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## The Impact of VUCA on Socio-Ecological Factors in Gili Ketapang's Marine Conservation Area Management

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**Abstract:** Effective marine conservation requires adaptive and integrated management strategies that consider the dynamic and unpredictable conditions of coastal environments. This study introduces the VUCA framework—volatility, uncertainty, complexity, and ambiguity—as a novel moderating factor in the relationship between economic, ecological, social, cultural, and institutional dimensions and management of the Gili Ketapang Marine Conservation Area (MCA). Using a quantitative survey method with data from 365 respondents selected via accidental sampling, this study investigates how these socio-ecological factors impact MCA management and how VUCA conditions influence these relationships. The findings reveal that economic and ecological factors do not significantly affect MCA management, whereas social, cultural, and institutional factors exert a significant positive impact. Furthermore, VUCA conditions negatively moderate the relationship between community culture and MCA management but positively moderate the institutional relationship. This study contributes a novel perspective by applying the VUCA concept, traditionally used in business and management contexts, to marine conservation governance, offering a new model for navigating socio-ecological complexity.

**Keywords:** VUCA, Marine Protected Areas, Conservation Management, Socio-Ecological Systems, Institutional Governance, Community Culture, Indonesia.

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## Vuca 对吉利凯塔邦海洋保护区管理中社会生态因素的影响

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**摘要:** 要成为一个最佳的海洋保护区, 就必须考虑吉力凯塔邦岛地区的 VUCA 条件, 在沿海地区进行尽可能好的管理。本研究以 VUCA 的形式探索新颖性, 作为经济, 生态, 社会, 文化和机构之间关系对吉利凯塔邦海洋保护区管理的调节影响。本研究旨在分析经济, 生态, 社会, 社区文化和机构对吉利凯塔邦岛海洋保护区管理的影响, 并分析 VUCA 作为经济, 生态, 社会, 社区文化和机构对吉利凯塔邦岛海这项研究使用调查方法与问卷从受访者获得。样本数量为 365 名受访者使用意外抽样。研究结果表明, 经济和生态对海洋保护区管理没有显著影响。社会、社区文化和制度对海洋保护区管理具有显著的积极作用。另一方面, VUCA 缓和社区文化对海洋保护区管理的影响显著负面, 而它对机构与海洋保护区之间的关系产生积极影响。这项研究的新颖之处在于 VUCA 概念在海洋保护区管理中的应用, 以前 VUCA 概念在商业和管理领域得到了更广泛的应用。由此产生的模型也有助于海洋保护区管理的新颖性, 这是一个相对没有使用 VUCA 进行广泛研究的区域。

**关键词:** 模糊性、复杂性、不确定性、波动性、海洋保护区管理

### 1. Introduction

Biodiversity conventions state that a country is obliged to set aside 10% of its water area as a conservation area<sup>[1,2]</sup>. Conventions of Biodiversity is an international legal instrument for the conservation of biodiversity, sustainable management, and providing fair and equitable benefits arising from the use of genetic resources<sup>[3,4]</sup>. In addition, the existence of a conservation area will also support the 14th Sustainable Development Goals (SDGs), namely, protecting marine ecosystems. Protecting marine ecosystems is expected to significantly reduce all types of marine pollution, manage and protect marine and coastal ecosystems, minimize and overcome the impact of increasing sea water acidity, regulate excessive harvesting of fish, consistently conserve at least 10% of marine coastal areas, and Another goal is to maintain marine ecosystems<sup>[5,6]</sup>.

Gili Ketapang Island was approved as a marine conservation area based on KEPMEN/64/2020 regulations. The biodiversity in the Gili Ketapang

conservation area is why Gili Ketapang was designated as a conservation area. The Gili Ketapang Conservation Area has diverse marine biota, coral reefs, and marine tourism potential<sup>[7]</sup>. In addition, Gili Ketapang Island has ecological characteristics, where there are many turtle habitats and protected fish species such as pilot whale mammals. However, the landscape and seascape of Gili Ketapang Island show worsening ecological conditions owing to anthropogenic factors<sup>[8]</sup>. In contrast, marine management of coastal areas and small islands, including marine conservation areas, has many problems, including ecosystem degradation, welfare of surrounding communities, unfriendly fishing practices, ineffective regulations, inappropriate design and implementation, and overlapping jurisdictions and objectives<sup>[9,10,11]</sup>.

Optimal marine conservation areas can be achieved by carrying out the best possible management of coastal areas by considering the conditions of volatility, uncertainty, complexity,

and ambiguity (VUCA) Gili Ketapang Island area. VUCA describes conditions full of change, challenges, and high uncertainty. VUCA has been widely applied in the health sector to describe the changing environment and challenges faced by health care professionals [12]. In a leadership context, VUCA is used to study the experiences of leaders, highlighting the changes faced in roles and relationships, as well as the need for ongoing professional learning and support for well-being [13].

In the context of conservation area management, VUCA refers to the dynamic and challenging environment faced by communities and managers. By understanding and overcoming the existence of VUCA in conservation area management, it is hoped that managers can better navigate the complexities of conservation area management and ensure sustainability. VUCA can be an understanding of strategies to reduce the harm it can cause, which is an integral part of crisis management and emergency response planning. In this study, VUCA moderated the influence of the relationship between conservation area management and its determinant factors.

The management of marine conservation areas requires several supporting elements that can be carried out optimally. These elements are determinant factors in the form of economic, ecological, social and cultural factors. On the other hand, managing conservation areas requires an institution that plays an important role in ensuring that the management of conservation areas can run effectively and sustainably [14]. Thus, the determinant factors for managing marine conservation areas are economic, ecological, social, cultural, and institutional [15,14,16].

Based on the above description, Gili Ketapang Island was chosen as the research location. This study highlights novelty in the form of VUCA as moderating the influence of the relationship between economics, ecology, social, cultural, and institutional factors on the management of the Gili Ketapang Marine Conservation Area. In addition, this study aims to determine the influence of economic, ecological, social, cultural, and institutional relationships on the management of the Gili Ketapang Marine Conservation Area. It is hoped that this research can identify factors that influence conservation area management and the moderating influence of VUCA, so that sectors that need improvement and evaluation can be identified to improve conservation area management.

## 2. Materials and Methods

### 2.1. Theoretical Framework and Research Hypothesis

#### *Management of Marine Protected Areas*

Water conservation area management is a working document that is updated periodically so that it can be used as an operational guide for managing water conservation areas. The management of marine conservation areas can be used as a guide for carrying out operational activities in conservation areas. Management is carried out by looking at area zoning by considering various aspects of resources, carrying capacity and ecological processes [17]. The main concept in managing marine conservation areas is to protect the diversity of aquatic resources so that they can provide economic benefits and community welfare of the community [18].

#### *Economy*

The economy used in this study is household economics. Household economics is a factor that influences household economic activities in the household [19]. Economic factors significantly influence the management of marine conservation areas. Effective management requires balancing economic needs with conservation goals, providing economic incentives for compliance, and increasing the capacity of local communities and governments to manage marine protected areas in a sustainable manner [20,21].

#### *Ecology*

Ecology is a science that studies the relationship between living things and their environment. Ecology also studies the structure and function of ecosystems, as well as how ecosystems can be maintained and developed to improve the quality of life of living creatures and humans [22]. Ecology is used to understand interactions between different species in an ecosystem. This emphasizes the importance of understanding the ecological niche of each species to effectively manage ecosystems and increase biodiversity [23]. In the context of conservation areas, ecology is the study of the interactions between living organisms and the environment in a protected area to maintain biodiversity and ecosystems [24,25].

#### *Social*

Social aspects, including everything related to nature conservation, cannot be separated from life. In its implementation, conservation provides not only natural benefits but also social benefits. The community will receive all forms of impact on the management of conservation areas [26]. To achieve optimal management, community

involvement is necessary to involve the community in it [27]. Therefore, increasing public awareness in the management of conservation areas needs to be carried out to instill public awareness and jointly protect the surrounding coastal ecosystem.

#### *Community Culture*

Culture includes values, norms, symbols, language, beliefs, and practices that are passed down from generation to generation. Community culture can also be understood through the concept of hospitality, which refers to the gathering of people from different backgrounds to engage in shared social practices and interactions [28]. In marine conservation areas, coastal culture has a significant influence on the formation of the cultural identity of coastal communities as a whole. As a social unit, coastal communities live, grow, and develop in coastal areas [29].

#### *Institutional*

Institutions become a forum as a form of order to regulate the continuity of social life [30]. Institutions include structures, processes, and traditions that shape how power, responsibility, and decision making are exercised [31,32]. Various efforts made by institutions and various objectives in defining and managing marine protected areas produce a variety of ecological, social, and economic results [33]. Institutions have rules established by members of an organization to regulate and shape political, social, and economic interactions. The aim of forming rules is to build better order and reduce uncertainty in the exchange process and local wisdom in the form of prohibitions or taboos [34]. Institutions that manage conservation areas play an important role and are managed by the relevant stakeholders.

#### *Conditions of Volatility, Uncertainty, Complexity, and Ambiguity (VUCA)*

VUCA is often used to describe the challenges faced in various fields, including business, conservation, and self-development. VUCA emphasizes the need for adaptability, resilience, and effective communication in dealing with complex and dynamic environments. The VUCA highlights the need for flexible and adaptive conservation strategies that can respond to sudden changes and uncertainties. This includes incorporating uncertainty into conservation planning, adopting a holistic and integrated conservation approach, and encouraging transparency in decision-making [35]. The VUCA provides a useful framework for understanding and addressing the complexity and uncertainty of the modern environment. It is applied in a variety of areas, including risk management, faculty

development, learning and development, school and career guidance, and leadership in the healthcare industry [36,37,38,39].

VUCA includes:

- 1) volatility, which describes unpredictable and sudden environmental changes that cause rapid changes in market trends, economic conditions, or social dynamics;
- 2) uncertainty, which describes a lack of clear information or predictability regarding future events resulting in difficulty in making decisions, planning the future, or understanding the results of actions;
- 3) complexity, which describes the interconnectedness and complex nature of the system, which creates challenges in understanding and managing the system and predicting results;
- 4) ambiguity, which describes a lack of clear definitions or boundaries that cause confusion, uncertainty, and difficulty in making decisions.

## **2.2. Research Hypotheses**

*Economic influence on conservation area management* [40] highlighted the importance of considering employment and income in conservation area management. This indicates that the economic sector influences the management of conservation areas. Incorporating local livelihood capital into conservation management can increase local support and interest in protected areas [41]. This indirectly affects the management of the conservation areas. However, there has not been much research on the influence of the economy on the management of conservation areas, so this research seeks to examine the influence of the economy on the management of conservation areas.

#### *The influence of ecology on conservation area management*

A study in conservation areas in Ethiopia found that ecological factors, such as biodiversity and ecosystems, are very important for the success of conservation efforts [42]. For protected areas to be resilient (and to contribute to broader social-ecological resilience), managers must be able to adapt to changing social and ecological conditions over time in ways that support the long-term sustainability of conservation populations, communities, and ecosystems [43]. Thus, ecology influences conservation area management.

#### *Social influences on conservation area management*

One way to determine local community participation is to analyze the community's perception as a social aspect. Local community

perceptions significantly influence the development of special areas in Mandalika [44]. According to [45], social aspects have a significant effect on community-based ecotourism. This indicates that social aspects have a significant influence on the management of conservation areas.

*The influence of community culture on the management of conservation areas*

[46] found that community culture played a central role as an environmental conservation agent in coastal areas. Community culture that supports environmental conservation, such as connections to marine and coastal ecosystems, as well as local culture and traditions, influences community conservation behavior. On the other hand, social capital has an important role in management of conservation areas [47]. Therefore, community culture has a significant influence on the management of conservation areas.

*The influence of institutions on conservation area management*

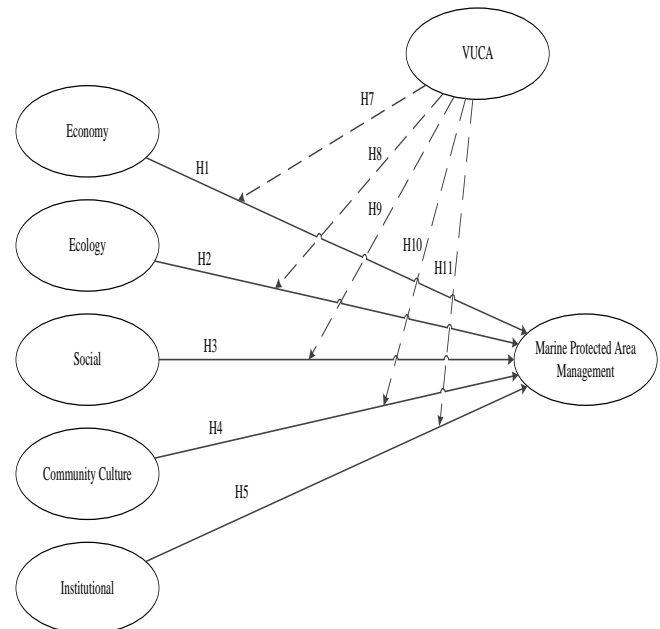
[48] show that the stakeholders who play a role in the management of the prospective Kolepom Island Park Conservation Area, namely the Papua Province Regional Development Planning Agency (BAPPEDA), the Sorong Coastal and Marine Resources Management Workshop (LPSPL), the Provincial Maritime and Fisheries Service (DKP) Papua, Village Government, District Government, Indigenous Community Institutions (LMA) in the Tabonji, Waan, and Kimaam areas, and Religious Institutions (churches) are key institutional elements in the sustainable management of prospective Park Conservation Areas. [33] shows that village liaison committees are effective institutions for supporting marine conservation activities. This indicates that institutions influence the management of conservation areas.

*The influence of VUCA as a moderator on the relationship between conservation area management and its determinants*

Currently, VUCA, as a moderation, is widely applied in business and management research. For example, research into [39] VUCA conditions impacts the strategic alignment capabilities of leaders in healthcare. [49] show that the moderating role of VUCA conditions can strengthen the relationship between company competence and company performance. There has been no research related to the moderation of VUCA in the concept of conservation area management. Therefore, this research raises VUCA as a moderation of the relationship between economic, ecological, social, cultural and institutional

aspects of conservation management as a novelty of this research.

Based on the study above, the research model in this study regarding economic, ecological, social, cultural and institutional influences as well as the moderating influence of VUCA on the management of marine conservation areas is presented in Figure 1.



**Fig. 1. Conceptual research model showing the moderating role of VUCA**

### 2.3. Data

This research data are the primary data obtained from the respondents. The respondents of this study were people in the Gili Ketapang Marine Conservation Area. With a population of 8509 people, 383 respondents were obtained using the Slovin formula, with an inaccuracy percentage of 5%.

$$n = \frac{N}{1 + Ne^2} = \frac{8509}{1 + 8509(0.05)^2} = 382.0406 \approx 383$$

(1)

Where:  $n$  – the number of sample;  
 $N$  – number of populations, residents of Gili Ketapang  
 $e$  – percentage of inaccuracy due to sampling error that is still tolerable/desired ( $e = 5\%$ ).

An accidental sampling method was used for the sampling. Data were collected using a questionnaire with a Likert scale ranging from one to 1-5. This questionnaire has been tested for

validity and reliability, so that it can be continued with analysis to test the research hypothesis.

**2.4. Research Methods**

This study uses quantitative methods with SEM PLS analysis to test the research hypothesis. SEM analysis consists of two models: the measurement model and the structural model. The measurement model was used to measure the best indicators in a variable. The measurement model used in this study was formative. Meanwhile, a structural model was used to determine the influence between variables to answer the hypothesis.

The goodness-of-fit criterion was used to obtain the best SEM model. This study used the SEM WarpPLS software to assist in data analysis.

**3. Results and Discussion**

**3.1. Goodness of Fit**

The goodness of fit was used to validate the accuracy of the resulting model against the actual data. Goodness of fit measures the extent to which the observed data are in harmony with the data from the results of the research model, so that the results can represent the actual situation [50].

Goodness value of fit in this study is presented in Table 1. The results in Table 1 show that all goodness criteria of fit have been accepted, so that the model in this study can be said to be good. This shows that this test produces a good confirmation of the variables and the causal relationship between them. This also shows that the model supports existing data. Because the research model is good, outer mode and inner model testing can be carried out.

**Tab 1. Goodness-of-fit indices for the structural equation model**

N	Model Fit/ Quality Indices	Value	Fit Criteria	Results
1	Average Path Coefficient	APC = 0.124 P = 0.010	P<0.05	Significant
2	Average R-Squared	ARS = 0.561 P ≤ 0.001	P<0.05	Significant
3	Average Adjusted R-Square	AARS = 0.543 P ≤ 0.001	P<0.05	Significant

4	Average Block VIF	AVIF = 1.981	Acceptable if AVIF ≤ 5 Ideal if AVIF ≤ 3.3	Ideal
5	Average Full Collinearity VIF	AFVIF = 2.289	Acceptable if AFVIF ≤ 5 Ideal if AVFIF ≤ 3.3	Ideal
6	Tenenhaus GoF	GoF = 0.630	Small if GoF ≥ 0.1 Medium if GoF ≥ 0.25 Big if GoF ≥ 0.36	Big
7	Sympson's Paradox Radio	SPR = 0.700	Acceptable if SPR ≥ 0.7 Ideal if SPR = 1	Acceptable
8	R-Squared Contribution Ratio	RSCR = 0.953	Acceptable if RSCR ≥ 0.9 Ideal RSCR = 1	Acceptable
9	Statistical Suppression Ratio	SSR = 1	Acceptable if SSR ≥ 0.7	Acceptable
10	Nonlinear Bivariate Causality Direction Ratio	NLBCD R = 0.900	Acceptable if NLBCDR ≥ 0.7	Acceptable

**3.2. Measurement Model (Outer Model)**

Factor value loading for reflective and outer indicator weights for formative indicators. Factor value loading or outer weight indicates the strength or weakness of the indicator as a measure of the latent variable. Indicators that have outer values loading/outer A large weight indicates that the indicator has a strong ability to form latent variables. This study uses a formative indicator model. The validity and reliability of the formative indicator model can be seen from the indicators that are significant in measuring variables based on outer-value weights. Table 2 presents the results of the measurement model are presented in Table 2.

**Tab. 2. Measurement model results of formative indicators**

Variable	Indicator	Weight	P-Value	Information
Economy (X1)	Revenue (X1.1)	0.584	<0.001	Significant
	Field Work (X1.2)	0.582	<0.001	Significant
	Capital (X1.3)	-0.015	0.404	Not significant
Ecology (X2)	Biodiversity (X2.1)	0.496	<0.001	Significant
	Naturalness (X2.2)	0.478	<0.001	Significant
	Uniqueness (X2.3)	0.526	<0.001	Significant
Social (X3)	Conflict Fisheries (X3.1)	-0.288	<0.001	Significant
	Participation (X3.2)	0.497	<0.001	Significant
	Behavior (X3.3)	0.530	<0.001	Significant
Culture (X4)	System (X4.1)	0.507	<0.001	Significant
	System Culture (X4.2)	0.310	<0.001	Significant
	System Knowledge (X4.3)	0.556	<0.001	Significant
Institutional (X5)	Role of Institutions (X5.1)	0.551	<0.001	Significant
	Management Unit (X5.2)	0.544	<0.001	Significant
	Rule (X5.3)	-0.195	<0.001	Significant
Conservation Area Management Waters (Y)	Supervision Integrated (Y.1)	0.501	<0.001	Significant
	Management Continuous (Y.2)	0.560	<0.001	Significant
	Governance (Y.3)	0.299	<0.001	Significant
VUCA (X7)	Volatility (X7.1)	0.388	<0.001	Significant
	Uncertainty (X7.2)	0.404	<0.001	Significant
	Complexity (X7.3)	0.214	<0.001	Significant
	Ambiguity (X7.4)	0.440	<0.001	Significant

The results in Table 2 show that one indicator is not significant. Capital indicators are not significant for measuring economic variables. Capital is an investment used for economic growth and creation of new jobs. Capital related to conservation areas is in the form of money and equipment to support tourism. Capital is not significant in measuring economic variables because the capital provided has not been able to have a direct impact on the economic sustainability around the water conservation area in Gili Ketapang. This could be because the capital provided is too small or because capital management is less than optimal. This needs to be studied further regarding the existing capital in the Gili Ketapang Conservation Area.

On the other hand, for economic variables, the two constituent indicators, namely income and employment, have almost the same ability to measure economic variables. Although the outer value of the income indicator loading is slightly larger, these two indicators are equally important because they have a large outer value loading that is almost the same. This shows that the amount of income and employment opportunities are the main pillars of the formation of the economy in the Gili Ketapang Marine Conservation Area.

For ecological variables, the uniqueness indicator was the best indicator for measuring ecological variables. Uniqueness is a special characteristic of the ecological identity and attraction of the Gili Ketapang Marine Conservation Area. Gili Ketapang is home to various flora and fauna, and forms an ecosystem within it. The presence of pilot whales and whale sharks, which are often found in the waters of Gili Ketapang Island, and the protection of coral reefs are unique to the ecosystem of the Gili Ketapang Marine Conservation Area.

On the other hand, behavioral indicators are the best indicators in measuring social variables. The behavior of the community and stakeholders shapes social conditions in the Gili Ketapang Conservation Area. Good behavior will support improving social conditions in the Gili Ketapang Conservation Area. Meanwhile, the fisheries conflict indicator measures social variables negatively and significantly, meaning that when the value of fisheries conflict is high, it will reduce the value of the social variable. This can happen because with fisheries conflicts, social harmony cannot be established. Therefore, if there is a fishery conflict, it is hoped that it can be resolved as best as possible so that social harmony can be established.

In terms of community culture indicators, the best indicator for measuring community culture

variables was the knowledge system indicator. The knowledge system measures people's knowledge of the existing culture so that it can become a benchmark for existing culture in society. The knowledge system includes knowledge of traditions, values, and norms as well as social practices that exist in society. The more people know about the culture around them, this shows that the community's culture is still being implemented.

The most important indicator of the institutional variable was the management unit. This indicates that the management unit plays an important role in forming institutions in the Gili Ketapang Marine Conservation Area. The rule indicator measures the Institutional Variable negatively and significantly. This is possible considering that the Gili Ketapang Marine Conservation Area is a new conservation area. This can cause misalignment between the rules and institutions that manage the Gili Ketapang Marine Protected Area, thereby allowing for obstacles that cause the rules to hamper existing institutional processes.

Sustainable Management Indicators are the most important for measuring Conservation Area Management Variables. Sustainable management is the effort to manage conservation areas so that they are sustainable. The main goal of sustainable conservation area management is to protect biodiversity and ecosystems while utilizing natural resources wisely and responsibly. Therefore, sustainable management is one of the most important aspects of conservation area management. To increase the management value of conservation areas in Gili Ketapang, it is necessary to increase sustainable management.

The ambiguity Indicator is the most important indicator for measuring the variable VUCA. A positive weight indicates that increasing the ambiguity value increases the VUCA value in the context of conservation area management in Gili Ketapang. Ambiguity refers to situations in which available information is unclear, incomplete, or can be interpreted in different ways.

### 3.3. Structural Model (Inner Model)

The structural model (Inner Model) tested the influence of the research variables. The structural model presents the magnitude of the influence between the research variables by presenting path coefficients and P- values. The influence between variables was considered significant if the P-value was  $<0.05$ . The results of testing the hypothesis of

direct influence between variables are presented in Table 3.

**Tab. 3. Hypothesis testing results for direct and moderated relationships**

Connection	Coefficient	P-Value	Hypothesis
Economy →MPA Management	0.043	0.239	H1 is rejected
Ecology →MPA Management	0.001	0.495	H2 is rejected
Social →MPA Management	0.164	0.003	H3 is accepted
Community Culture →MPA Management	0.292	$<0.001$	H4 is accepted
Institutional →MPA Management	0.332	$<0.001$	H5 accepted
VUCA as moderation of Economy →MPA Management	0.070	0.127	H6a is rejected
VUCA as moderation of Ecology →MPA Management	0.059	0.169	H6b is rejected
VUCA as moderation of Social →MPA Management	0.093	0.063	H6c is rejected
VUCA as moderation of Community Culture →MPA Management	-0.132	0.015	H6d accepted
VUCA as moderation of Institutional →MPA Management	0.126	0.017	H7d accepted

Table 3 shows that economics and ecology did not have a significant effect on the management of conservation areas. This illustrates that better economy and ecology in the Gili Ketapang Conservation Area will not necessarily increase the management value of the Gili Ketapang Conservation Area. This is possible because the Gili Ketapang marine conservation area has only been established for four years; therefore, the results are not yet visible. Therefore, the management of conservation areas that should provide economic benefits to the community is



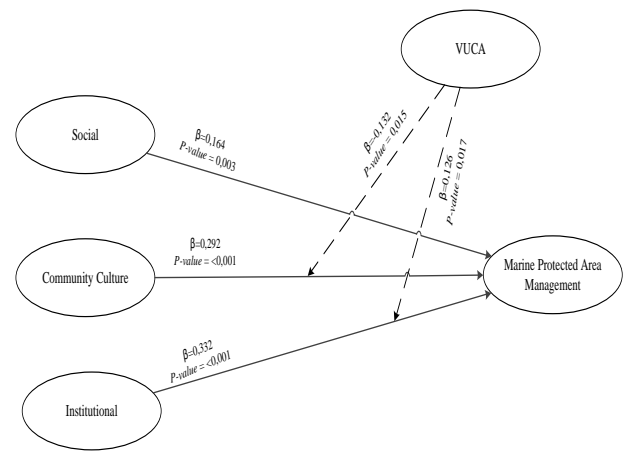
currently not visible. In addition, the Gili Ketapang marine conservation area already has uniqueness and diversity before it was designated as a marine conservation area, making it possible for ecology to have no significant influence on the management of the conservation area.

Social, community culture, and institutional variables have a significant influence on the management of conservation areas. The coefficient of social influence on MPA Management was 0.164. A positive coefficient value indicates that the influence of social and MPA Management is positive. This means that every increase in social value significantly increases the value of MPA Management. In addition, the coefficient of the influence of community culture was 0.292. This shows that community culture has a significantly positive effect on MPA Management. Likewise, the coefficient of institutional influence on MPA Management is 0.332. This indicates that institutionalism has a significant influence on MPA Management.

The role of VUCA as a moderating variable can be seen from its role in moderating the influence between the community's culture and institutional MPA management. The VUCA moderation coefficient for the relationship between community culture and MPA management was -0.132. The negative coefficient value indicates that VUCA influences the community's cultural relationship with MPA Management in a significantly negative way.

On the other hand, VUCA moderation of the relationship between institutions and MPA management has a coefficient value of 0.126. The coefficient value is positive, indicating that VUCA positively and significantly influences the institutional relationships with MPA management. This shows that the institution that manages the Gili Ketapang Conservation Area is in harmony with the existing VUCA. Based on the results of the analysis, the final model of this research was trimmed, as presented in Figure 2.

Based on the results, it can be concluded that the variables that influence the management of marine conservation areas are social, community culture, and institutional variables. Social, community, and institutional cultures have significant positive effects on the management of conservation areas.



**Fig. 2. Final trimmed model based on empirical results**

The social influence on MPA Management in this study is in line with previous research conducted by [27,51,52]. Social aspects, including everything related to nature conservation, cannot be separated from life. In its implementation, conservation provides not only natural benefits but also social benefits. To achieve optimal management, it is necessary to include a community. This confirms that social aspects play a very important role in achieving sustainable development in marine conservation areas.

On the other hand, the significant influence of community culture on MPA Management is also in line with research by [53,54,55], which confirms that community culture plays an important role in achieving sustainable development in marine conservation areas. Gili Ketapang Island has a strong culture and belief system. The belief system here is in the form of spiritual or religious beliefs held by society, which influence everyday life. As strong followers of Islam, observing religious days is one way to protect existing natural resources.

Institutional has a significant positive effect on conservation area management, in line with research by [56,57,58]. Institutions are an important aspect of management, which will later influence the efficiency and effectiveness of sustainable programs. Institutions are patterns of relationships that bind to each other and are determined by limiting and binding factors, including norms, codes of ethics, formal and informal rules for controlling social behavior, and incentives to work together and achieve common goals. The management of conservation areas improves when institutions work according to their functions.

On the other hand, VUCA significantly negatively moderates the influence of community culture on the management of conservation areas. This means that the culture in the Gili Ketapang

Conservation Area cannot be adapted to VUCA in the management of the Gili Ketapang Conservation Area. Based on the results of research conducted on Gili Ketapang Island, six traditions were found on Gili Ketapang Island: sea fishing, *onjem* (FADs, which is one way for the people of Gili Ketapang Island to increase fish catches), work contracts (related to fishing activities, starting from the recruitment of crew members to the distribution of profits), *nyabis* (visiting *kiayi*), *andun* (fishermen who fish outside their home area either permanently or irregularly within a certain time frame), *pengambek* (people who provide capital to fishermen), and *telasan* (sharing food at the end of Ramadan and Eid al-Fitr). In addition, policies issued by the government change quickly, resulting in rapid and unpredictable changes in the environment, often disrupting the traditional practices of local communities. Therefore, there has not been a harmonization between the VUCA Era and community culture in managing the Gili Ketapang Island marine conservation area. Therefore, the moderation of the VUCA Era weakens the effect of community culture on the Management of Regional Marine Protected Areas.

On the other hand, VUCA significantly positively moderates the influence of institutions on the management of conservation areas. Existing institutions require better coordination and collaboration between institutions so that rapidly changing conditions can be overcome. With the issuance of KP Ministerial Regulation No. 31 of 2022 as a basis for related institutions (Provincial Fisheries Service and Situbondo Service Branch and POKMASWAS Gili Bahari) to work together and coordinate the management of the Gili Ketapang Island marine conservation area. Therefore, there has been harmonization between the VUCA Era and institutions in the management of the Gili Ketapang Island marine conservation area. Therefore, VUCA moderation strengthens the institutional effect on regional Marine Protected Area management.

In this study, previous research could not be brought up, because on Gili Ketapang Island, similar research has never been conducted with the same variables, especially using VUCA moderation in managing conservation areas.

## 4 Conclusions

The results of this research show that economy and ecology do not have a significant effect on marine protected area management. Social and community cultures and institutions have a significant influence on marine protected area

management. social, community culture, and institutional variables have a significant positive effect on marine protected area management with institutional being the variable that has the greatest influence on marine protected area management. This shows that every increase in social and community value culture and institutions will increase the value of marine protected area management.

However, VUCA does not affect the relationship between the economy, ecology, and society regarding marine protected area management. However, VUCA negatively moderates the influence of the community's culture on marine area management. Meanwhile, VUCA positively moderates the influence of institutions on marine protected area management. This shows that community culture has not been able to adapt to the existing VUCA, so the existing VUCA inhibits the influence of community culture on marine protected area management. Meanwhile, institutions have succeeded in synchronizing with the existing VUCA so that the existence of VUCA will increase institutional influence on community culture.

Thus, if the manager of the Gili Ketapang Marine Conservation Area wants to increase the management value in the Gili Ketapang Marine Conservation Area, then the manager needs to increase social and community values. culture and institutional. On the other hand, community culture must begin to adapt to the existing VUCA. Based on these research findings, further research is recommended to develop research findings related to community and institutional adaptation to the VUCA era. Although this study achieved the research objectives, there are still limitations. This research was limited to respondents' ability to answer the questionnaire. Filling out the questionnaires was mostly assisted by a team of surveyors to read the questionnaires because of the respondents' limited ability to read and write; therefore, there may be some differences in perception between surveyors and respondents.

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## Author Contributions

Conceptualization: ER and S; methodology - ER and S; software - S and RA; validation - S

and HR; formal analysis - ER and S.; investigation - ER and HR.; resources – ER and HR; data curation–S; visualization – ER and S; writing—original draft preparation, ER, HR, S, and RA; writing—review and editing – ER, HR, S, and RA; supervision–ER; project administration – ER. All the authors have read and agreed to the published version of the manuscript.

### Conflict of Interest Declaration

The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

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