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Institutional Structural Modelling of District Governments for Sustainable Management in the Danau Sentarum Landscape

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ABSTRACT

The Danau Sentarum landscape in West Kalimantan, Indonesia, is a catchment area containing important peat wetland ecosystems that support biodiversity conservation, local livelihoods, and hydrological functions in the upper Kapuas River Basin. However, under Law No. 23/2014 on Regional Government, formal authority over watershed management in the forestry sector lies with the central and provincial governments, whereas regency governments retain responsibility for other sectoral functions that affect watershed conditions. This study examined the structural relationships among district government functions relevant to sustainable landscape management in Danau Sentarum. Data were collected through a literature review, focus group discussions, and expert interviews with relevant institutional representatives and analyzed using Interpretive Structural Modelling. The analysis identified 30 functional elements and produced an inconsistency index of 9.56%. Environmental management, spatial planning, and land administration were positioned as the main driver functions with high driving power and low dependence. Agriculture, fisheries, tourism, trade, industry, labor, and energy and mineral resources formed linkage functions that connected ecological governance with nature-based production and local economic activities. Settlement, connectivity, investment, cooperatives and small and medium enterprises, social protection, community empowerment, and public order functions were positioned as more dependent outcomes. These results suggest that district-level watershed governance in the Danau Sentarum landscape may be improved by emphasizing environmental management, spatial planning, and land administration above the coordination of productive and welfare sectors. This study presents a function-based institutional map for district-level planning in Danau Sentarum, and requires additional validation to evaluate its use in other watershed environments.

Introduction

Danau Sentarum landscape, West Kalimantan, Indonesia is a key site that blends ecological, economic, and social functions in a unique tropical peat wetland system [1,2], arguably one of the largest and oldest kind of tropical peat swamp forests in the world. The environment may direct water flow into the Kapuas River [3], offer livelihoods for communities through fishing, forest honey collection, agriculture and ecotourism [4–8] and shelter endangered and endemic species [9,10]. The landscape is a Ramsar site (1994), a national park (1999) and a UNESCO Biosphere Reserve core zone (2018) and is an ecological governance context requiring coordination among multiple institutions for the ecological protection and welfare of local communities.

However, are numerous structural limits in the form of Indonesian decentralization legislation that affects any governance to do with Danau Sentarum terrain. Existing legislation does not have the characteristic of

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district-based administration. The regional government Law (Law No. 23/2014 on Regional Government) gives the ability to manage watershed immediately under the centralized administration and the provinces [11]. But district governments (*kabupaten*) also have concurrent power over spatial planning, land administration, environmental management, agriculture and fisheries, and public works, tasks that together determine the real state of watershed conditions. Several studies have shown that better multi-sectoral integration and stakeholder coordination are needed for effective watershed governance [12–14] and the important role of district government [15]. Roslinda et al. [16] showed that Danau Sentarum National Park can only be administered effectively if the district government is actively involved. However, their stakeholder analysis was used merely to rank the important participants in the conservation areas into power and interest matrices. It did not identify the institutional drivers of highest potential within district sector functions, nor functional interdependences across district government sectors within the sub-watershed. This leaves practitioners without any empirical basis to prioritize institutional interventions at the district level.

However, none has specified the main institutional drivers of change in watershed governance and their position in the structural hierarchy of district government activities. Edison et al. [15] identified the importance of the roles of district level actors in watershed governance, but the key functions that drive systemic change by the district-government were not identified and the study did not define the functions within the context of the structural hierarchy. Current paradigms in study on watershed governance have difficulty dealing appropriately with this challenge. Stakeholder analysis is usually about the power and interests of actors, but it is rarely expressed in terms of the causal leverage of one institutional function over another [17]. Network structure analysis indicates informational bridges between players, but is not able to provide an order explaining which functions are able to be changed in order to disseminate most change within a system [18]. But neither approach produces an actionable functional hierarchy with which decision makers can order the intercessions to be sequenced or a point of structural leverage especially when formal watershed authority is withheld from the district level but its sectoral functions co-construct watershed governance.

To address this gap, this study uses Interpretive Structural Modelling (ISM) to identify institutional drivers of watershed governance change among important district-government tasks relevant to watershed governance, and to evaluate their structural hierarchy. ISM is a systematic modelling framework based on expert opinion. It classifies variables into driver and linkage sectors and dependent outcomes. The driving power and dependence classification results in a tiered functional hierarchy, where each layer is one step away from direct institutional influence, thus identifying those functions that, when strengthened, promote cascading effects throughout the governance system [15]. The study will be based on the functions of the district, which are legally specified by Law No. 23/2014 and Government Regulation No. 18/2016 on Regional Apparatus, and this study produces a practical institutional map that clarifies the structural roles of district government sectors in watershed governance. The results directly respond to the diagnostic need identified by Roslinda et al. [16] by specifying that district engagement matters and precisely which district functions should be prioritized and in what hierarchical sequence to achieve meaningful governance improvement in the Danau Sentarum landscape.

Materials and Methods

Study Area

The landscape of Danau Sentarum is a locally defined catchment area as Daerah Tangkapan Air (DTA) Danau Sentarum located at 0°35’42”–1°21’41” N and 111°37’13”–112°34’47” E, entirely within Kapuas Hulu District, West Kalimantan Province Indonesia (Figure 1). It was chosen because it is the natural catchment for the Kapuas River, was designated as a Ramsar site (1994) and a national park (1999), is part of a UNESCO Biosphere Reserve (2018), and is one of Indonesia's national priority lakes (2021).

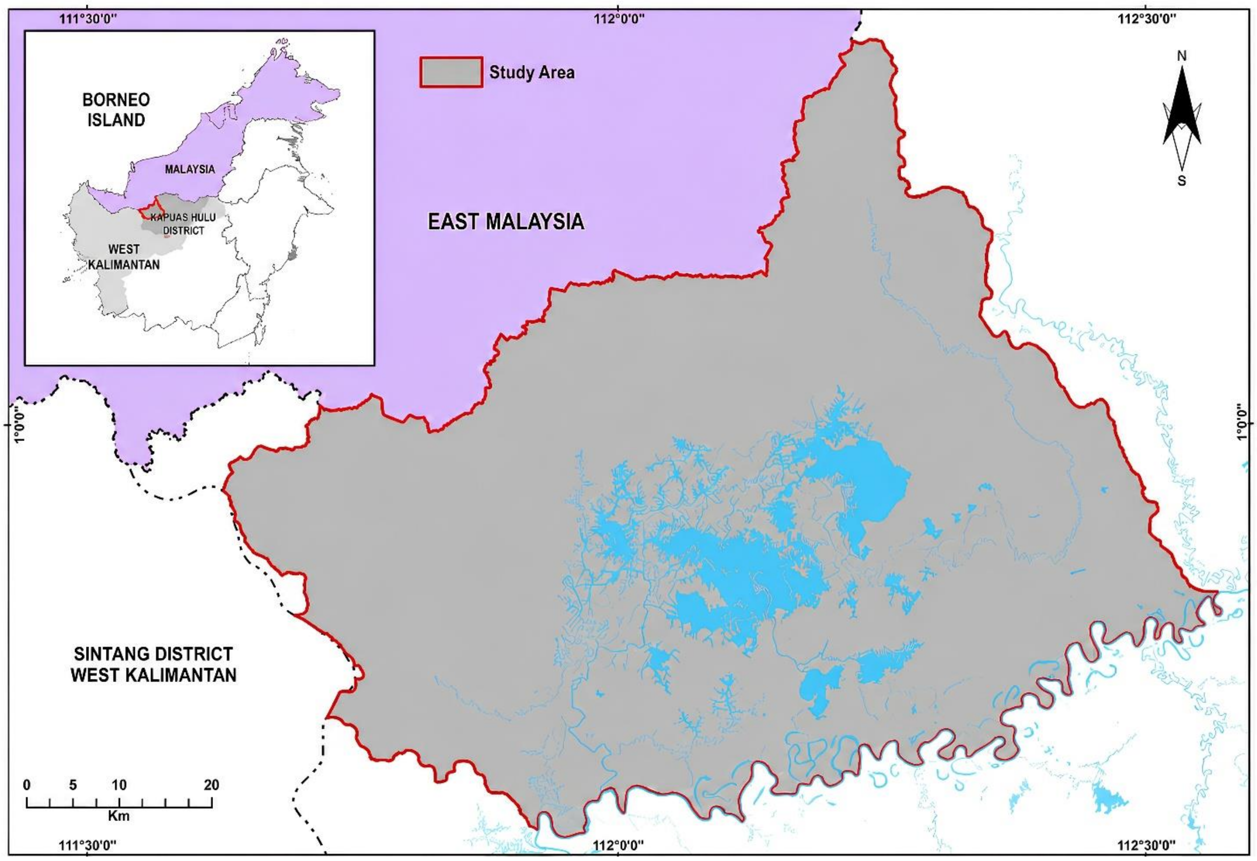

Figure 1. The Danau Sentarum Landscape Area located in Kapuas Hulu District, West Kalimantan Province Indonesia. The inset map shows the location of the study area within Borneo Island.

Data Collection

Study Design and Data Sources

This study used a qualitative, participatory, and interpretive design combined with Interpretive Structural Modelling (ISM). This design was selected to examine the structural relationships among district government functions in the Danau Sentarum landscape. Accordingly, this study was positioned as an institutional-structural diagnostic rather than an assessment of policy implementation, governance outcomes, spatial change, social network structure, or institutional performance indicators. Data were collected between April and June 2025 through literature and official document reviews, Focus Group Discussions (FGDs), expert interviews, and external validation consultations. Secondary data were sourced from scientific publications, official government documents, planning documents, and key legal instruments. The main legal references of what comprises district government matters pertinent to watershed and landscape administration were established using Law No. 23/2014 on Regional Government [19] and Government Regulation No. 18/2016 on Regional Apparatus [20]. These legal references provided a delineation of the contextual bounds within district government functions. Management issues in the Danau Sentarum environment were discovered using scientific literature, policy papers, and preliminary institutional information. Focus Group Discussions (FGDs) and interviews with invited experts were conducted to confirm and further improve the outcomes of the document evaluation.

Respondent Selection

Respondents were selected by purposive sampling with snowball identification. The purposive criteria were developed based on the expert selection framework as proposed by Yusuf et al. [21], which emphasizes the value of competence, authority to make decisions, and professional understanding. Respondents were considered eligible if they met at least one of the following three criteria: (1) they had academic or research-based knowledge relevant to issues at the watershed, landscape, governance, or sectoral development level; (2) they were in a decision-making or policy-related position in a government or non-government institution; and/or (3) they had specific expertise or certification relevant to the assessed sector.

During the selection process, the District Development Planning Agency, Environmental Agency, and Danau Sentarum National Park (DSNP) were chosen as entry point institutions. These institutions were deemed to be relevant to the concerns in Danau Sentarum, including planning, environmental management, and/or conservation. Additional experts were identified via snowball referrals from these people and organizations involved in the management of the Danau Sentarum area.

In this study, purposive sampling was used and fifteen experts were selected at the district level. They include planning, environmental management, public works, spatial planning, agriculture and food security, fisheries, industry and trade, community and village empowerment, forestry, national park, health, education, and biodiversity conservation. Not only this, respondents were not choosing based on the educational background but also at least have more than 10 years entered interpreting the contents of Law No. 23/2014 about the Law No. 23/2014 on Regional Government and Government Regulation No. 18/2016 on Regional Apparatus. Nine respondents were selected based on technical expertise or professional competence, and six were selected based on policy-related positions. This composition was used to balance technical knowledge and institutional authority in decision-making in the ISM judgement process. The ISM evaluation was focused on the district level, thus the people who responded to it were selected because they knew about the district's responsibilities and the intersectoral commitments of the government. The local perspective was included by identifying significant concerns and validating them via external validation consultations.

Focus Group Discussion (FGD) and Interviews

The selected respondents were subjected to two FGDs. The key management concerns in the Danau Sentarum landscape were first recognized via an FGD and compared to 32 concurrent government affairs based on Law No. 23/2014 concerning Regional Government and Government Regulation No. 18/2016. From this stage, a list of 26 government matters related to the landscape management of Danau Sentarum was developed.

The second FGD broke down the 26 key government affairs into more practical functional elements in the ISM analysis. This refinement was necessary because several formal government affairs contained more than one operational function relevant to watershed governance. For example, public works and spatial planning were separated into spatial planning, water resource infrastructure, road infrastructure, and building and environmental sanitation. Public order and civil protection were separated into public order, security, and disaster management. Through this process, the experts agreed on 30 functional elements as the final ISM elements. The elements were coded E1 to E30 and utilized in pairwise assessments.

All experts were given a list of 30 functional elements along with a form containing pairwise assessment to be filled out before the second FGD. The experts independently scored the association of government functional elements using the VAXO coding system. V is element i influenced element j; A is element j influenced element i; X is both elements directed influence each other and O mean there are no direct relationship between two elements [22]. To reduce the dominating behaviors of the participants, individual pre-assessments were employed as an initial basis for discussion in the group.

Then discussed the filled forms in FGD session in open. For the situations when a pair of elements was assigned the same VAXO judgment by experts, such judgement was accepted. When the assessments varied, the facilitator requested the experts to explain the rationale behind their judgements. This discussion is seen through the prism of the institutional mandate, practical connection, and governance rationale between the two. If they achieved an agreement, the code was placed in the Structural Self-Interaction Matrix (SSIM). In the event that agreement could not be obtained via discussion, a majority vote was required for the ultimate decision. All pairwise relationships were consistently treated in the same way.

Individual interviews were conducted after the FGDs to explain certain chosen linkages and expound on sectoral responsibilities that could not be discussed in detail in group settings. The interviews provided evidence for the interpretation of the ISM hierarchy and decreased the dependence on statements at the group level.

Data Analysis

SSIM Construction

The Structural Self-Interaction Matrix (SSIM) was developed from the agreed VAXO judgements produced during the second FGD. The SSIM captured the perceived directional relationships among the 30-district government functional elements relevant to sustainable management in the Danau Sentarum landscape.

The aggregate of the pairwise assessments were performed in a systematic way. First, the individual VAXO forms were compared to identify agreement and disagreement among the experts. Second, pairwise relationships with similar judgements were directly accepted. Third, pairwise relationships with different judgements were openly discussed until the experts reached an agreement; if full agreement was not possible, majority agreement was reached. Fourth, the final agreed VAXO codes were compiled into the SSIM. This process reduced dependence on individual judgements and strengthened the deliberative basis of the matrix. The final agreed VAXO codes were compiled into the SSIM and used as the basis for the reachability matrix in the ISM analysis.

ISM Processing

The SSIM was processed using the EXSIMPRO software for Interpretive Structural Modelling under a professional personal licence. ISM processing was performed in five steps. First, the VAXO-based SSIM was converted into a binary reachability matrix using the standard ISM transformation rules. Second, transitivity was checked to ensure that indirect relationships among the elements were logically represented. Third, the driving power and dependence scores were calculated for each element. Driving power was determined by the number of elements influenced by a given element, and dependence was determined by the number of elements influencing that element. Fourth, the elements were categorized into four quadrants depending on the driving power and dependence (autonomous, dependent, linkage, and independent). Fifth, the levels were split to determine where the items are in the hierarchy.

Reliability and consistency were evaluated using the inconsistency index with the EXSIMPRO software program. The highest threshold degree of discrepancy was 10%. If the inconsistency index was higher than this level, experts were invited to re-evaluate their matrix together. Experts re-evaluated inconsistent VAXO connections and passed verdicts. This technique was iterative and was executed until the matrix was consistent with the consistency criteria used in this study.

The data were triangulated via document review, Focus Group Discussions (FGDs), expert interviews, and external validation. The outcomes of categorizing the preliminary ISM hierarchy quadrants were addressed with other stakeholders who were not part of the FGDs, including sub-district authorities, village representatives, and local academics and senior district officials. In external validation, the ISM matrices were not recomputed. It explored the institutional plausibility of the established hierarchy and its relevance to the governance setting of Danau Sentarum. This input was utilized to enhance the interpretation of findings.

Results and Discussion

Results

District Government Sectors in the Danau Sentarum Landscape Management

The study involved 15 respondents representing 15 areas of expertise related to district-level landscape and watershed governance, including environmental management, social forestry, development planning, public works and infrastructure, agriculture, food security, fisheries, industry and trade, community and village empowerment, forest management, conservation, health, and education. Respondents were affiliated with 12 institutions, covering district planning and sectoral technical agencies, forest and conservation authorities, and one non-governmental organization. Most held senior administrative or technical positions with 10–30 years of professional experience, providing cross-sectoral empirical input for identifying government functions relevant to the Danau Sentarum landscape.

A review of documents and FGDs identified five main management issue domains: ecological, economic, social, basic infrastructure, and spatial planning. A comparison with the 32 concurrent government affairs stipulated in Law No. 23/2014 and Government Regulation No. 18/2016 showed that 26 of the 32 affairs (81.25%) were directly relevant to landscape management, comprising six mandatory basic service functions, 14 mandatory non-basic service functions, and six optional functions (Table 1). This distribution shows that the functional scope of Danau Sentarum landscape management extends beyond environmental and forestry-related affairs and includes basic services, non-basic public services, and productive sector functions. The institutional aspect was not classified as a separate concurrent government affair but was positioned as a supporting governance process for assessing the coordination among the identified government functions.

Table 1. District government sectors relevant to the Danau Sentarum landscape management. The diverse sectors outline the multi-stakeholder configuration required for comprehensive watershed and landscape governance.

No.	Government function	Sectors
1	Mandatory basic service functions	Education, health, public works and spatial planning, housing and settlement areas, public order and civil protection, social
2	Mandatory non-basic service functions	Labor, women's empowerment and child protection, food security, land administration, environment, community and village empowerment, population control and family planning, transportation, communication and informatics, cooperatives and small medium enterprises, investment, youth and sports, culture, library services
3	Optional functions	Fisheries, tourism, agriculture, trade, energy and mineral resources, industry

Institutional Quadrant and Hierarchy Structure

Through the FGD, experts refined and aligned the elements relevant to district government sectors, resulting in a set of 30 government functional elements that were used in the ISM analysis (Table 2). The ISM analysis of these 30 elements produced an inconsistency index of 9.56% and generated both a driver–dependency quadrant diagram (Figure 2). Driver-dependence analysis classified these elements into four quadrants: independent (high driving power, low-to-moderate dependence), linkage (moderate-to-high driving power and dependence), dependent (low-to-moderate driving power, high dependence), and autonomous (low driving power and dependence). The independent elements included E1–E3, E4–E6, E8, and E17–E22. Linkage elements covered economic and productive sectors (E7, E10–E11, E13–E16), while dependent elements comprised settlement, connectivity, empowerment, social protection, and public order functions (E9, E12, E23–E30). No element was autonomous, indicating that all functions were structurally relevant.

Table 2. Government functional elements and the code used in the ISM analysis. These codes are utilized to construct the structural self-interaction matrix (SSIM) in the modeling process.

Code of element	Functional element
E1	Environmental management
E2	Spatial planning
E3	Land administration
E4	Water resources infrastructure
E5	Building and environmental sanitation
E6	Road infrastructure
E7	Energy and mineral resources
E8	Disaster management
E9	Public housing and residential areas
E10	Agriculture
E11	Fisheries
E12	Food security
E13	Tourism
E14	Trade
E15	Industry
E16	Labor
E17	Education
E18	Culture
E19	Library services
E20	Youth and sports
E21	Health
E22	Population control and family planning
E23	Transportation
E24	Communication and informatics
E25	Investment
E26	Cooperatives and small and medium enterprises
E27	Community and village empowerment
E28	Women's empowerment and child protection
E29	Social protection
E30	Public order and security

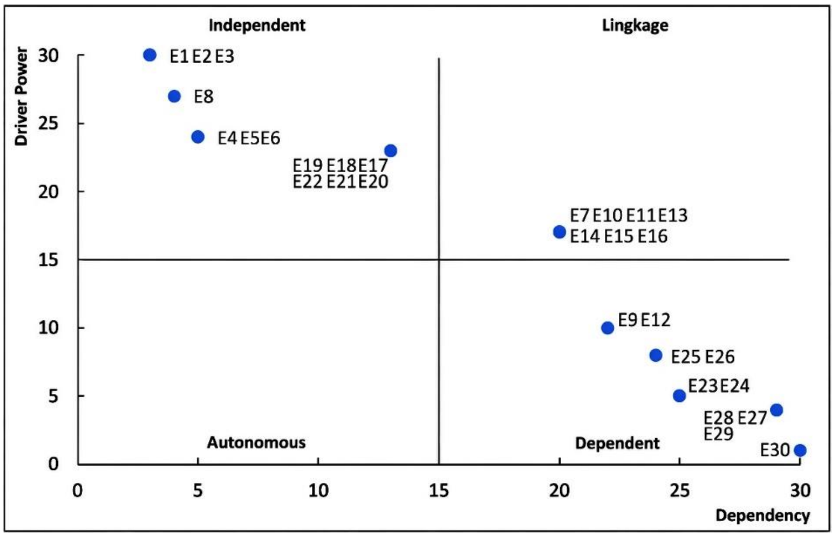

Figure 2. The quadrant of government functional elements in the Danau Sentarum landscape. The final ISM results show that all government functional elements are interconnected, with none classified as autonomous.

The ISM hierarchy consisted of ten levels, ranging from foundational driver functions at the base to dependent functions at the upper levels (Figure 3). Level 10 (E1–E3) formed the core drivers, followed by disaster management (E8), infrastructure (E4–E6), and human development elements (E17–E22) at intermediate levels. Level 6 contained linkage elements mediating between drivers and outcomes (E7, E10–E11, E13–E16). Upper levels (1–5) represented dependent outcomes, including housing, food security, investment, cooperatives, transportation, communication, community and women's empowerment, social protection, and public order (E9, E12, E23–E30). This hierarchy provides an empirical basis for understanding the functional interdependencies in the administration of the district and represents an organized progression from environmental, spatial, and governance drivers through productive sectors to social and adaptive functions.

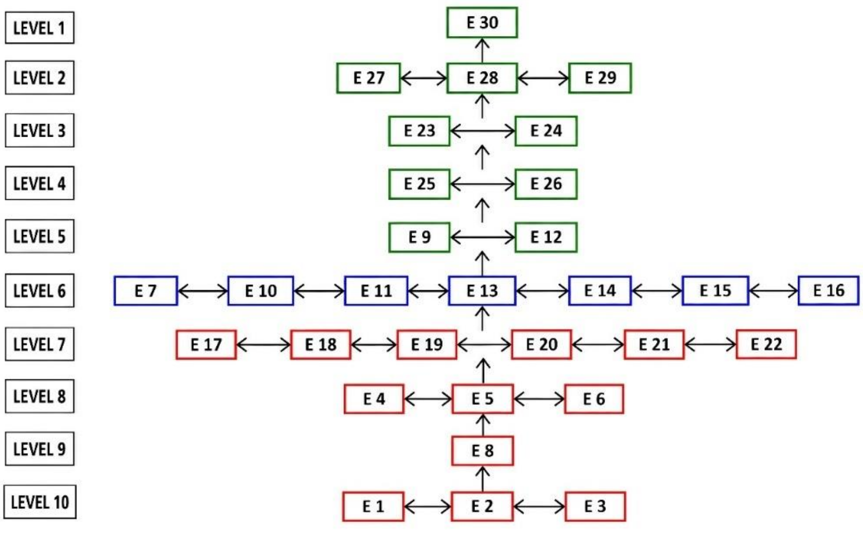

Figure 3. Hierarchical structure of district government functional elements in Danau Sentarum landscape. The elements form a cascading structure where lower levels drive the levels above them.

Discussion

Government Sectors in the Danau Sentarum Landscape Management

There are 26 district government issues that need to be coordinated, such as required basic services, non-basic services, and optional functions to achieve sustainable development, which can be implemented throughout the Danau Sentarum landscape. This broader institutional mandate goes beyond the ecological approach established under Law No. 23/2014 on Regional Government, which places watershed management primarily within the forestry sector [11]. García et al. [23] found that local governments across six countries (El Salvador, Nicaragua, Sweden, the United States, Brazil, and Peru) hold administrative authority in watershed governance that goes beyond narrowly defined sectoral responsibilities. While local governments are recognized as important actors in sustainable development, this analysis offers a more comprehensive understanding by mapping the structural hierarchy among district functions and identifying those acts as primary drivers for systemic change, the functions that mediate ecological and economic, and those whose implementation depends on the successful execution of other functions.

Previous research on the Danau Sentarum landscape has highlighted the important role of district-level government involvement. Roslinda et al. [16] demonstrated this through their stakeholder analysis, while Edison et al. [15] identified district-level institutions as key actors within the Sekampung Watershed governance network. However, a thorough examination of the functional hierarchy has not been conducted and these studies have been mostly concerned with the identification of actors and the assessment of collective power or influence. This study addresses this gap by identifying district functions based on Law No. 23/2014 on Regional Government and Government Regulation No. 18/2016 on Regional Apparatus, as the principal structural drivers of watershed governance. By integrating functional and hierarchical dimensions, this perspective provides an operational framework for institutional diagnosis that supplements traditional stakeholder-based analysis.

Institutional Quadrant and Hierarchy Structure

ISM analysis results positioned environmental management, spatial planning, and land administration along the foundational hierarchical level due to high driving power and low dependence. These have become the fundamental operational levers for watershed governance, with shortcomings in any one temporarily limiting performance across other sectors, as much as it involves resource-based productive activities and community welfare outcomes. The hierarchical approach does not consider spatial planning as a mere determinant in the framework of enabling conditions, as done by previous studies; rather, it points to it as a necessary precondition for effective governance, supported by the findings of Narendra et al. [13] and Basuki et al. [12]. The next tiers are dedicated to disaster management and infrastructure functions (water resources, roads, environmental sanitation) connecting ecological governance with service delivery and risk mitigation.

The linkage quadrant consists of functions such as agriculture, fisheries, tourism, trade and industry, labor, energy, and mineral resources, which take on an intermediate function role as they are both driven themselves and can act as transmitters of changes onward to other quadrants. The effectiveness of these functions is contingent on the strength of their foundational components, underscoring the close interrelationship between ecological and economic outcomes. Evidence from similar settings reinforces this relationship. In Indonesian sub-watersheds, the integration of ecological capacity into spatial planning helped maintain ecosystem services without compromising economic productivity [24,25]. Likewise, studies of Chinese river basins showed that incorporating ecosystem services into planning resulted in a 9.4% increase in total ecosystem service value [26]. This connection indicates where governance interventions can maximize co-benefit opportunities.

The adaptive quadrant is made up of food security, housing, transportation, investment community empowerment, social protection and public order. These are the results at the downstream level that are contingent on the integrity of the driver and linking functions. The autonomous quadrant is functionless. That is, all 30 district functional parts are structurally interconnected, and none are autonomous. The three quadrants and ten levels of the overall hierarchy form a ladder of functionality that pragmatically operationalizes ecological governance into socio-economic welfare advantages. This is consistent with the social-ecological systems perspective, in which sustainability results are the consequence of interactions across ecological, institutional, and socio-economic subsystems [27–30]. The hierarchical mapping is thus diagnostic, since it assists district governments to concentrate on the basic driving functions, environmental management, spatial planning and land administration, before to arrive in adaptive results.

This hierarchy informs the governing leverage and coordination of institutions. High driving power functions have more strategic anchoring points for intervention and point to the potential to optimize subsequent policies and programs, in particular, how the capacity of environmental management, spatial planning, and land administration can drive positive outcomes. They are the main links between these improvements, indicating where cross-sector collaboration is needed to make additional progress towards achieving the SDGs. Opiyo et al. [31] stated that decentralized watershed management in Kenya is constrained by poorly defined responsibilities and insufficient institutional coordination. This hierarchical analysis gives an evidence-based ordering of responsibilities for interagency responsibilities. Sulistyaningsih et al. [11] documented institutional fragmentation due to the implementation of Law No. 23/2014 on Regional Government without practical recommendations, translates hierarchical insights with operational guides: a district spatial plan or *Rencana Tata Ruang Wilayah Kabupaten* (RTRWK) and district medium-term development plan or *Rencana Pembangunan Jangka Menengah Daerah Kabupaten* (RPJMD *Kabupaten*) can unite driver functions early in planning cycles before coupling linkage Sectors and designing adaptive outcomes. This sequencing offers a systematic framework for parceling out leadership, mediation, and support roles to agencies to support integrated ecological stewardship and community development.

The hierarchy may also have practical ramifications for program execution under Indonesia's decentralized governance setup. By prioritizing the driving functions of the organization, thus provide the greatest potential for governance to sustain future investments in adaptive outcomes. This driver-linkage-adaptive categorization helps clarify responsibilities, reduce redundancy, and strengthen responsibility across sectors. More broadly, this approach offers a replicable solution for other districts with a more complex socio-ecological setting, where official watershed authorities exist at higher levels of government and local agencies assume the sectoral implementation responsibilities.

Interpreting the functional hierarchy requires careful consideration of methodological considerations. ISM shows a connection at one point in time and provides a static picture that may alter with policy reforms, environmental changes, or political upheaval. This might be further investigated in terms of temporal evolution in future research, using some form of system dynamics models. Respondents from the district government were purposively chosen to reflect the functional domains and legal authorities. However, exploratory engagement with nongovernmental actors, communities, and private sector stakeholders may have provided more insight into the linkages among agencies. Last but not least, the driving sequence of district functions is theoretically supplied, but it has to be empirically studied (e.g. longitudinal or quasi-experimental design) if the emphasis on driver functions leads to visible changes in watershed governance.

Conclusions

This study describes how sustainable landscape management in Danau Sentarum is not only an issue of ecological elements that are within the mandates of central and provincial governments but also of almost any other government function at the district level, including six mandatory basic service functions as well as fourteen mandatory non-basic services, and six optional functions. Environmental management, spatial planning, and land administration were highlighted as the main drivers by the ISM analysis, which also showed how other functions would establish a system linking governance with community outcomes. This institutional-structural diagnostic tool identifies thrust areas and functional dependencies, which are intended to drive interventions at the district level by concentrating on the basic functions with greater driving force. These will reinforce these key roles in ways that might simplify cooperation across multiple institutional entities and enable more effective watershed governance within present legal and organizational constraints. The findings may be valuable in providing guidance for various watershed environments, but their application should be specific and sensitive to the local ecological, institutional, and legal factors.

Author Contributions

IK: Conceptualization, Methodology, Software, Investigation, Writing - Review & Editing; **RS**: Conceptualization, Writing - Review, Supervision (policy and institutional); **LBP**: Conceptualization, Writing - Review, Supervision (landscape ecology); **AS**: Conceptualization, Writing - Review, Supervision (system and modelling).

AI Writing Statement

During the preparation of this work, the authors used Paperpal to assist in correcting grammar, spelling, and language fluency. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Conflicts of Interest

There are no conflicts to declare.

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References

1. Giesen, W. Flora and Vegetation of Danau Sentarum: Unique Lake and Swamp Forest Ecosystem of West Kalimantan. *Borneo Res. Bull.* **2000**, *31*, 89–122.
2. Ruwaimana, M.; Anshari, G.Z.; Silva, L.C.R.; Gavin, D.G. The Oldest Extant Tropical Peatland in the World: A Major Carbon Reservoir for at Least 47 000 Years. *Environ. Res. Lett.* **2020**, *15*, 114027, doi:10.1088/1748-9326/abb853.
3. Klepper, O. *A Hydrological Model of the Upper Kapuas River and the Kapuas Lakes*; Asian Wetland Bureau: Bogor, ID, 1994;
4. Dika, B.S. Pemberdayaan Petani Lebah Madu Di Kawasan Taman Nasional Danau Sentarum Kabupaten Kapuas Hulu Provinsi Kalimantan Barat. Undergraduate Thesis, Institut Pemerintahan Dalam Negeri, Jatinangor, ID, 2023.
5. Kotimah, S.N.; Wardhani, H.A.K.; Ratnasari, D.; Sari, Y.N. Teknik Pemanenan Madu Hutan Lebah Apis Dorsata Di Kawasan Danau Sentarum Kabupaten Kapuas Hulu. *Edumedia J. Kegur. dan Ilmu Pendidik.* **2023**, *7*, 30–35, doi:10.51826/edumedia.v7i1.754.
6. Arini, W.; Saputra, V.R.; Ramadani, H. Traditional Use of Local Plants in Increasing Food Security by Dayak Iban Tribe in Mensiau Village, West Kalimantan. *Biotropika J. Trop. Biol.* **2021**, *9*, 38–45, doi:10.21776/ub.biotropika.2021.009.01.05.
7. Agustini, S.R.; Swasto, D.F. Identification of Local Wisdom in Community Culture in Danau Sentarum National Park. *Built Environ. Stud.* **2023**, *4*, 14–24, doi:10.22146/best.v4i2.6681.
8. Astari, W.; Yustiana, Y.; Prihadi, N. Business Models and Strategies for Managing Indigenous-Based Natural Tourism in and around Danau Sentarum National Park (Ecotourism Meliau Hamlet). *J. Ilmu Kehutan.* **2023**, *17*, 163–172, doi:10.22146/jik.v17i2.6497.
9. Santoso, N.; Hasundungan, J.T.; Sutopo; Hadiwijaya, I.; Aripin; Ramadhan, Y.; Ridwan, S.M. Habitat Characteristics and Roaming Area of Proboscis Monkey (Nasalis Larvatus Wurmb. 1787) in Danau Sentarum. *Media Konserv.* **2023**, *28*, 24–34, doi:10.29244/medkon.28.1.24-34.
10. Yuliani, E.L.; Bakara, D.O.; Ilyas, M.; Russon, A.E.; Salim, A.; Sammy, J.; Sunderland-Groves, J.L.; Sunderland, T.C.H. Bornean Orangutan Pongo Pygmaeus Pygmaeus Population Estimate within and around Danau Sentarum National Park, Kapuas Hulu, West Kalimantan. *Conserv. Sci. Pract.* **2023**, *5*, e12916, doi:10.1111/csp2.12916.
11. Sulistyaningsih, T.; Nurmandi, A.; Salahudin, S.; Roziqin, A.; Kamil, M.; Sihidi, I.T.; Romadhan, A.A.; Loilatu, M.J. Public Policy Analysis on Watershed Governance in Indonesia. *Sustainability* **2021**, *13*, 6615, doi:10.3390/su13126615.
12. Basuki, T.M.; Nugroho, H.Y.S.H.; Indrajaya, Y.; Pramono, I.B.; Nugroho, N.P.; Supangat, A.B.; Indrawati, D.R.; Savitri, E.; Wahyuningrum, N.; Purwanto; et al. Improvement of Integrated Watershed Management in Indonesia for Mitigation and Adaptation to Climate Change: A Review. *Sustainability* **2022**, *14*, 9997, doi:10.3390/su14169997.
13. Narendra, B.H.; Siregar, C.A.; Dharmawan, I.W.S.; Sukmana, A.; Pratiwi; Pramono, I.B.; Basuki, T.M.; Nugroho, H.Y.S.H.; Supangat, A.B.; Purwanto; et al. A Review on Sustainability of Watershed Management in Indonesia. *Sustainability* **2021**, *13*, 11125, doi:10.3390/su131911125.

14. Pambudi, A.S. Watershed Management in Indonesia: A Regulation, Institution, and Policy Review. *Indones. J. Dev. Plan.* **2019**, *3*, 185–202, doi:10.36574/jpp.v3i2.74.
15. Edison; Banuwa, I.S.; Yuwono, S.B.; Damai, A.A.; Hidayat, K.F.; Suroso, E.; Hasani, Q. Institutional Analysis of Sustainable Management of the Sekampung Watershed, Lampung Province, Indonesia. *J. Sylva Lestari* **2025**, *13*, 173–189, doi:10.23960/jsl.v13i1.1041.
16. Roslinda, E.; Darusman, D.; Suharjito, D.; Nurrochmat, D.R. Stakeholders Analysis on the Management of Danau Sentarum National Park Kapuas Hulu Regency, West Kalimantan. *J. Manaj. Hutan Trop.* **2012**, *18*, 78–85, doi:10.7226/jtfm.18.2.78.
17. Bendtsen, E.B.; Clausen, L.P.W.; Hansen, S.F. A Review of the State-of-the-Art for Stakeholder Analysis with Regard to Environmental Management and Regulation. *J. Environ. Manage.* **2021**, *279*, 111773, doi:10.1016/j.jenvman.2020.111773.
18. Zanin, M. On the Limits of the Intervention on Complex Systems Guided by Functional Networks. *Sci. Rep.* **2025**, *15*, 22304, doi:10.1038/s41598-025-08933-z.
19. Government of the Republic of Indonesia. Undang-Undang Republik Indonesia Nomor 23 Tahun 2014 tentang Pemerintah Daerah; State Secretariat of the Republic of Indonesia: Jakarta, ID, 2014;
20. Government of the Republic of Indonesia. Peraturan Pemerintah Republik Indonesia Nomor 18 Tahun 2016 tentang Perangkat Daerah; Government of the Republic of Indonesia: Jakarta, ID, 2016;
21. Yusuf, M.; Nurhamlin; Setiawan, Y.; Supeni, E.A. *Decision Support System Di Era 4.0: Teori Dan Aplikasi Tools Analysis*; IPB Press: Bogor, ID, 2020; ISBN 9786232561564;
22. Attri, R.; Dev, N.; Sharma, V. Interpretive Structural Modelling (ISM) Approach: An Overview. *Res. J. Manag. Sci.* **2013**, *2*, 3–8.
23. García, M.M.; Hileman, J.; Bodin, Ö.; Nilsson, A.; Jacobi, P.R. The Unique Role of Municipalities in Integrated Watershed Governance Arrangements: A New Research Frontier. *Ecol. Soc.* **2019**, *24*, 1–9, doi:10.5751/ES-10793-240128.
24. Susilowati, Y.; Kumoro, Y.; Nur, W.H. Integrated Water Quality Modelling for Spatial Planning. *IOP Conf. Ser. Earth Environ. Sci.* **2020**, *483*, 012041, doi:10.1088/1755-1315/483/1/012041.
25. Rizalie, A.; Yunita, R.; Kadir, S.; Saidy, A.R. Environmental Carrying Capacity for Spatial Planning of Lemo Sub-Watershed, North Barito Regency, Central Kalimantan, Indonesia. *J. Hunan Univ. Nat. Sci.* **2022**, *49*, 68–76, doi:10.55463/issn.1674-2974.49.4.8.
26. Che, L.; Zhou, L.; Xu, J. Integrating the Ecosystem Service in Sustainable Plateau Spatial Planning: A Case Study of the Yarlung Zangbo River Basin. *J. Geogr. Sci.* **2021**, *31*, 281–297, doi:10.1007/s11442-021-1847-7.
27. Lebel, L.; Anderies, J.M.; Campbell, B.; Folke, C.; Hatfield-Dodds, S.; Hughes, T.P.; Wilson, J. Governance and the Capacity to Manage Resilience in Regional Social-Ecological Systems. *Ecol. Soc.* **2006**, *11*, 1–21, doi:10.5751/ES-01606-110119.
28. Berkes, F. Environmental Governance for the Anthropocene? Social-Ecological Systems, Resilience, and Collaborative Learning. *Sustainability* **2017**, *9*, 1232, doi:10.3390/su9071232.
29. Leach, M.; Reyers, B.; Bai, X.; Brondizio, E.S.; Cook, C.; Díaz, S.; Espindola, G.; Scobie, M.; Stafford-Smith, M.; Subramanian, S.M. Equity and Sustainability in the Anthropocene: A Social-Ecological Systems Perspective on Their Intertwined Futures. *Glob. Sustain.* **2018**, *1*, 1–13, doi:10.1017/sus.2018.12.
30. Reyers, B.; Folke, C.; Moore, M.L.; Biggs, R.; Galaz, V. Social-Ecological Systems Insights for Navigating the Dynamics of the Anthropocene. *Annu. Rev. Environ. Resour.* **2018**, *43*, 267–289, doi:10.1146/annurev-environ-110615-085349.
31. Opiyo, S.B.; Opinde, G.; Letema, S. Multi-Level Governance of Watersheds in Kenya under Devolution Framework: A Case of Migori River Watershed. *Int. J. River Basin Manag.* **2024**, *22*, 253–269, doi:10.1080/15715124.2022.2118284.