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Between Local Participation and Karst Conservation in the Context of Sustainability

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Abstract

This study examines the governance of the Rammang-Rammang karst area in South Sulawesi, Indonesia, integrating the frameworks of Environmental, Social, and Governance (ESG), Adaptive Co-Management (ACM), Adaptive Governance (AG), Social–Ecological Systems (SES), political ecology, and the coloniality of knowledge. It does so through an exploratory case study approach, drawing on 28 research informants (in-depth interviews), Focus Group Discussions, and participant observation techniques, which are interpreted through thematic analysis using NVivo 14 to identify cross-narrative patterns and interactions among stakeholders. Six interrelated dynamics are revealed: the cultural–ecological meaning of karst as a living space; community resistance to extractive threats; structural power asymmetry; the dominance of techno-administrative knowledge; the challenges of integrating ESG–ACM–AG; and the emergence of organic local governance practices. These dynamics illustrate the ongoing tension between formal institutional structures and community-based governance systems. The development of an integrative conceptual model that positions locally-based ESG, ACM-driven collaboration, and multilevel AG coordination as three bridging mechanisms to align both subsystems.

1. Introduction

Karst is one of the most complex and vulnerable landscapes in social and ecological systems. Geomorphological processes formed through the dissolution of carbonate rocks produce shaft structures, cave networks, underground rivers, and drainage systems that are sensitive to changes in land cover and human activities. Ford and Williams assert that minor disturbances to the karst environment can trigger long-term ecological damage (Ford & Williams, 2007). In addition, karst provides a variety of important ecosystem services such as groundwater regulation, carbon storage, habitat for endemic species, and biodiversity conservation spaces (Bai et al., 2025; Zerga, 2024). In many regions, karst is not only an ecological space, but also a sociocultural space where local communities have coexisted with the environment for generations (Day, 2010). UNESCO Global Geopark recognition strengthens the strategic position of karst areas by integrating geological conservation, education, tourism, and sustainable development (Henriques & Brilha, 2017). The Rammang Rammang karst area in South Sulawesi is an important example that combines geomorphological, archaeological, ecological, and socio-cultural values, making it a strategic location for studying the interaction between global conservation and local dynamics.

Increasing global attention to sustainability is driving the adoption of Environmental, Social, and Governance (ESG) frameworks across sectors, including conservation area management. ESG serves as a guide to ensure that environmental governance is carried out ethically, inclusively, and transparently (Friede et al., 2015). Although initially used in the investment and corporate sectors, ESG has been extended to the management of natural resources, especially in areas with high social and ecological complexity (Amir & Serafeim, 2018). The concept of socio-ecological systems (SES) emphasizes the importance of understanding the interconnectedness between humans and nature as a system that affects both (Folke, 2010). In areas like Rammang Rammang, local ecological knowledge is an important

part of SES dynamics and serves as social capital for sustainability (Berkes, 2012). Therefore, ESG adaptation in the context of karst cannot be separated from cultural values, histories of resistance, and local management practices that have developed from generation to generation.

In addition to ecological and socio-cultural factors, the governance of karst areas is also influenced by power relations and knowledge politics. Political ecology explains that conservation policy is often an arena for attracting interests between global actors, countries, and local communities (Robbins, 2012). Conservation interventions on an international scale have the potential to bring about epistemic biases that displace or marginalize local knowledge (Peet & Watts, 2004). The notion of coloniality of knowledge strengthens this argument by showing how modern knowledge can dominate and erase traditional knowledge (Quijano & Ennis, 2000; Santos, 2014). In the context of geoparks, Henríquez et al. noted that the lack of effective participation mechanisms and weak multi-stakeholder coordination are the main obstacles to governance (Henríquez & Brilha, 2017). Studies on ecological justice show that environmental conflicts are often rooted in structural inequities and histories of institutional dominance (Buscher & Fletcher, 2020; Moore, 2015). Rammang Rammang has a history of community resistance to industrial exploitation, so local political dynamics are an important component in understanding karst governance.

To overcome the complexity of karst governance, adaptive co-management (ACM) and adaptive governance (AG) approaches are relevant. ACM emphasizes collaboration between various stakeholders, integration of local and scientific knowledge, and adaptive learning cycles (Armitage et al., 2007). The AG emphasizes the importance of institutional flexibility, cross-scale coordination, and response to ecological uncertainty (Chaffin et al., 2014). Studies on collaborative governance show that social capital, institutional networks, and meaningful participation are key factors for successful resource management (Bodin, 2017; Pretty, 2003). In the context of karst, conservation success is highly dependent on the relationship of mutual trust between communities and governments, as well as the ability to adapt to external pressures such as tourism and industry (Wu et al., 2019). However, the integration of ESG, ACM, and AG into a single analytical framework for karst geoparks remains rare in the global literature.

Although research on karst, SES, ESG, political ecology, and adaptive governance has evolved, significant gaps remain underexplained. First, there is no theoretical understanding of how ESG can be adapted to the social and ecological characteristics of karst areas, especially those that have strong cultural values and a history of resistance. Second, empirically, there are still limited studies that illustrate how local actors in Rammang Rammang, such as the community, Village-Owned Enterprises (BUMDes), Tourism Awareness Groups (Pokdarwis), village governments, and local governments, navigate global conservation standards and industry pressures. Third, conceptually, there is no integrated model that combines ESG, ACM, and AG as the basis for adaptive and inclusive karst governance. These three gaps point to the urgent need to develop analytical frameworks that can bridge the gap between global sustainability and local realities.

This research aims to fill this gap by developing an integrative framework of Adaptive Co-Management, Adaptive Governance, and Environmental, Social, and Governance to understand the governance of the Rammang Rammang karst area. This research asks three main questions: how local actors navigate power relations in regional management, how local knowledge and histories of resistance contribute to adaptive governance mechanisms, and how integrative frameworks can be designed to improve ecological sustainability and community well-being. This research contributes to three aspects. Theoretically, this study contributes a new conceptual model that integrates ESG, ACM, and AG within the context of karst as a social-ecological system. Empirically, this study presents a thematic analysis of governance dynamics in Rammang Rammang. In practical terms, this research offers policy recommendations for local governments and UNESCO to strengthen inclusive, adaptive, and sustainable geopark governance.

2. The Relationship Between Communities and Karst Landscapes: Existing Interpretations and the Conceptual Gap

The relationship between communities and karst landscapes has long been understood through social and ecological systems frameworks that emphasize the interconnectedness between biophysical processes and the social structures that manage or depend on karst areas. Karst landscapes have fragile hydrogeological characteristics because they are formed by the dissolution of carbonate rocks, which create cavities, caves, and underground drainage networks that are sensitive to human disturbance. Damage to these structures is often permanent and has a wide impact on water availability and ecosystem stability (Ford & Williams, 2007). In addition to its geological value, karst provides various ecosystem services, such as biodiversity habitats, carbon storage, and support for traditional agricultural systems that underpin the sustainability of local communities (Day, 2010). The framework of social and ecological systems shows that karst sustainability is strongly influenced by the interaction between cultural values, social structures, and local ecological knowledge that develops from generation to generation (Berkes, 2012; Folke, 2010). However, the scientific literature still tends to focus on geological and hydrological aspects, so the social and political dimensions of karst management receive little attention. This limits the understanding of how community dynamics, conflicts of interest, and traditional management practices contribute to the sustainability of karst areas.

The growth of the sustainability discourse over the last two decades has made the ESG framework an important reference for assessing environmental responsibility, social welfare, and governance integrity. ESG is considered capable of increasing accountability in the public and conservation sectors by providing more standardized indicators (Friede et al., 2015). In geopark conservation, ESG is seen as relevant because it integrates environmental protection, community participation, and multilevel governance (Henriques & Brilha, 2017). However, a number of studies suggest that ESG is often overly corporate-oriented and fails to fully capture the social and ecological complexities of areas such as karst (Amir & Serafeim, 2018; Bodin, 2017). In societies with strong social capital and traditional ecological practices, universal ESG indicators often fail to reflect local values or community-based management

practices. This inconsistency raises questions about the extent to which ESG can be an adaptive framework sensitive to the unique characteristics of karst as a social and ecological system.

The challenge of karst management lies not only in the ecological or technocratic dimensions but is also closely related to the power relations that shape interactions among global actors, states, and local communities. The perspective of political ecology shows that conservation is often shaped by power inequalities, in which external institutions impose definitions, values, and conservation targets that do not always reflect the needs of local communities (Robbins, 2012). This phenomenon is reinforced by the coloniality of knowledge, which is the dominance of modern epistemology that places local knowledge in a less legitimate or less scientific position (Quijano & Ennis, 2000; Santos, 2014). In practice, communities with a long history of ecological management are often sidelined when conservation decisions are made centrally. Studies on geoparks in Latin America, for example, show that governance tends to be top-down with limited space for community participation (Henriques & Brilha, 2017). A similar situation is found in strictly based conservation that marginalizes public access in the name of nature protection (Buscher & Fletcher, 2020). When community voices are not considered in the decision-making process, conservation legitimacy weakens and can trigger local resistance. Research shows that the long-term success of conservation relies heavily on recognition of the social roles, identities, and local histories that shape people's relationship with the landscape (Moore, 2015).

In response to these challenges, adaptive approaches offer a more dynamic perspective on understanding governance in a complex region such as the karst. ACM emphasizes multi-stakeholder collaboration, integration of local and scientific knowledge, and continuous learning cycles to respond to changing ecological conditions. This approach recognizes that effective governance requires flexibility and active participation of communities (Armitage et al., 2007). Meanwhile, the AG highlighted the importance of cross-agency coordination and of institutions' ability to adapt policies to ecological uncertainties (Chaffin et al., 2014). Both approaches are relevant in karst areas that face pressures from tourism, extractive industries, and land-use change. The quality of relationships between actors such as local communities, governments, customary institutions, and external organizations plays a key role in determining the success of adaptive governance (Bodin, 2017; Pretty, 2003). However, empirical studies on the application of ACM and AG in karst areas are still limited. Research in China shows that karst governance is often sectoral and non-adaptive, thus hampering conservation efforts (Wu et al., 2019). In addition, the ACM and AG approaches have not been systematically linked to ESG, even though the combination of the three has the potential to complement each other's weaknesses.

Internal social dynamics of the community are also important for understanding karst management. Communities with strong social ties have informal mechanisms for maintaining social order and minimizing conflict (Silver & Miller, 2004). In the context of shared resource management, social capital can increase collective capacity to prevent damage and overcome conflict (Pretty, 2003). But social capital does not always result in harmonization; it can lead to social exclusion or strengthen local elites' dominance (Alecu et al., 2022). In karst areas that have a history of resistance to industrial exploitation, these dynamics are particularly relevant. The success of conservation is often determined by the ability

to bring ecological values together with multi-layered local social structures. However, the literature on karst still rarely examines how the community's internal social dynamics affect regional governance.

The social legitimacy of the management institution is also an important factor in the success of environmental management. Society's perception of procedural justice, distributive justice, and institutional responsiveness affects the extent to which they are willing to engage in environmental management (Mastrofski, 2004). This is important in a karst context that requires sustainable community participation to maintain its ecological function. However, most karst studies have not examined the social legitimacy in the management of geoparks or other conservation areas. In many areas, conservation policies tend to ignore local cultural values, creating a gap between formal policies and community management practices.

The synthesis of the literature shows some of the main limitations in karst research. First, karst studies still focus on biophysical aspects and lack integration of social, political, and cultural dynamics that affect sustainability. Second, the application of ESG in the context of karst remains generic and has not accounted for local practices or power dynamics. Third, political ecology explains the roots of conflict and inequality, but does not offer an operational framework for adaptive governance. Fourth, ACM and AG are promising but have not been comprehensively tested in the context of karst geoparks and have not been integrated with ESG. Fifth, there is no literature that integrates these five perspectives into a single conceptual framework for understanding karst governance as a whole.

This conceptual gap underscores the need for a more integrative approach to understanding karst governance dynamics. A conceptual model is needed that can bridge ESG, ACM, and AG within the framework of social and ecological systems and consider the relationship between power and local knowledge, as outlined in political ecology. Such an approach is especially important in areas such as Rammang-Rammang, which face high ecological pressures, complex social dynamics, and a long history of community resistance to environmental exploitation.

3. Methodology

3.1. Research Design

This research uses a qualitative approach with an exploratory case study design to understand the dynamics of governance in the Rammang-Rammang karst area within a complex socioecological context. The case study design was chosen because the researcher examines in depth the processes, interactions between sectors, and specific conditions that shape karst management practices in a single location with unique characteristics (Yin, 2018; Merriam, 2009). Increased community involvement in research is driven by local participation factors that shape governance development. The ESG framework, Adaptive Co-Management, and Adaptive Governance approaches are interpreted, negotiated, and practiced by various stakeholders.

The research location is the Rammang-Rammang karst area, Salenrang Village, Bontoa District, Maros Regency, South Sulawesi. This area was chosen purposively because it is part of the Maros–Pangkep UNESCO Global Geopark in South Sulawesi. This region is an arena for interaction between global conservation interests, tourism, and community-based practices.

3.2. Participants and Data Collection Techniques

The research data concern the selection of informants as research participants through purposive sampling based on their involvement in karst governance. All participants have provided verbal consent for the study, which has been approved by the Institutional Review Board of Universitas Hasanuddin. The composition of informants comprised 46 participants, with details of 28 collected through in-depth interviews and 13 directly involved in Focus Group Discussions (FGD). The following Table 1, a list of 28 in-depth interviews with government actors, area managers, village leaders, traditional figures, ecotourism actors, local youth, Village-Owned Enterprises (BUMDes), environmental communities, academics, and Micro, Small, and Medium Enterprises actors.

Table 1
Research Informants for In-Depth Interviews

Role of Informants	**Informants**
Government Actors	3 Informants
Karst Area Management	2 Informants
Village leader	2 Informants
Traditional Leaders	2 Informants
Ecotourism Actors	4 Informants
Local Youth	3 Informants
Village-Owned Enterprises (BUMDes)	1 Informants
Academics	2 Informants
Environmental Community	2 Informants
Micro, Small, and Medium Enterprises actors	3 Informants
Local Community	3 Informants
Source: Primary Data, 2025	

The Focus Group Discussion (FGD) involved 13 participants from various institutions, including the Maros Regency Government, the Tourism Office, the Tourism Group (Pokdarwis), Village-Owned Enterprises (BUMDes), tour operators, indigenous communities, local journalists, and environmental activists. Table 2 below lists the FGD participants.

Table 2
Focus Group Discussion Participants

Participant Categories	Institution/Community
Local Government	Regent of Maros
Local Government	Tourism
Village Government	Head of Salenrang Village
Tourism Institutions	Pokdarwis
Village Economy	BUMDes
Karst Circle Youth	Local communities
Traditional Leaders	Indigenous
Academics	Hasanuddin University
Geopark Practitioner	Geologist
Local Media	Journalist
Local MSMEs	Tourism actors
Tour Operators	Boat group
Environmental Activist	Civil society organizations
Source: Primary Data, 2025	

The research also employed participant observation during ecotourism activities, community meetings, and other field activities to understand organic governance practices. Participatory observation corroborated the data from in-depth interviews and focus group discussions.

3.3. Research Procedure

The research began with an in-depth literature review covering karst governance, ESG, adaptive governance theory, and community participation. Stakeholder mapping was conducted to identify relevant actors and relationship structures within the research area.

Research instruments, in the form of interview guidelines and observation sheets, were prepared and tested on a limited basis to ensure the suitability and clarity of the questions. Data collection took place from May to October 2025.

The interviews were conducted in a semi-structured manner to explore experiences, perceptions, and dynamics of power relations. FGD is used to capture deliberative processes, differences in views between actors, and coordination patterns in regional management. Participatory observation was conducted to observe firsthand the practices of space use, tourism arrangements, and informal conflict

resolution mechanisms. All data are obtained ethically with participant consent, and anonymity is maintained by assigning a code to each informant.

3.4. Data Analysis

The analysis was carried out using *thematic analysis* (Braun & Clarke, 2006), with the following stages. First, open coding, which involves identifying concepts and important pieces of information from interview transcripts, FGDs, and observation notes.

Second, Axial coding groups codes into themes that reflect patterns of meaning, such as power relations, resistance, local knowledge, co-governance practices, and ESG interpretation. Third, Selective coding, which involves preparing a conceptual narrative that connects key themes to answer research questions and form an analytical model.

The entire analysis process is supported by triangulation of methods and data sources to ensure the credibility and accuracy of the findings. NVivo 14 software is used to support data organization, code tracking, and documentation of the analysis process.

4. Revealing Inter-Related Patterns and Complexities of the Socio-ecological Systems that Shape Local Governance Practices

Thematic analysis of interview, FGD, and field observation data revealed the dynamics of Rammang-Rammang karst governance, shaped by interactions among local values, historical experiences, power relations, and daily management practices. Six key themes explain how communities understand, respond to, and participate in karst management amid growing ecological and institutional pressures. The following themes show interrelated patterns and reflect the complexity of the socio-ecological systems that shape local governance practices.

4.1. Karst as a Social-Ecological Heritage

Karst is understood by the community as a living space that is integrated with identity, family sustainability, and cross-generational history. The participants described karst as an integral part of their lives, both ecologically and emotionally. A community leader explained that "this karst is not just a place, it is part of our life from the past" (Interview 07). Similar expressions recur in other interviews, suggesting that people interpret karst not only physically but also culturally and spiritually.

This meaning can be seen in the daily practices of people who use karst to farm, sail, and meet basic needs, while maintaining the ecosystem that sustains them. At the same time, field observations show that these activities are carried out with reference to local ecological knowledge, such as understanding water flows, sedimentation patterns, and spaces considered sacred. In addition, participants often associate karst with ancestral history, so its presence is perceived as a moral responsibility to preserve. These findings show that the meaning of karst as a social-ecological heritage forms the ethical foundation that underlies people's attitudes towards management and conservation.

In addition to cultural and spiritual values, karst is also understood as a support for the family economy, especially through community-based tourism. Locals perceive that their economic sustainability depends on the sustainability of the karst. One of the tour guides stated, "If karst is damaged, our livelihood will be exhausted" (Interview 12). This confirms that, for the community, karst is not only an aesthetic or objective source but also an ecological asset that directly affects survival. This awareness makes communities the main actors in maintaining karst sustainability, although they also face external pressures that can disrupt ecological systems.

4.2. Local Resistance to the Threat of Exploitation

The history of conflict and resistance to plans for karst exploitation shaped the community's collective identity as the guardian of its territory. Many participants recalled the mining effort that was proposed a few years ago, which forced the community to unite and confront the threat. "We have to survive, otherwise this village can be lost," said one of the Pokdarwis members (Interview 15). This resistance arises from a combination of ecological concerns, anxiety about the loss of living space, and historical experiences of power inequality in decision-making.

Forms of resistance are not always open demonstrations. Most residents use informal strategies such as refusing to sign land approvals, engaging in internal mediation, or organizing village deliberations to strengthen their bargaining positions. The findings of the FGD show that resistance is also carried out by strengthening horizontal solidarity among citizens, especially when external pressure comes from industry groups or government institutions. "If someone wants to take land, we agree first in the village, no one should go alone," (FGD2-Participant3). This pattern reflects a form of collectivity that is an important social capital in the face of the threat of exploitation.

Repeated resistance leads to heightened alertness to new interventions, including tourism programs or zoning policies. Many residents said they "don't want to miss again" after the previous experience. This shows that resistance has become both an instrument of social defense and a response to the power imbalance in karst governance. On the other hand, this resistance also creates tensions between communities and government agencies, which can affect the sustainability of conservation policies if not managed properly.

4.3. Power Relations and Knowledge Asymmetry in Governance

The power relationship between the community and government actors emerged as a significant factor influencing the karst management process. Many participants stated that management policies, including tourism zoning or conservation regulations, are often decided without adequate consultation. "Often new rules come, but we are not talked to first," said one of the residents (Interview 18). These findings show a misalignment between formal decision-making mechanisms and participatory values important in local communities.

In addition, there is an inequality in the technical understanding of karst management. Informants said that policy language, technical reports, or spatial plans are often difficult for people to understand, so they feel they lack the capacity to participate equally. As a result, formal institutions indirectly hold greater authority in determining the direction of management. Some participants stated that they felt "dictated by rules from above" (Interview 21), indicating an epistemological tension between scientific knowledge and local knowledge.

This knowledge asymmetry affects policy legitimacy. Field observations show that some government initiatives are slow or ineffective due to a lack of public acceptance. Instead, informal instructions or community agreements are more likely to be adhered to. These findings confirm that karst governance is not only influenced by formal structures but also by public perceptions of procedural fairness in decision-making processes. Unbalanced power relations weaken collaboration and hinder conservation efforts that require multisectoral support.

4.4. Dominance of Techno-Administrative Knowledge and Neglect of Local Knowledge

In addition to the power imbalance, the dominance of technocratic knowledge is also evident in karst management. Many participants said that external standards-based approaches to conservation and tourism are more often used than traditional community practices. "We often only accept rules, not ask for opinions," said one resident (Interview 10). This shows that, for the public, the consultation process is often only a formality.

In some FGDs, participants stated that certain tourism standards, such as the division of tourist routes or rules for boat use, were perceived as "more suitable for tourists than locals" (FGD1-Participant2). This experience creates the impression that local values do not have a place in policy design, even though communities have ecological knowledge that has been tested through their experience. Knowledge of water patterns, seasons, cave characteristics, or erosion-prone points is rarely used as a basis for formal planning.

Field observations support these findings. Many technical decisions are made in formal forums involving only a handful of community representatives, so that more widespread community-level knowledge is not accommodated. These findings suggest that karst governance faces epistemological challenges, in which local knowledge has the potential to make an important contribution but has not yet been fully integrated into policy. The dominance of administrative approaches reduces much-needed collective learning space in a rapidly changing environment.

4.5. Challenges of ESG Integration, Adaptive Co-Management, and Adaptive Governance

Efforts to implement sustainability principles through the ESG framework, together with adaptive co-management and adaptive governance at the local level, face various obstacles. Although some local

actors recognize the term ESG, many interpret the concept as an administrative requirement, rather than a substantive sustainability principle. A BUMDes manager explained that "ESG is more about reports and document requirements" (Interview 05). These findings suggest that ESG implementation focuses more on administrative aspects than on strengthening social sustainability or the recognition of local knowledge.

The principle of adaptive co-management has emerged organically in community activities, such as conflict-resolution deliberations and cooperation in protecting tourist areas. However, this mechanism has not been connected to formal or institutional government processes. The FGD revealed that coordination often relies on personal relationships among actors rather than on well-established structures. "If the people get along, the road goes smoothly; otherwise, it will be done separately," (FGD3-Participant4). This situation reflects that adaptive capacity already exists in practice but has not been underpinned by policies that support learning mechanisms and cross-institutional coordination.

Adaptive governance, which requires flexibility and multi-level coordination, is also weak. When decisions require the approval of the district government, the process is often hampered by lengthy bureaucratic flows or misalignment of priorities between agencies. These findings suggest that the ESG–ACM–AG integration requires strong institutional support, something that is still in its early stages in Rammang-Rammang. These barriers suggest that successful adaptive governance requires harmonization between formal structures and informal practices that are already effective.

4.6. The Emergence of Organic Local Co-Governance

Amid the limitations of formal institutions, local co-governance practices emerged as an adaptive, situational management mechanism. Collaboration among BUMDes, Pokdarwis, boat groups, and community leaders forms an unwritten management system that functions effectively in addressing everyday issues. "We just take care of each other so that everything goes well," said a tour manager (Interview 14). These collaborations reflect the emergence of trust-based co-management practices and local experiences.

This co-governance practice can be seen in the regulation of tourist routes and boat schedules, as well as efforts to maintain a clean environment. Most of these practices are not governed by formal regulation, but by community consensus. In addition, informal groups play an important role in mediating minor conflicts and maintaining a balance of interests between local actors. However, this practice has limitations, especially when dealing with issues that require support from district governments or decisions with broad administrative implications.

Nevertheless, these findings suggest that local co-governance could be strengthened as part of a more formal adaptive governance framework. These practices that grow from below reflect the capacity of communities to adapt to changes and conservation needs. These findings also suggest that effective governance structures require a blend of formal regulation and informal mechanisms that have long functioned at the community level.

The six main themes above show that Rammang-Rammang karst management is a process influenced by social values, history of resistance, power relations, and co-governance practices that develop organically. These findings underscore the need for responsive, inclusive, and adaptive governance, especially in the face of increasingly complex ecological and institutional pressures. These findings also provide a strong empirical basis for developing further theoretical analysis of ESG integration, adaptive co-management, and adaptive governance in the Discussion.

5. The Interactions Between Socio-ecological Values, History of Resistance, Power Relations, and Local Co-governance Practices

The findings of this study suggest that Rammang-Rammang karst governance is shaped by the complex interactions among socio-ecological values, the history of resistance, power relations, and local co-governance practices that develop within an unstable institutional context. The six thematic themes produced show that karst is not simply understood as a physical landscape but as a living space that contains social memory, collective identity, and ecological knowledge passed down across generations. At the same time, societies face external pressures that create tensions between formal governance structures and community-based management mechanisms. This discussion integrates these findings with global theories to demonstrate the theoretical, empirical, and policy contributions of this research.

Overall, the findings suggest that karst governance in Rammang-Rammang operates through two systems that run simultaneously but often do not intersect. The first system is a formal structure, characterized by government policies, administrative standards, and technocratic approaches, including the use of ESG-based sustainability indicators. The second system is a local socio-ecological system that develops from community practices and local ecological knowledge, forming an experiential adaptive mechanism. The tension between these two systems is evident in a variety of themes, especially local resistance, knowledge asymmetry, and the dominance of technical approaches by external institutions.

In addition, there is a consistent pattern that shows that communities have strong adaptive capacities, reflected in local co-governance practices that develop organically. But this capacity is often not connected to formal institutional structures, creating governance fragmentation. This synthesis shows that the core of the problem does not lie in the lack of community capacity or the weakness of government institutions alone, but in the insynchronization of two knowledge systems, two power structures, and two forms of governance.

Meanwhile, distinct interpretations are made possible within the confines of global theories. Within the framework of social-ecological systems (SES), for example social and ecological systems are inextricably interrelated and influence each other (Folke et al., 2010). The findings of this study show that the Rammang-Rammang community has a deep understanding of this relationship through the concept of karst as a living space rather than merely an ecological object. This interpretation emphasizes that people practice the SES approach intuitively, even though it is not formalized. Tension arises when

external technocratic approaches are unable to recognize these relational dimensions. This is consistent with the global criticism that conservation failures often stem from the inability of formal interventions to integrate local social–ecological relationships.

Meanwhile, adaptive co-management (ACM) combines collaboration with adaptive learning processes (Armitage et al., 2007). The findings of this study show that elements of ACM have emerged as internal deliberations, cooperation, and informal mediation used to manage tourism and maintain karst ecosystems. However, these elements are not systematically connected to formal structures, so adaptation occurs only at the community level. This shows that society's adaptive capacity has developed, but it has not gained the institutional strengthening needed to be part of broader governance.

In another case, adaptive governance (AG) emphasizes flexibility, multi-level coordination, and the capacity to respond to change (Chaffin et al., 2014). The findings of this study show that coordination between government agencies is inadequate and often relies on personal relationships rather than institutional mechanisms. This limits the AG's potential to connect communities, village governments, district governments, and geopark institutions. This coordination gap explains why tensions and overlapping roles often arise in karst management.

Similarly, environmental, social and governance (ESG) frameworks are often promoted as global sustainability standards, but findings suggest that their implementation at the local level is more administrative than substantive. Social sustainability indicators and recognition of local knowledge do not appear prominently in ESG practices in Rammang-Rammang. This reinforces the criticism that ESG focuses too much on reporting and technical indicators (Amir & Serafeim, 2018), and risks ignoring local contexts and more complex socio-ecological dynamics.

From a political ecology perspective, the findings of this study show that karst governance conflicts are not just technical issues but also related to power relations, control over space, and the distribution of benefits. Local resistance to karst exploitation reflects the community's struggle to defend its living space against the domination by external actors with access to political and economic resources. This is in line with the global literature, which states that conservation conflicts are often rooted in unfair representation and unequal access to decision-making (Robbins, 2012).

Lastly, the point of the coloniality of power/knowledge shows the dominance of technocratic knowledge that ignores local knowledge, illustrating a form of knowledge colonization (Quijano & Ennis, 2000; Santos, 2014). In this context, the community is positioned as the recipient of the policy, not as the legitimate owner of ecological knowledge. These findings clarify how coloniality operates not only through political power but through a hierarchy of knowledge that defines which knowledge is considered valid.

5.1. Impacts on Concepts

The conceptual model developed in this study shows that karst governance in Rammang-Rammang is shaped by the simultaneous interactions among formal structures, community practices, and power dynamics within complex socio–ecological contexts. This model integrates the Environmental, Social, and Governance (ESG), Adaptive Co-Management (ACM), and Adaptive Governance (AG) frameworks through the perspective of Social-Ecological Systems (SES), as well as the lens of political ecology and the coloniality of knowledge. This integration yields a new understanding of how sustainability can be achieved by harmonizing formal institutional structures with community-based adaptive practices.

At the heart of this model is the idea that karst governance operates through two large, interacting but often asymmetrical subsystems: *formal subsystems* and *community subsystems*. Formal subsystems include local governments, geopark institutions, and administrative rules that rely on technocratic sustainability frameworks, such as ESG standards. This subsystem has advantages in regulatory capacity, access to resources, and legal legitimacy, but its weaknesses lie in limited understanding of the socio-ecological context at the community level.

On the other hand, community subsystems include organic co-governance practices, local ecological knowledge, sociocultural rhythms, local resistance histories, and deliberation-based problem-solving mechanisms. These subsystems have strong flexibility, adaptive capacity, and social legitimacy, but are often disconnected from or unrecognized by formal structures. The dominance of technocratic knowledge and the inequality of access to the decision-making arena place the community subsystem in a subordinate position, despite its central role in maintaining karst sustainability.

This conceptual model places the tension between the two subsystems as a critical point of karst governance. These tensions arise through three main mechanisms:

1. Knowledge asymmetry: Relational local ecological knowledge is often not considered valid in formal planning processes that rely on technical indicators. This gives rise to the colonization of knowledge, where local knowledge is delegitimized.
2. Dominance of structural power: Decision-making is more tightly controlled by formal actors, strengthening their position in determining policy direction and resource allocation. This creates a situation where communities face policies that are less sensitive to their socio-ecological context.
3. Governance fragmentation: The practices of co-governance that develop at the community level are not connected to formal adaptive structures. As a result, the community's adaptive capacity does not contribute optimally to the area’s management.

In this model, karst sustainability is achieved when dynamic integration occurs between two subsystems through three conceptual bridges:

1. ESG Based on Local Context: ESG is understood not only as an administrative standard but also as a framework that recognizes local socio-ecological values, community legitimacy, and the equitable distribution of benefits. Contextual ESG becomes a common language between communities and formal actors.
2. Adaptive Co-Management (ACM): ACM serves as a social bridge, a place where routine negotiations, shared learning, and collaborative relationships between communities and formal institutions take place. Through ACM, community co-governance practices gain space to contribute to decision-making.

2. Adaptive Governance (AG): AG serves as an institutional bridge that enables cross-level coordination, policy flexibility, and rapid responses to ecological dynamics. AG connects formal structures to community adaptive mechanisms, thereby reducing governance fragmentation.

When these three bridges function simultaneously, the model shows that inclusive, adaptive, and socially embedded karst governance can be realized. Sustainability is not understood as compliance with static administrative standards but as a relational process involving power negotiation, recognition of local knowledge, and continuous collaboration.

The following diagram illustrates the integrated conceptual model and the structural forces shaping interactions among governance actors in the Rammang-Rammang karst landscape.

As the Fig. 1 conceptual model illustrates, karst governance is shaped by interactions among contextual drivers, formal governance mechanisms, and community-based adaptive practices, mediated by social–ecological processes and overlaid by structural power relations. ESG, ACM, and AG form three conceptual bridges linking formal institutions and community systems, enabling more inclusive, adaptive, and context-sensitive governance. Coloniality and power relations function as transversal forces that influence knowledge, authority, representation, and decision-making pathways across all components.

Building on this conceptual foundation, the next section discusses how the empirical findings align with, extend, or challenge the integrated model. It also elaborates on how the observed practices in Rammang-Rammang demonstrate the dynamic interplay among formal governance structures, community agency, and broader political–ecological forces that shape environmental decision-making.

The conceptual model developed in this study provides a theoretical foundation for understanding how governance processes in karst landscapes are shaped by the dynamic interactions among formal institutional structures, community practices, and power relations within socio-ecological contexts. The empirical findings of this study demonstrate a strong fit with the model's architecture, especially in describing how formal subsystems and community subsystems interact, often asynchronously, and ultimately influence governance outcomes in Rammang-Rammang.

First, the findings clearly show how knowledge inequality arises in day-to-day governance practices. Local communities rely on relational ecological knowledge built from experience, seasonal conditions, and cultural memory. However, this knowledge is often sidelined by the technocratic and administrative standards associated with the ESG framework or formal regulations. This condition reinforces the asymmetric mechanism of knowledge in conceptual models, where local knowledge is marginalized in the planning and decision-making process.

Second, empirical data illustrate the dominance of structural power, especially in determining zoning, licensing, conservation planning, and tourism regulations. Decision-making centered on formal actors limits the space of communities to influence the management of space and resources, even though they have high dependencies and deep knowledge of karst ecosystems. These findings are very much in line with the conceptual model that places coloniality and political power as transversal forces influencing governance pathways.

Third, this study reveals significant fragmentation in governance. Various community-led initiatives, such as internal agreements, tourism arrangements, conflict mediation, and adaptive responses to ecological change, operate independently of formal institutional support. Although this practice demonstrates the community's adaptive capacity, the lack of integration with formal governance limits its long-term effectiveness. This fragmentation directly reflects the argument in the conceptual model that a community's adaptive capacity is not fully realized due to the absence of connections to formal adaptive governance structures.

Meanwhile, the empirical findings also indicate an opportunity to develop the three conceptual bridges outlined in the model. Community-based tourism management, collaboration between BUMDes, Pokdarwis, and boat groups, and increasing recognition of local ecological knowledge are potential entry points for contextual ESG development. The internal deliberation process and collaborative pattern that have been running at the community level show a strong foundation for the practice of Adaptive Co-Management. Increasingly intense interaction with geopark institutions also creates opportunities for more coordinated Adaptive Governance at various levels.

Thus, the empirical findings not only support the conceptual model but also enrich understanding of how such dynamics operate in the field, particularly in geoparks with high ecological sensitivity, cultural depth, and histories of resistance. This analysis forms the basis for subsequent discussions that will outline the theoretical contributions and practical implications of efforts to integrate ESG, ACM, and AG frameworks with the realities of community-based governance in karst landscapes.

5.2. Theoretical Contributions and Novelties of Research

The findings of this study not only confirm the relevance of the conceptual model developed but also make significant theoretical contributions to the study of karst governance, community-based sustainability, and the global literature on environmental governance. The novelty of this research lies in

three main dimensions that enrich academic discourse and provide a new direction for the development of theories in the field of natural resource governance.

First, this study offers a new understanding of how ESG frameworks can be adapted in complex socio-ecological contexts such as karst. So far, ESG has been criticized for its overly corporatist and technocratic nature. This research shows that ESG can be a more contextual framework when integrated with social values, community legitimacy, local ecological knowledge, and deliberation mechanisms. Thus, this research expands the ESG function from a mere reporting instrument to a relational framework capable of engaging with the complexity of fragile ecological systems and communities with long histories of environmental management.

Second, this study strengthens the literature on Adaptive Co-Management (ACM) and Adaptive Governance (AG) by showing that adaptive practices do not always rely on established formal structures. In the case of Rammang-Rammang, adaptive capacity actually grew from organic co-governance practices that have long developed at the community level. These findings challenge the assumption that institutional adaptation should be top-down, and posit that adaptation can take root in communities through social flexibility, networks of beliefs, and rapid responses to ecological change. Thus, this study adds the perspective that AG and ACM are not only institutional approaches but also social practices embedded in people's daily lives.

Third, the political ecology and coloniality of knowledge approaches used in this study provide a critical lens to understand why governance practices are often hampered, even though formal frameworks such as ESG, ACM, and AG have been implemented. Findings on the marginalization of local knowledge, the dominance of formal actors in decision-making, and technocratic tendencies in defining sustainability show that environmental governance is a political arena marked by inequalities in representation and power hierarchies. By placing the dimension of coloniality in the analysis, this study expands the scope of the governance literature towards a more sensitive study of epistemic and political dynamics.

Overall, this study shows that sustainability in karst areas cannot be achieved through the implementation of formal standards alone. Strategies that bridge technocratic logic and community values through adaptive collaborative mechanisms are needed. The ESG-ACM-AG integrative approach developed in this study provides a conceptual foundation applicable to other karst areas in Indonesia and globally, particularly in regions with high ecological sensitivity and complex social dynamics.

5.3. Policy Implications

The findings of this study provide several important policy implications for strengthening the governance of the Rammang-Rammang karst area and similar areas. These implications focus on strengthening multilevel governance, integrating local knowledge, and aligning formal sustainability frameworks with social–ecological dynamics at the community level.

First, this study emphasizes the need for a more substantive and inclusive consultation mechanism in the planning and decision-making process. Community involvement has often served as an

administrative formality, rather than a deliberative space that allows for meaningful contributions from the community. Regional policies and geopark mechanisms need to adopt a participatory model that provides communities with equal access to voice their ecological knowledge and life experiences. Building structured and regular participatory forums can strengthen the social legitimacy of policies and reduce potential conflicts between formal actors and communities.

Second, local governments and geopark managers need to develop a more flexible and adaptive coordination framework. The current institutional fragmentation hinders the flow of information, synchronization of actions, and rapid response to ecological changes and external pressures. The Adaptive Governance approach can be integrated by establishing a cross-sectoral coordinating platform that connects village governments, districts, BUMDes, Pokdarwis, and other community groups. Stronger coordination enables governance decisions to be made based on a shared understanding of the region's socio-ecological conditions.

Third, the implementation of the ESG framework needs to be tailored to the local context to ensure that sustainability indicators do not exclude social values and community knowledge. Governments and geopark institutions need to develop locally based ESG guidelines that incorporate non-technical indicators, such as the recognition of local knowledge, the distribution of tourism benefits, social justice, and cultural sustainability. This approach can improve policy accountability while ensuring that sustainability is not defined solely by technocratic parameters.

Fourth, karst management policies need to consider the social history and dynamics of local resistance that have shaped people's relationships with the landscape. Decision-making that ignores the historical experiences of communities can lead to rejection and reduce the effectiveness of conservation policies. Therefore, geopark policies should include in-depth social studies as the basis for spatial planning and tourism development.

Fifth, institutional capacity building at the village and community levels is also urgently needed. Communities have strong adaptive capacities, but do not always have access to the resources, training, or institutional networks necessary to expand their influence in regional governance. Capacity building can be done through environmental management training, policy literacy, conflict facilitation, and the development of a community-based monitoring system.

Overall, the implications of this policy emphasize that sustainable karst governance requires an approach that is not only technical but also sensitive to social contexts, local histories, and power structures. Governments, geopark institutions, and communities need to move towards adaptive and inclusive collaborative models to ensure that ecological sustainability goes hand in hand with social sustainability.

5.4. Practical Implications for Communities

In addition to its policy implications, this research makes a relevant practical contribution to the local communities in Rammang-Rammang, as well as to communities in other karst areas. The study's

findings show that communities have strong adaptive capacity and social capital. However, their role in governance is still often hampered by formal structures that are not fully participatory or do not understand local dynamics. Therefore, several practical implications can strengthen the community's position in karst management.

First, the community needs to strengthen the co-governance mechanism that has been developing organically. Practices such as village deliberations, the arrangement of tourist routes, the division of boat schedules, and internal mediation have proven effective in maintaining social order and preserving karst ecosystems. Practical strengthening can be achieved by expanding space for collaboration among groups such as Pokdarwis, BUMDes, boat groups, and community leaders to create a more stable and organized management structure. This reinforcement does not have to be formal but can be achieved through more regular communication, the development of common rules, and the documentation of local practices.

Second, communities can utilize local ecological knowledge as a basis for building a community-based monitoring system. Community knowledge of water flow patterns, seasonal changes, erosion-prone points, and ecosystem dynamics can be translated into simple but effective monitoring indicators. Community-based monitoring not only helps maintain karst ecological functions but can also serve as a basis for advocacy when communities are faced with external interventions that potentially threaten their territory.

Third, increasing the capacity of policy literacy and sustainability literacy at the community level is an important need. Many local actors do not understand policy documents or technical terms such as zoning, carrying capacity, and ESG indicators, so their bargaining position is weakened in the decision-making process. Simple training on policy interpretation, village planning, ecological risk analysis, and data preparation can help communities engage more equally with formal actors.

Fourth, communities need to develop more systematic advocacy strategies to deal with external pressures, such as extractive industry plans or non-inclusive tourism policies. These strategies may include creating community databases, writing letters of objection, documenting ecological impacts, or working with civil society organizations. Structured advocacy allows people to voice their interests more forcefully in formal forums.

Fifth, communities can strengthen social networks with external actors who are on the side of sustainability, such as academics, environmental NGOs, geopark researchers, and karst community networks in other areas. These networks can be a source of scientific, legal, and political support when communities face threats to their living spaces. This kind of collaborative network also allows for the exchange of experiences and learning across regions.

Overall, these practical implications suggest that communities have a central role in maintaining karst sustainability. However, this capacity needs to be strengthened through knowledge support, internal

collaboration, and improved bargaining positions in formal governance. Community empowerment is not only a social strategy, but also an ecological foundation for the long-term sustainability of karst areas.

6. Conclusion

This research shows that karst governance in Rammang-Rammang is shaped by the dynamic interaction between formal institutional structures, community practices, and power relations inherent in complex socio-ecological contexts. The findings of the study reveal that karst functions not only as a physical landscape, but also as a living space that contains cultural values, social memory, and ecological knowledge that are passed down across generations. This relational meaning makes local communities important actors in maintaining the sustainability of karst ecosystems, while exposing them to structural pressures from formal institutions and external interests.

The asynchrony between formal subsystems and community subsystems emerges as a major challenge in karst governance. Formal structures tend to rely on technocratic approaches, administrative standards, and ESG frameworks that are still generic. Meanwhile, communities develop organic co-governance mechanisms that are flexible, relevant to local ecological dynamics, and rooted in social values and collective experiences. The tension between these two subsystems is reinforced by knowledge inequality, dominance of power in decision-making, and institutional fragmentation.

By integrating ESG frameworks, Adaptive Co-Management, Adaptive Governance, Social–Ecological Systems, as well as political ecology and coloniality of knowledge perspectives, this research offers a new understanding of how sustainability can be designed in karst areas. The resulting integrative approach shows that sustainability cannot be achieved through compliance with formal standards alone, but requires a continuous negotiation process between formal actors and communities, recognition of local knowledge, and the establishment of adaptive collaborative mechanisms.

Theoretically, this study expands the governance discourse by showing that global sustainability frameworks such as ESG can have different meanings and functions when applied to value-rich socio-ecological contexts and histories of resistance. Empirically, this study shows how co-governance practices at the community level can be an important adaptive resource in the face of ecological and institutional pressures. These findings provide the basis for the formation of a more inclusive, responsive, and contextual karst governance model.

Practically, this study emphasizes the need for substantial consultation mechanisms, adaptive cross-agency coordination, and strengthening community capacity in understanding and influencing management policies. The integration of local knowledge in planning, context-based ESG implementation, and strengthening community co-governance structures are important steps to achieve long-term sustainability.

In conclusion, karst sustainability can only be realized through governance that is able to unite the strength of formal institutions with the adaptive capacity of local communities. This research provides

the foundation for building a more ecologically and socially equitable governance framework, as well as opening up space for further research that can expand and deepen understanding of karst governance in various contexts.

6.1. Limitations of the Research

This research has a number of limitations that need to be considered to understand the scope of its contribution more comprehensively. The study's focus is limited to one location and makes these findings highly contextual and cannot necessarily be generalized to all karst areas in Indonesia. In addition, most of the data was obtained through the perception of local actors who were influenced by personal experiences and their respective social positions, so the interpretation of the findings needed to be done carefully.

The relatively short time span of the study also makes long-term dynamics, both ecological and policy changes, not fully captured. The qualitative approach used provides depth of understanding, but does not allow for a quantitative assessment of the effectiveness of ESG implementation or adaptive governance mechanisms. On the other hand, the reading of the issue of knowledge coloniality and power relations mainly relies on narratives and field observations, so that further analysis can be carried out by expanding data sources to historical documents or archives.

All of these limitations open up opportunities for advanced studies to expand geographic coverage, extend observation periods, or combine quantitative and qualitative methods. Nevertheless, the findings of this study still make an important contribution to understanding karst governance that is adaptive and rooted in the local socio-cultural context.

6.2. Next Direction of Research

This research opens up a number of opportunities for the development of further studies on karst governance and socio-ecological dynamics in conservation areas. One of the important directions is to expand the research location to other karst areas, both in Indonesia and abroad, in order to produce a more comparative understanding. Each karst area has different social, political, and ecological characteristics, so cross-site studies will help identify common patterns and local uniqueness that affect governance effectiveness.

In addition to regional expansion, long-term research is also an urgent need. Adaptive governance is not a static process; It evolves with changing seasons, policy dynamics, tourism pressures, and social changes in the community. Longitudinal studies can capture these changes more fully, including how community co-governance mechanisms have evolved over time and how relationships between formal and local actors are being renegotiated.

The incorporation of quantitative methods or mixed approaches can also enrich the understanding of the effectiveness of ESG frameworks, Adaptive Co-Management, and Adaptive Governance. Quantitative assessments of environmental indicators, participation rates, benefit distribution, or regulatory

effectiveness will provide a stronger empirical basis for assessing the sustainability of karst governance. This kind of approach can also fill in gaps that pure qualitative analysis cannot reach.

Future research can also further explore the dimensions of knowledge coloniality and power relations through the analysis of policy documents, historical archives, or discourse studies. This approach will help show how the concept of sustainability is formulated, who is given the authority to define it, as well as how local knowledge is negotiated within modern policy frameworks. Deepening this aspect is important to build more epistemicly fair governance.

Another direction that can be developed is to examine the role of social technology and community innovation in strengthening social-ecological resilience. Community-based monitoring practices, digitization of ecotourism information, or local coordination systems can be examples of how communities develop innovations that are relevant to their own needs. Studies highlighting such innovations could provide inspiration for other karst regions facing similar pressures.

Finally, further research can encourage a broader theoretical dialogue between sustainability studies, political ecology, and adaptive governance theory. The development of interdisciplinary approaches will enrich the understanding of how sustainability is shaped by the interaction between ecological dynamics, social structures, as well as political practices at the local level. Strengthening this theoretical dimension is important to build a stronger conceptual foundation for future karst governance.

Declarations

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Ethics Statement: This study has obtained ethical clearance from the Universitas Hasanuddin institutional review board, number 00518/UN4.22/PT.01.03/2025, and carried out following the relevant guidelines of the Declaration of Helsinki. Informants participating in this study have provided verbal consent and acknowledged this in the ethical clearance. Verbal consent was obtained, as the session was conducted in a Focus Group Discussion format with policymakers and stakeholders relevant to the study.

Declaration of generative AI use: The authors report generative AI was not used in their research or preparation of this manuscript.

Informed consent:

Informed consent was obtained from all study participants.

Author Contribution

S.M: Conceptualization, Writing; S.A: Conceptualization, Writing; H.R: Conceptualization, Writing; A.N: Conceptualization, Writing; E.P: Conceptualization, Writing, B.A.P: Writing.

Data Availability

The data that support the findings of this study are available from the corresponding author, SM, upon reasonable request

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Figures

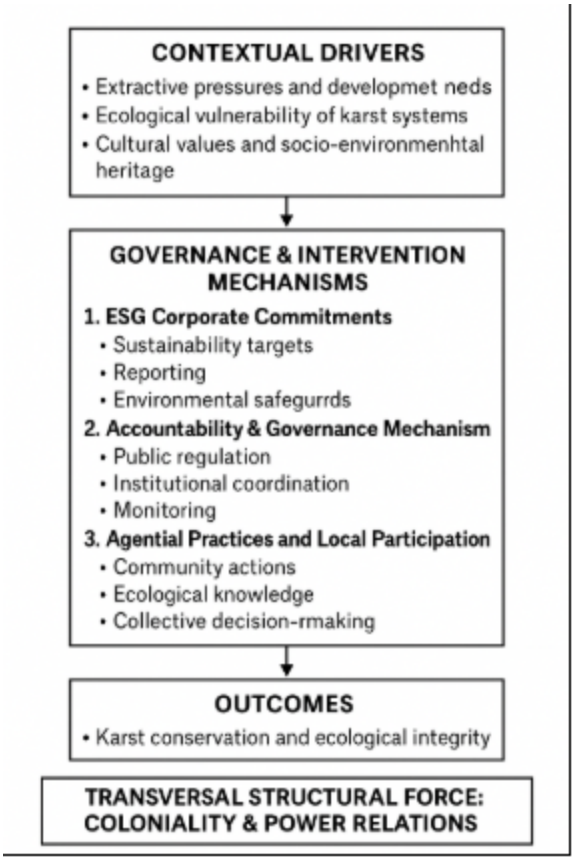


Figure 1

Integrated Conceptual Model of Karst Governance (ESG–ACM–AG Framework)

Source: Authors (2026)