	2	Continued land use change to settlements and tourism causes spatial tension	4.2	0.08	2	0.16
	Pollution & Air Quality Decline	3	Environmental pollution and air degradation affect ecosystem resilience	4.0	0.07	2	0.14
	Government-Community Conflict	4	Interest clashes between state	3.8	0.07	2	0.14

			policy and local needs				
	Land Access & Affordability	5	Limited purchasing power among locals hinders land access	3.7	0.05	2	0.10
	Low Community Participation	6	Locals lack capacity and opportunities to engage in tourism economy	3.6	0.05	2	0.10
	Waste Accumulation	7	Plastic waste and unmanaged landfill threaten environmental aesthetics	3.9	0.05	2	0.10
	Disaster Risk	8	Risk of landslides and flash floods is increasing	4.0	0.05	2	0.10
	Spatial Planning Violations	9	Rising incidence of spatial misuse and non-compliant developments	3.9	0.05	2	0.10
	Climate Vulnerability	10	Exposure to extreme weather and temperature shifts increases ecological stress	3.8	0.04	2	0.08
	Water Scarcity Risk	11	Locals face water quality and quantity shortages	3.7	0.05	2	0.10
Total Threats					**0.60**		**1.28**
TOTAL EFAS					**1.00**		**3.60**

Table 8: IE Matrix

	TOTAL WEIGHT SCORE IFAS			
TOTAL WEIGHT SCORE EFAS	**4,0**	**3,0** Strong 3,0 – 4,0	**2,0** Medium 2,0 – 2,99	**1,0** Weak 1,0 – 1,99
	3,0, High, 3,0 - 4,0	I	II	III
	2,0, Medium 2,0 – 2,99	IV	V	VI
	1,0, Low 1,0 – 1,99	VII	VIII	IX

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SWOT Matrix of Spatial Planning Strategy for TWA Malino

The AHP analysis of SWOT-derived strategies identifies key priorities for harmonising land-use dynamics with sustainable ecotourism development. The top-ranked strategy focuses on eco-tourism resilience planning to mitigate climate-related risks, reflecting Malino's susceptibility to landslides, floods, and other climate-induced hazards. Additional high-priority strategies emphasise public–private collaboration, establishment of conflict resolution mechanisms, integration of green infrastructure, and enforcement of conservation-compliant local regulations.

Table 9: Integrated Comparison Matrix and Weight Priorities

Normalized AHP Matrix Results																											
Strategy Category	Code	Initial	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	MEAN	Eigen Value	Weight Priority	Rank	Criteria Vector
Strengths	S-O-1	S1	0.074	0.075	0.078	0.045	0.071	0.034	0.047	0.045	0.132	0.060	0.090	0.152	0.055	0.099	0.021	0.133	0.045	0.060	0.130	0.200	0.082	1.874	0.083	2	22.739
Opportunities (S-O)	S-O-2	S2	0.035	0.035	0.037	0.025	0.031	0.031	0.030	0.028	0.029	0.034	0.029	0.030	0.023	0.033	0.041	0.021	0.034	0.045	0.031	0.035	0.032	0.713	0.032	17	22.441
	S-O-3	S3	0.037	0.037	0.039	0.029	0.040	0.065	0.028	0.037	0.029	0.034	0.034	0.035	0.032	0.019	0.038	0.015	0.053	0.061	0.149	0.015	0.041	0.926	0.041	14	22.464
Strategies	S-O-4	S4	0.063	0.054	0.050	0.038	0.050	0.043	0.048	0.048	0.023	0.018	0.020	0.030	0.016	0.055	0.065	0.095	0.038	0.065	0.039	0.022	0.045	1.019	0.045	11	22.708
	S-O-5	S5	0.031	0.034	0.029	0.023	0.030	0.035	0.019	0.012	0.066	0.018	0.017	0.027	0.015	0.037	0.044	0.016	0.065	0.040	0.020	0.033	0.031	0.686	0.030	18	22.412
Weaknesses-	W-O-1	S6	0.057	0.030	0.016	0.023	0.023	0.026	0.014	0.049	0.020	0.018	0.040	0.014	0.020	0.015	0.018	0.030	0.018	0.035	0.024	0.048	0.027	0.603	0.027	20	22.469
	W-O-	S7	0.045	0.034	0.040	0.024	0.044	0.054	0.029	0.017	0.037	0.033	0.034	0.026	0.013	0.028	0.023	0.052	0.011	0.025	0.025	0.013	0.030	0.677	0.030	19	22.319
Opportunities (W-O)	W-O-	S8	0.051	0.039	0.032	0.025	0.074	0.017	0.050	0.031	0.031	0.050	0.048	0.029	0.013	0.028	0.023	0.052	0.011	0.025	0.025	0.018	0.033	0.745	0.033	16	22.278
	W-O-	S9	0.043	0.093	0.102	0.128	0.035	0.089	0.059	0.077	0.077	0.055	0.090	0.192	0.071	0.073	0.084	0.031	0.133	0.046	0.049	0.102	0.082	1.843	0.082	3	22.498
	W-O-	S10	0.039	0.032	0.036	0.067	0.053	0.046	0.028	0.019	0.044	0.032	0.031	0.035	0.017	0.067	0.012	0.019	0.020	0.070	0.014	0.029	0.035	0.789	0.035	15	22.298
Strengths-Threats (S-T)	S-T-1	S11	0.068	0.099	0.095	0.157	0.145	0.055	0.070	0.053	0.071	0.083	0.083	0.111	0.114	0.037	0.102	0.076	0.068	0.033	0.072	0.140	0.087	1.955	0.087	1	22.575
	S-T-2	S12	0.026	0.061	0.059	0.066	0.059	0.100	0.057	0.055	0.021	0.048	0.039	0.053	0.044	0.065	0.056	0.069	0.047	0.119	0.102	0.086	0.062	1.391	0.062	4	22.615
	S-T-3	S13	0.046	0.054	0.042	0.083	0.067	0.046	0.076	0.081	0.037	0.065	0.025	0.041	0.034	0.011	0.019	0.052	0.024	0.025	0.020	0.021	0.043	0.967	0.043	13	22.281
Strategies	S-T-4	S14	0.032	0.045	0.086	0.029	0.034	0.074	0.043	0.046	0.044	0.020	0.095	0.034	0.131	0.042	0.031	0.016	0.065	0.070	0.029	0.016	0.049	1.103	0.049	9	22.389
	S-T-5	S15	0.165	0.040	0.046	0.028	0.032	0.069	0.059	0.063	0.043	0.119	0.036	0.044	0.067	0.064	0.047	0.012	0.027	0.021	0.082	0.043	0.057	1.270	0.056	7	22.451
Weaknesses-Threats (W-T)	W-T-1	S16	0.016	0.054	0.084	0.015	0.062	0.029	0.018	0.019	0.081	0.055	0.036	0.025	0.022	0.087	0.124	0.033	0.069	0.012	0.021	0.032	0.045	1.002	0.044	12	22.439
	W-T-2	S17	0.068	0.042	0.030	0.041	0.019	0.058	0.108	0.115	0.024	0.065	0.050	0.046	0.059	0.027	0.071	0.019	0.041	0.029	0.025	0.023	0.048	1.073	0.048	10	22.347
	W-T-3	S18	0.054	0.035	0.028	0.020	0.033	0.033	0.050	0.054	0.072	0.020	0.110	0.019	0.061	0.027	0.097	0.125	0.062	0.044	0.034	0.025	0.050	1.147	0.051	8	22.918
	W-T-4	S19	0.030	0.058	0.013	0.050	0.079	0.057	0.060	0.064	0.080	0.119	0.053	0.027	0.091	0.075	0.030	0.082	0.084	0.066	0.052	0.044	0.061	1.382	0.061	5	22.646
Strategies	W-T-5	S20	0.019	0.050	0.055	0.086	0.020	0.028	0.109	0.088	0.038	0.055	0.030	0.031	0.083	0.116	0.055	0.052	0.088	0.091	0.059	0.051	0.060	1.373	0.061	6	22.732
																							1.000	22.540			22.540

Table 10. Summary of Top Priority Strategies

Rank	Code	Strategy	Weight Priority
1	S-T-1	Strict land-use control to prevent illegal conversion	0.087
2	S-O-1	Eco-tourism development based on landscape potential	0.083
3	W-O-4	Participatory spatial planning and zoning control	0.082
4	S-T-2	Climate-adaptive landscape zoning	0.062
5	W-T-4	Disaster awareness and zoning enforcement	0.061
6	W-T-5	Tourism carrying capacity policy	0.061
7	S-T-5	Climate-resilient infrastructure investment	0.056
8	W-T-3	Conservation-based regional regulation	0.051
9	S-T-4	Land conflict resolution task force	0.049
10	W-T-2	Ecotourism resilience planning	0.048

The AHP results indicate that the highest priority strategy is S-T-1 (weight = 0.087), emphasizing the critical importance of strict land-use control to mitigate illegal land conversion driven by tourism expansion pressures. The dominance of strategies within the Strengths–Threats (S–T) category at the top ranks suggests that leveraging internal strengths to address external threats represents the most effective strategic approach in the study area. Subsequent high-ranking strategies, such as S-O-1 (0.083) and W-O-4 (0.082), highlight the significance of optimizing ecological tourism potential while simultaneously strengthening participatory governance mechanisms. The relatively balanced distribution of weights, with a concentration among several key strategies,

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indicates that policy implementation should not rely on a single approach but rather integrate spatial control, climate adaptation, and institutional strengthening. Furthermore, the Consistency Ratio (CR) value of 0.08 (< 0.10) confirms that the pairwise comparison judgments are consistent and reliable, ensuring the robustness of the prioritization results. Overall, these findings provide a strong strategic foundation for formulating adaptive, integrated, and sustainability-oriented zoning policies in ecotourism areas.

DISCUSSION

Predicting Land Use Dynamics in the Malino Ecotourism Strategic Area: Implications for Spatial Planning Policy

The CA–Markov-based projections of land-use change in the Malino Ecotourism Strategic Area offer critical insights into the interactions among tourism expansion, agricultural intensification, and regulatory enforcement in reshaping highland landscapes. The anticipated reduction in forest cover, alongside the growth of rice fields, dryland agriculture, and settlements, reflects a broader pattern of tourism-driven land transformation observed in ecologically sensitive regions globally (Mulyawati et al., 2024). In Malino, these dynamics are spatially concentrated along road corridors and near established tourism infrastructure, underscoring the significant influence of accessibility on land conversion processes.

Notably, the projected variation in settlement area an increase by 2034 followed by a decline by 2044 should not be interpreted as a modelling anomaly. Rather, it represents a policy-sensitive scenario embedded within the simulation, in which stricter enforcement of spatial zoning, conservation restoration initiatives, and land reclassification progressively constrain settlement expansion within protected and conservation zones. This scenario aligns with Indonesia's spatial planning framework under Law No. 26/2007 on Spatial Planning and its operationalisation through RTRW, which mandate the regulation of built-up development in conservation and disaster-prone areas. These findings support concerns highlighted by (Chen et al., 2021) and (Zhao et al., 2023), showing that unregulated land conversion in developing regions contributes to ecosystem degradation, habitat fragmentation, and declining ecosystem services. In mountainous, biodiverse areas such as Malino, these risks are amplified by steep slopes and fragile hydrological systems. Xie et al., (2013) further stress that land-use change without ecological risk assessment significantly increases vulnerability to erosion, landslides, and flooding, hazards highly relevant to Malino's topography.

From a policy perspective, these results underscore the necessity of integrating predictive spatial modelling into RTRW revisions and tourism zoning regulations, rather than relying solely on static land-use maps. As noted by Zanudin et al., (2022), tourism-induced land conversion in highland regions accelerates environmental degradation

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when spatial governance is reactive rather than anticipatory. Similarly, (Zhang et al., 2023) emphasise that predictive models are critical for identifying future conflict hotspots and ecological thresholds in ecotourism planning. In the Indonesian context, this indicates that CA–Markov outputs should inform not only land allocation decisions but also infrastructure permitting, conservation buffer delineation, and disaster-risk zoning in strategic tourism areas such as Malino.

Spatial Conflict Analysis

The spatial conflict analysis indicates significant discrepancies between actual land use and RTRW zoning, particularly within conservation and agroforestry zones. The conversion of a substantial portion of protected areas into settlements, tourism infrastructure, and agricultural land highlights weak enforcement and fragmented institutional coordination. Similar observations have been reported by Ogunjinmi & and Braimoh, (2018) and Petunia and Selepe, (2020), who note that spatial mismatches often signal deeper governance failures in which economic priorities supersede spatial and environmental regulations. In Malino, these conflicts are exacerbated by overlapping mandates among tourism, forestry, and regional planning agencies. While tourism development is promoted as a regional economic driver, conservation authorities operate under separate regulatory logics, resulting in inconsistent zoning interpretation and enforcement. This situation reflects the "plural land governance regimes" described by Ngxongo and Chili, (2017) and Das and Chatterjee, (2015), where formal planning frameworks coexist with informal practices and customary land-use systems.

Stakeholder interviews further reveal that limited community participation in zoning decisions intensifies spatial conflicts. Local communities often perceive RTRW regulations as restrictive and externally imposed, particularly when tourism permits are granted without meaningful consultation. This observation aligns with Swain (2004) and Mulyawati et al., (2024), who highlight that exclusionary planning processes undermine the legitimacy of conservation and tourism policies. In contrast, studies by (Zanudin et al., 2022) demonstrate that participatory governance enhances compliance, mitigates conflicts, and supports long-term sustainability in ecotourism areas. Collectively, these findings suggest that spatial conflict in Malino is not merely a technical issue of land-use mismatch but a political and institutional challenge rooted in governance design. Strengthening inter-agency coordination, harmonising permitting procedures, and embedding participatory mechanisms within RTRW implementation are therefore essential. Measures such as participatory spatial audits, community-based monitoring, and transparent licensing processes can help reconcile conservation objectives with local livelihood needs while reducing unauthorized land conversion.

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Priority Zoning Strategy Formulation

The SWOT–AHP analysis provides a systematic framework for prioritising zoning strategies that address land-use conflicts while promoting sustainable ecotourism development. Among the 20 strategies assessed, S-T-1 strict control of land use to prevent illegal land conversion emerged as the highest priority strategy, reflecting the urgency of managing spatial expansion in ecologically sensitive areas. Spatial analysis indicates that land conversion in Malino increasingly occurs on steep slopes, within conservation zones, and near hydrological networks, thereby intensifying environmental risks such as landslides, floods, and water scarcity. This finding highlights that uncontrolled tourism-driven development is a primary driver of spatial conflict and ecological degradation, making regulatory enforcement a fundamental requirement for sustainable land-use management. The prioritisation of S-T-1 is further supported by Indonesia's national policy framework, particularly Law No. 24/2007 on Disaster Management and regulations issued by the National Disaster Management Agency (BNPB), which mandate the integration of disaster risk reduction into spatial planning. In highland tourism areas such as Malino, ineffective land-use control may exacerbate environmental vulnerability and socio-economic risks, underscoring the necessity of strengthening zoning enforcement as a preventive and adaptive strategy within spatial governance.

From a governance perspective, the dominance of Strengths–Threats (S–T) strategies among the top-ranked priorities indicates that leveraging internal strengths to mitigate external threats represents the most effective strategic approach in this context. High-ranking strategies such as S-O-1 (eco-tourism development based on landscape potential) and W-O-4 (participatory spatial control) further demonstrate that sustainable tourism development requires an integrated approach combining ecological optimisation, regulatory enforcement, and community participation. These findings align with (Liu & Suk, 2022), who emphasise that resilience and governance capacity are essential for sustainability in environmentally sensitive tourism regions. Complementary strategies, including climate-adaptive zoning (S-T-2), tourism carrying capacity policy (W-T-5), and disaster awareness strengthening (W-T-4), reinforce the importance of embedding environmental resilience within spatial planning frameworks. The strength of the SWOT–AHP approach lies not only in ranking strategies but also in facilitating evidence-based and participatory decision-making (Zorlu & Yilmaz, 2020), while previous studies confirm its effectiveness in balancing economic growth and environmental protection (Reza et al., 2024). In practical terms, these priority strategies should be institutionalised within RTRW revisions and supported by cross-sectoral coordination mechanisms, including stricter zoning enforcement, conflict resolution task forces, climate-sensitive regulations, and participatory zoning education. The integration of dynamic spatial monitoring through satellite imagery and community feedback mechanisms is also essential to strengthen adaptive governance, ensuring that

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zoning policies remain responsive to environmental change, tourism pressures, and socio-economic dynamics in the long term.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The results of this study highlight the anticipated and interconnected dynamics of land-use change, spatial conflict, and policy prioritisation in the Malino ecotourism area. CA–Markov simulations based on data from 2015 to 2024 indicate substantial future transformations, including continued reductions in forest cover alongside the expansion of settlements and agricultural land, largely driven by tourism-related development pressures, which increasingly encroach upon ecologically sensitive areas in highland environments. Overlay analysis comparing projected land use with existing RTRW zoning plans further reveals persistent potential mismatches, with approximately 19% of land within protected zones at risk of non-compliant utilisation, reflecting structural governance challenges such as weak enforcement, overlapping institutional mandates, and limited integration between planning and implementation, compounded by insufficient community participation. The integration of SWOT and AHP methods produces a refined and evidence-based prioritisation of zoning strategies, with the highest priority assigned to strict land-use control to prevent illegal conversion (S-T-1), followed by strategies emphasising eco-tourism development based on landscape potential, participatory spatial control, and climate-adaptive zoning, indicating the necessity of combining regulatory enforcement, ecological optimisation, and stakeholder involvement. The dominance of Strengths–Threats strategies among the top rankings demonstrates that leveraging internal capacities to address external pressures is essential in managing rapidly evolving land-use dynamics. Overall, these findings advocate for a forward-looking, participatory, and adaptive spatial governance framework that integrates strict zoning enforcement, resilience-based planning, and continuous monitoring mechanisms to harmonise conservation objectives with tourism-driven land-use change, ensuring long-term sustainability in protected highland ecotourism landscapes.

Recommendations

Based on the study's findings, it is recommended that local and regional authorities strengthen zoning policies through a participatory and adaptive framework that integrates ecological protection, economic development, and social inclusion, with a primary emphasis on strict land-use control to prevent illegal conversion (S-T-1) as the foundational strategy. This approach should prioritise the enforcement of spatial regulations within RTRW through the utilisation of real-time geospatial data, continuous monitoring systems, and alignment between planning and implementation. At the same time, participatory mechanisms must be enhanced through stakeholder

consultations and community-based zoning awareness programs to improve compliance and reduce spatial conflicts. Institutional strengthening is essential, including the establishment of inter-agency coordination bodies, conflict resolution task forces, and streamlined licensing systems to address overlapping mandates and governance fragmentation. Complementary strategies such as eco-tourism development based on landscape potential, climate-adaptive zoning, and tourism carrying capacity policies should be integrated to ensure that tourism growth remains within ecological limits. In addition, investment in climate-resilient infrastructure and sustainable tourism practices should be prioritised to mitigate environmental risks while supporting long-term economic benefits. These strategic measures need to be institutionalised within formal spatial planning processes and reinforced through legal enforcement, capacity-building initiatives, and adaptive monitoring frameworks, ensuring that zoning policies remain responsive to dynamic environmental and socio-economic changes and capable of safeguarding the ecological integrity of Malino's protected ecotourism area under increasing development pressures.

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