ISSN 1533-9211

DOI: 10.5281/zenodo.10931944

ASSESSMENT OF COASTAL RESOURCES IN SUMBERKIMA VILLAGE, BULELENG, BALI: A FOUNDATION FOR SUSTAINABLE AQUACULTURE-BASED MINATOURISM DEVELOPMENT

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Abstract

This research explores the diverse ecosystems of Sumberkima Village, situated in Gerokgak Subdistrict, Buleleng Regency, Bali Province, Indonesia, to assess their potential for ecotourism development. The study focuses on the rich ecological resources, particularly coral reef ecosystems, seagrass beds, seaweed, and mangroves, which offer unique opportunities for visitors interested in experiencing the underwater world. Additionally, the presence of fish farming activities using floating net cage systems adds another layer of attraction, allowing visitors to gain insights into fish farming processes and enjoy fresh seafood products. The combination of ecological diversity and fish farming activities provides a strong foundation for developing ecotourism programs centered around direct interaction between visitors and coastal resources. This research underscores the importance of conservation and sustainable management practices to ensure the long-term viability of ecotourism initiatives in Sumberkima Village, while also emphasizing the active involvement of local communities in tourism development and resource management efforts.

Keywords: Community Involvement, Conservation, Coral Reefs, Ecotourism, Fish Farming, Floating Net Cage Systems.

INTRODUCTION

Sumberkima Village, situated in Gerokgak District, Buleleng Regency, Bali, features a unique topography that extends from west to east, with its northern part directly bordering a water area. This village holds significant potential for beach tourism due to its stunning natural panorama and the clear sea water at Sumber Kima Beach, which is ideal for activities like bathing, playing in the sand, and sunbathing (Irawan et al., 2023). The village's proximity to the water, along with its infrastructure, transportation, and healthcare facilities, contributes to its suitability for ecotourism sites (Nurjayanti, 2023). Moreover, effective management of community-based tourism destinations, such as Melasti Beach, plays a crucial role in enhancing the overall tourist experience (Azis et al., 2020; Hai et al., 2020; Liberato et al., 2018). Aligned with traditional village practices and government policies, this management

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.10931944

leads to the improvement of infrastructure, facilities, and tourist attractions, ultimately benefiting the local economy (Mas Wiartha et al., 2022). Additionally, the concept of Impact Chains serves as a methodological framework for assessing the impact of climate change on coastal tourism destinations, emphasizing the importance of systematic evaluation and classification (Arabadzhyan et al., 2020). In the context of rural tourism development, community participation is vital. Studies have shown that involving various stakeholders, including local government representatives, youth organizations, and entrepreneurs, is essential for the successful regional tourism development of areas like North Halmahera Regency (Singgalen et al., 2019). This participatory approach aligns with the principles outlined in the development of tourist villages, aiming to accelerate rural development and empower local communities through collaborative efforts (Ananda Citra et al., 2023).

The assessment of coastal resources in Sumberkima Village, Buleleng, Bali, aims to lay the foundation for sustainable aquaculture-based minaTourism development. This village is known for its diverse coastal ecosystem, including coral reefs, mangroves, seagrass beds, and beaches with black and white sand. Gili Putih Island, a natural destination in the area, is particularly famous for its pristine white sand beaches. These coastal assets play a crucial role in supporting various marine species and enhancing the overall biodiversity of the region (Kurniawan, 2022).

The ecological significance of these coastal resources cannot be overstated, as they provide vital habitats for marine life and contribute significantly to the region's biodiversity (Kurniawan, 2022). Sustainable development initiatives in coastal areas like Sumberkima Village are essential to ensure the preservation of these ecosystems while promoting economic activities such as aquaculture-based minaTourism (González Rodríguez & Tussyadiah, 2021).

By focusing on the conservation and sustainable use of coastal resources, communities like Sumberkima Village can benefit from both environmental protection and economic development opportunities (González Rodríguez & Tussyadiah, 2021). Balancing conservation efforts with tourism development is crucial to ensure the long-term viability of coastal ecosystems and the well-being of local communities (N. Natih et al., 2021). The rich coastal diversity of Sumberkima Village in Bali underscores the importance of integrating conservation practices with tourism development to support sustainable aquaculture-based minaTourism. Preserving these coastal assets not only safeguards marine habitats and biodiversity but also creates opportunities for responsible economic growth in the region (González Rodríguez & Tussyadiah, 2021).

The potential for ecotourism and minaTourism in Sumberkima Village is immense. The presence of diverse ecosystems such as coral reefs, mangroves, and seagrass beds offers unique opportunities for visitors to engage in eco-friendly activities like snorkeling, diving, birdwatching, and nature walks. Additionally, the picturesque beaches with their contrasting black and white sands provide ideal settings for relaxation and recreation. By leveraging these natural assets sustainably, the village can not only attract tourists but also ensure the preservation of its fragile marine ecosystems. The study aims to assess the current state of coastal resources in Sumberkima Village, including the health of coral reefs, the extent of mangrove coverage, and the abundance of seagrass beds. Through comprehensive data

ISSN 1533-9211
DOI: 10.5281/zenodo.10931944

collection and analysis, it seeks to identify potential threats to these ecosystems, such as pollution, overfishing, and coastal development. By understanding the ecological dynamics at play, the study aims to develop strategies for conservation and sustainable management.

MATERIAL AND METHODS

Study area

The research was carried out from May to December 2023, at the location Sumberkima Village, Gerokgak District, Buleleng Regency, Bali, Indonesia.

Figure 1: Research Location

The survey stations were located at specific coordinates within the study area. Station 1, situated at coordinates 8.1287939 latitude and 114.5860706 longitude, was characterized by coral reefs. Station 2, positioned at coordinates 8.1343691 latitude and 114.5875553 longitude, featured a combination of coral reefs and seagrass fields. Station 3, located at coordinates 8.1407983 latitude and 114.608914 longitude, was also identified as having coral reefs. Finally, Station 4, positioned at coordinates 8.1365998 latitude and 114.6001057 longitude, was distinguished by the presence of mangroves.

Data Collection

The research was conducted by carrying out initial surveys, collecting secondary data, socializing the research plan to stakeholders, collecting primary data, data analysis, and reporting.

ISSN 1533-9211

DOI: 10.5281/zenodo.10931944

Research on the ecological potential of the coastal area of Sumberkima Village was conducted in mangrove ecosystems, coral reefs, seagrass beds, water conditions, and fish farming activities.

a) Mangrove research was conducted by observation based on the types of constituents and the Importance Value Index using the quarter method (Point Centered Quarter Method). The Point-Centered Quarter Method (PCQM) has been widely utilized in mangrove research to assess the types of constituents and the Importance Value Index. This method involves laying out transects and measuring the distance to the nearest tree in each quadrant around a random point (Hijbeek et al., 2013). Studies have applied the PCQM to evaluate mangrove density levels, identify mangrove species, and assess the structural importance of vegetation in various research sites (Isroni et al., 2019; Katili et al., 2017; Murniasih et al., 2022; Utina et al., 2019). The PCQM has been recommended for its efficiency and accuracy in sampling mangrove ecosystems, especially in areas with multi-stem trees (Volpato et al., 2010).

b) Seagrass bed research used the Quadrat Transect Method through purposive sampling aimed at determining the composition of species, density, estimation of coverage, frequency, dominance, and distribution patterns of seagrasses in the coastal area of Sumberkima Village. The application of the Quadrat Transect Method in seagrass research has facilitated the understanding of seagrass community structures, carbon absorption potential, and the relationship between seagrasses and associated fauna (Bongga et al., 2021; Kilawati et al., 2021; Kilawati & Islamy, 2019, 2021; Marliana et al., 2021; Purnomo & Nugraha, 2020; Tebaiy et al., 2021). This methodological approach enables researchers to assess the health and dynamics of seagrass beds, supporting conservation efforts and sustainable management practices in coastal ecosystems.

c) Coral reef ecosystem research used the Line Transect Method conducted with SCUBA diving to collect data: 1) Coverage of live coral; 2) Coverage of substrate types in the observed coral reef ecosystem; 3) Observation of coral reef indicator organisms; 4) Values of coral diversity, evenness, and dominance; and 5) Coral mortality index (Riskiani et al., 2019; Urbina-Barreto et al., 2021)

d) Fish abundance research was conducted using the Underwater Visual Census (UVC) method. This method involves direct observation below the water surface to identify and count the number of reef fish at the research site. The Line Intercept Transect (LIT) method, as described in the references (Permana et al., 2020; Prabowo et al., 2012, 2023; Roziq et al., 2016), has been widely used in coral reef ecosystem research to collect data on various parameters such as live coral coverage, substrate types, indicator organisms, coral diversity values, and coral mortality index. This method involves laying out transect lines and recording the points where the line intercepts live coral, different substrate types, and other relevant features. Additionally, the study by (Latypov & Селин, 2012) provides insights into the composition and structure of protected coral reefs, showcasing the importance of understanding the ecosystem dynamics for conservation efforts.

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Water Quality Analysis

Water quality analysis typically involves several parameters including temperature, salinity, acidity (pH), dissolved oxygen (DO), conductivity (Cond), and turbidity. The data for each parameter were collected using established procedures consistent with standard protocols in aquatic environmental research. Temperature measurements were obtained by immersing a calibrated thermometer or temperature probe directly into the water at the specified sampling locations. Salinity levels were determined using either a refractometer or a conductivity meter, with water samples collected and analyzed for their refractive index or electrical conductivity, respectively. The acidity (pH) of the water was assessed using a pH meter, which was carefully calibrated prior to each measurement to ensure accuracy. Dissolved oxygen concentrations were determined using the Winkler Method, where water samples were collected, preserved with appropriate reagents, and titrated to quantify dissolved oxygen levels. Conductivity measurements were conducted using a calibrated conductivity meter, with probes immersed into the water to measure its electrical conductivity, indicative of ion concentration. Turbidity assessments were performed either using a turbidimeter to measure light scattering by particles in the water column or the Secchi disk method, whereby a black and white disk was lowered into the water, and the depth at which it disappeared from view was recorded. These methodologies were meticulously executed to ensure the reliability and validity of the data collected for each parameter, thus contributing to the scientific rigor of the study.

RESULT AND DISCUSSION

Water Quality in Sumberkima Village

Sumberkima Village, Gerokgak District, based on Bali Provincial Regulation Number 3 of 2020, has been designated as a strategic area for the economy of Bali Province. This marks a change from Regional Regulation Number 16 of 2009 concerning the spatial planning of Bali Province for the years 2009 - 2029. Consequently, the water quality of Sumberkima Village must adhere to the water quality standards for tourism.

Table 1: Sumberkima Village Water Quality Test Results

Parameter	St 1	St 2	St 3	St 4	Water Quality Standards KepMenLH 51 /2004
Temperature (°C)	28.7	29.4	29.2	28.4	Natural
Salinity (ppt)	32.3	32.5	32.3	30.4	Natural
Acidity	9.19	9.3	8.7	8.9	7 – 8.5
Dissolved Oxygen (mg/L)	0.03	0.08	0.03	0.04	> 5
Conductivity (µmhos/cm)	49.2	49.5	49.3	46.7	
Turbidity (NTU)	10	10	10	1.85	5

The research indicates that water temperature ranges between 28.4°C to 29.4°C, which still falls within the standard limits for seawater quality for marine tourism and marine biota. The research findings indicating a water temperature range of 28.4°C to 29.4°C, falling within standard limits for seawater quality in marine tourism and marine biota, align with existing literature on the impact of temperature on various marine organisms and ecosystems. Studies

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DOI: 10.5281/zenodo.10931944

such as those by published article (Martinez et al., 2023; Tian et al., 2022) have highlighted the significance of temperature in influencing the physiological processes and developmental stages of marine organisms. For instance, published study observed gonadal sex differentiation in scallops based on temperature variations (Tian et al., 2022), while another study demonstrated the role of temperature in accelerating smoltification in Atlantic salmon (Martinez et al., 2023). Moreover, the study by (Bevilacqua et al., 2020) emphasized the importance of maintaining specific temperature limits in marine environments to prevent thermal pollution and its adverse effects on subtidal sessile assemblages. This underscores the critical balance required to sustain marine ecosystems within optimal temperature ranges. Additionally, the research by Goffredo (Goffredo et al., 2008) highlighted the challenges that corals face in acclimating to rapid water warming, emphasizing the need for conservation efforts to mitigate the impacts of temperature stress on coral reefs.

The salinity values reported in the research, ranging from 30.4‰ in mangrove areas to 32.3–32.5‰ in marine waters, are crucial parameters that influence the health and sustainability of coral reef ecosystems and the marine life inhabiting these waters. These salinity values fall within the normal conditions of seawater quality, aligning with the reference values for natural seawater quality, typically ranging from 30‰ to 35‰. The importance of maintaining appropriate salinity levels in marine environments is well-documented in the literature, as salinity variations can significantly impact the growth, reproduction, and overall well-being of marine organisms, including corals and reef-associated species. Studies such as those by published study have highlighted the significance of salinity in shaping coral reef ecosystems (Freeman et al., 2012; Z. Qiu, 2015). Storm frequency is related to reef morphology, with different coral species dominating reefs based on salinity variations and storm exposure. Additionally, The essential role of associated microorganisms in marine cnidarians, such as corals, in maintaining ecosystem productivity and resilience, particularly under changing salinity conditions. Furthermore, the research by Bibin (Bibin, 2021) underscored the importance of sustainable coral reef ecosystem management, emphasizing the need for integrated approaches to protect and conserve coral reefs in the face of environmental stressors, including salinity fluctuations.

The recorded acidity levels in the waters of Sumberkima Village, ranging from 8.7 to 9.3, are within the standard range for ideal marine tourism water quality. This prompts a discussion on the implications for marine ecosystems and tourism activities. The acidity levels fall within the acceptable range for supporting marine life and tourism in the region. The stability of these values indicates a healthy aquatic environment suitable for recreational activities like diving and snorkeling, meeting optimal quality standards.

Literature comparisons highlight the importance of water quality parameters in marine environments. Stress the integration of tourism activities with bioeconomic models and addressing marine pollution concerns to sustain coastal tourism destinations. Leisure constraints, destination attractions, and their impact on water-based tourism experiences, emphasizing the relationship between environmental quality and tourist satisfaction (Kim & Zhang, 2011).

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ISSN 1533-9211

DOI: 10.5281/zenodo.10931944

The dissolved oxygen (DO) levels in the waters of Sumberkima Village range from 0.03 to 0.08, which falls significantly below the standard required to support marine life, raising concerns about the health of marine ecosystems in the area. Literature comparisons shed light on the broader implications of low DO levels on marine environments and the need for urgent remedial actions. Published studies emphasize the critical role of dissolved oxygen in marine ecosystems and the potential consequences of declining oxygen levels on biodiversity and ecosystem functioning (Greenwood et al., 2010; Hamzah, 2019; Masithah & Islamy, 2023).

The published research demonstrates the innovative use of dissolved oxygen pop-up satellite archival tags to monitor DO levels in free-ranging fish, highlighting the importance of real-time monitoring for understanding oxygen dynamics in marine environments (Coffey & Holland, 2015). Furthermore, the study by Vaquer-Sunyer et al. (2015) on dissolved organic nitrogen inputs underscores the interconnected nature of oxygen dynamics and nutrient cycling in marine ecosystems. The research by Aoyama (Aoyama et al., 2008) on the marine biogeochemical response to rapid warming in the Kuroshio stream highlights the complex interactions between dissolved oxygen content, seawater temperature, and biogeochemical parameters in oceanic systems.

Additionally, the effects of moderately low oxygen regimes on amphipods emphasizes the detrimental impact of low dissolved oxygen on marine organisms' bioenergetics, growth, and reproduction. These findings collectively underscore the urgency of addressing low DO levels in Sumberkima Village to safeguard marine life and ecosystem health (Wu & Or, 2005).

The conductivity values ranging from 46.7 to 49.5 in the waters of Sumberkima Village indicate favorable conditions that align with water quality standards for marine tourism. These values reflect a stable salinity density crucial for maintaining marine ecosystem balance and supporting marine tourism activities like snorkeling and diving. Literature comparisons shed light on the significance of conductivity in marine environments and its implications for ecosystem health and tourism experiences. Studies emphasize the importance of monitoring water quality parameters, including conductivity, to assess marine pollution and habitat benefits in coastal areas (Brodie et al., 2020; Laglbauer et al., 2014).

Stress the importance of monitoring water quality parameters, including conductivity, to evaluate marine pollution and habitat benefits in coastal areas (Zhang & Wang, 2023). Additionally, shed light on the impact of residential waste on water quality, underscoring the significance of maintaining suitable conductivity levels for aquatic communities (Hyvärinen et al., 2021). Water tourism management strategies underscores the pivotal role of water quality in sustaining coastal tourism destinations.

Coral reef health assessment demonstrates the relevance of water quality parameters, including conductivity, in evaluating marine ecosystem conditions. These findings collectively emphasize the criticality of maintaining optimal conductivity levels to support marine life and enhance the marine tourism experience in Sumberkima Village (C. Wang et al., 2023).

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Mangrove Vegetation

Mangrove vegetation along the coastal areas of Sumberkima Village is found in Pelabuhan Bangsal, Sumberpao, Pura Tirta Sudamala, and Teluk Pegametan, covering an approximate area of 9.59 hectares. Research indicates the presence of 12 mangrove species classified as woody plants, including: *Aegiceras floridum, Avicennia marina, A. officinalis, Bruguiera gymnorhiza, B. sexangula, Ceriops decandra, C. tagal, Lumnitzera racemosa, Rhizophora apiculata, R. mucronata, R. stylosa,* and *Sonneratia alba.*

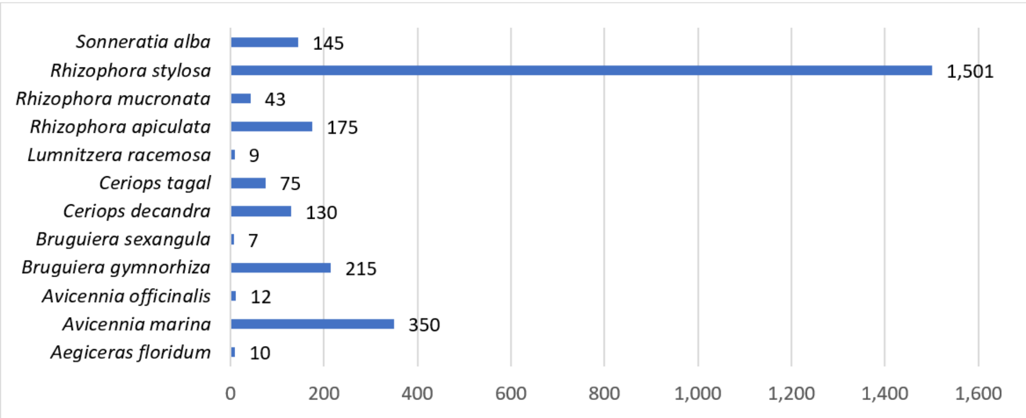

Figure 2: Types of Mangroves on the Coast of Sumberkima Village

The mangrove ecosystem along the coast of Sumberkima Village displays intriguing characteristics, as evidenced by the measured indices of diversity, evenness, and dominance. With a diversity index of 1.38, the mangrove ecosystem exhibits a relatively good level of diversity, indicating a significant variety of species (Su et al., 2021). Additionally, an evenness index of 0.55 suggests a uniform distribution of mangrove populations within the ecosystem, reflecting a healthy ecological balance. The low dominance index of 0.10 indicates a balanced ecosystem diversity not dominated by specific mangrove species, fostering stability to support diverse organisms and human activities (Hai et al., 2020). The presence of a well-diversified mangrove ecosystem in Sumberkima Village offers potential for sustainable eco-tourism development. Mangrove-based ecotourism can provide economic benefits to the local community, promote environmental conservation, and educate about the importance of mangrove ecosystem preservation (Getzner & Islam, 2020). The high biodiversity represented by the 12 mangrove species in the village creates opportunities for the development of biodiversity-based eco-tourism, offering diverse experiences for visitors and supporting sustainable economic activities (Malik et al., 2015). Mangroves are essential components of ecosystems, providing ecological, economic, and social benefits to local communities. The presence of mangroves in Sumberkima Village presents opportunities for sustainable aquaculture-based eco-tourism, as mangroves serve as habitats for various marine biota crucial for aquaculture practices (Kairo et al., 2021). Furthermore, mangroves play a role in maintaining water quality, mitigating natural disasters, and offering economic value through non-timber products like medicinal plants and food. Integrating eco-tourism development with

ISSN 1533-9211
DOI: 10.5281/zenodo.10931944

conservation and sustainable utilization of mangrove resources can be a sustainable approach with long-term benefits for the community and environment of Sumberkima Village (Aldus Sondak et al., 2019).

Seagrass Fields

The seagrass ecosystem was found at Station 2 which is the Pasir Putih Island area in Sumberkima Village. Research shows an even distribution with a cover of 6.11 – 13.25%, of the 5 types of seagrass found, namely: *Cymodocea rotundata, Enhalus acoroides, Halodule uninervis, Halophila ovalis, dan Thalassia hemprichii.*

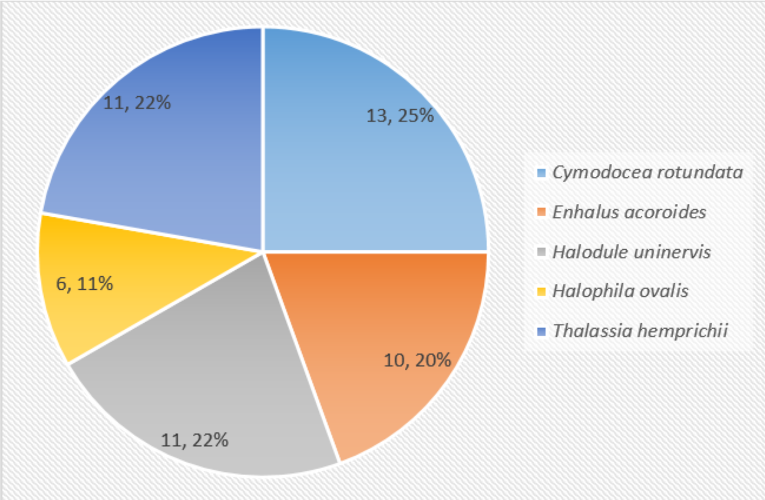

Figure 3: Types of Seagrasses in the Waters of Sumberkima Village

Research into seagrass ecosystems in Sumberkima Village has revealed promising findings that could bolster tourism development. The study indicates that the seagrass distribution in the area is relatively uniform, with coverage ranging from 6.11% to 13.25%. This uniform distribution suggests that Sumberkima Village possesses a widespread seagrass ecosystem, making it a potentially appealing destination for underwater tourism enthusiasts (Saunders et al., 2013).

Moreover, the potential of seagrass ecosystems in attracting tourists aligns with the broader significance of seagrass habitats. Seagrass meadows are recognized for their ecological importance, serving as carbon sinks and providing essential ecosystem services. They support diverse marine life, contribute to nutrient cycling, and offer habitats for various species, including commercially important fish and invertebrates (Gallagher et al., 2022; Shayka, 2023; Unsworth & Butterworth, 2021). While the study in Sumberkima Village highlights the tourism potential of seagrass ecosystems, it is essential to consider factors that could impact these habitats. Research has shown that seagrass habitats are vulnerable to environmental stressors such as nutrient enrichment, herbivory, and physical disturbances. Understanding the interactions between these stressors and seagrass ecosystems is crucial for their conservation and sustainable management (Burkholder et al., 2013; Hastings et al., 2020; B. Wang et al., 2022).

ISSN 1533-9211

DOI: 10.5281/zenodo.10931944

In conclusion, the research findings on seagrass ecosystems in Sumberkima Village underscore the importance of these habitats not only for their ecological value but also for their potential in supporting tourism activities. By recognizing the significance of seagrass ecosystems and implementing measures to protect and conserve them, coastal communities can harness the benefits of these valuable marine habitats while ensuring their long-term sustainability.

Coral Reef

The coral reef ecosystem has a bad history, where in the era before 2000 it experienced enormous pressure from the use of bombs, fishing for ornamental fish with potassium, coral mining, uncontrolled aquaculture activities, and a lack of concern for the coral reef ecosystem. In the era after 2000, public awareness increased to preserve the coral reef ecosystem.

Research at 3 research stations showed that abiotic cover dominated at all stations ranging from 58.4 -89%, consisting of rubble (coral fractures), sand (sand), and rock (stone). The high percentage of rubble cannot be separated from the past impacts experienced by the coral reef ecosystem, but the good thing that is happening now is that coral recruitment is starting to grow among this rubble cover.

Station 1, which is the outermost part of the bay, has 34.2% live coral cover consisting of Acropora and non-Acropora groups, while Station 2 has 17.4% and the lowest is Station 3 with 4.8%. The low live coral cover at Station 3 is because this area is close to the coast which has high sedimentation and there is very intense fishing activity in the form of floating net cages.

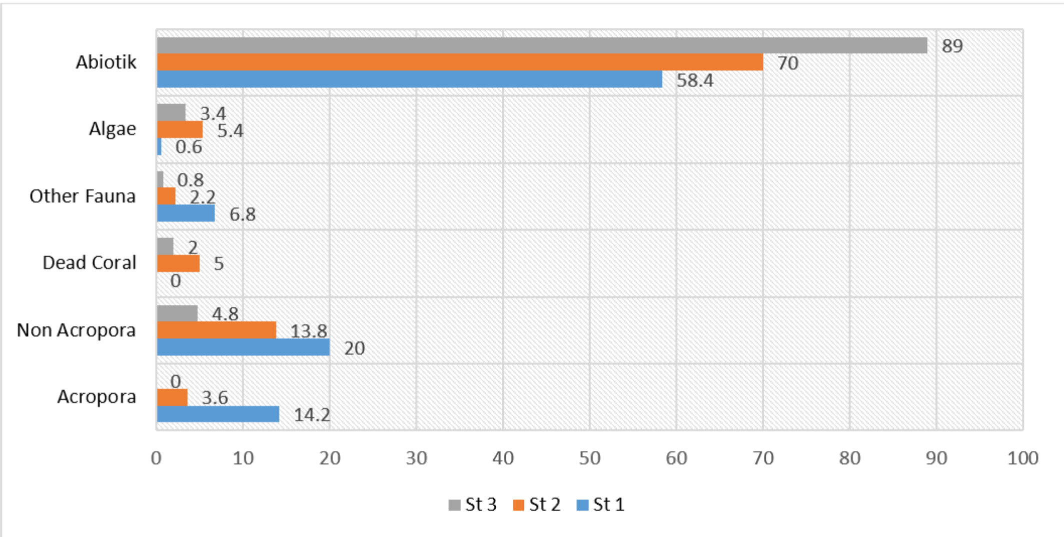

Figure 4: Closure of the Coral Reef Ecosystem in Sumberkima Village

Research shows that there are 39 coral genera in Sumberkima Village waters spread across 3 research stations. Coral lifeforms of the coral genus from the Acropora group are found in the forms: branching, encrusting digitata, submassive, and tabulate. Non Acropora group with lifeforms: encrusting, branching, foliose, massive, submassive, and mushroom.

ISSN 1533-9211
DOI: 10.5281/zenodo.10931944

The Other Fauna group, consisting of soft corals, sponges, zoantids, and others, were found 6.8% at Station 1, 2.2% at Station 2, and 0.8% at Station 3. Meanwhile, the Algae group was mostly found at Station 2 with 5.4% and the lowest at Station 1 with 0.6% consisting of Algae Assemblage, Coralline Agae, Halimeda, Macro Algae, and Turf Algae

Table 2: Abundance of Coral Genus in Sumberkima Waters

Genus	St 1	St 2	St 3
Acropora	√	√	√
Alveopora		√	√
Anacropora	√		
Astreopora		√	
Caulastrea	√		
Coscinaraea	√		
Ctenactis	√		
Cycloseris	√		
Duncanopsammia			√
Echinophyllia	√		
Echinopora		√	
Euphyllia	√	√	
Favia	√	√	
Favites			√
Fungia	√		
Galaxea		√	
Goniastrea	√		
Goniopora	√		
Heliofungia		√	
Herpolitha	√		
Hydnopora	√		
Isis	√		
Leptoria	√		
Leptoseris	√	√	
Lobophyllia	√		
Montastrea	√		
Montipora	√	√	√
Pachyseris		√	
Palauastrea	√		
Paraclavarina			√
Pavona	√	√	
Physogyra		√	
Pocilopora	√		
Porites	√	√	√
Psammocora	√		
Seriatopora	√	√	√
Stylopora	√	√	
Tubipora	√		
Turbinaria	√	√	

ISSN 1533-9211
DOI: 10.5281/zenodo.10931944

The diversity of coral genera in the waters of Sumberkima Village indicates a varied coral community with representation from different genera across the surveyed stations. Key genera such as Acropora, known for its role in reef-building, are present in multiple stations, suggesting the potential for healthy reef ecosystems in the region.

Similarly, the presence of genera like Montipora and Seriatopora, known for their tolerance to environmental stressors, may indicate resilience within the coral community to various disturbances. However, some genera are only found in specific stations, indicating localized distributions or environmental preferences. For instance, Alveopora and Montastrea are observed only in Station 2, suggesting specific habitat requirements or localized environmental conditions favoring their presence in that area. The published study supports the presence of Acropora and Montipora genera in coral communities, aligning with the findings in Sumberkima Village (Nishitsuji et al., 2023).

Additionally, the research discusses the genetic diversity of organisms, which can be crucial in understanding the distribution and abundance of coral genera in different locations (Pafčo et al., 2019). Moreover, the study on dinoflagellates in coral reef systems provides insights into the relative abundance of specific species, contributing to understanding the overall ecosystem dynamics in coral communities (Irola Sansores et al., 2018). By examining the microbial communities associated with coral reefs, potential coral disease pathogens can be identified, shedding light on factors influencing coral health and abundance (Zhou et al., 2022).

Analysis of Fish Abundance

Based on the research conducted, 20 families and 732 individual fish were found in the waters of Sumberkima Village.

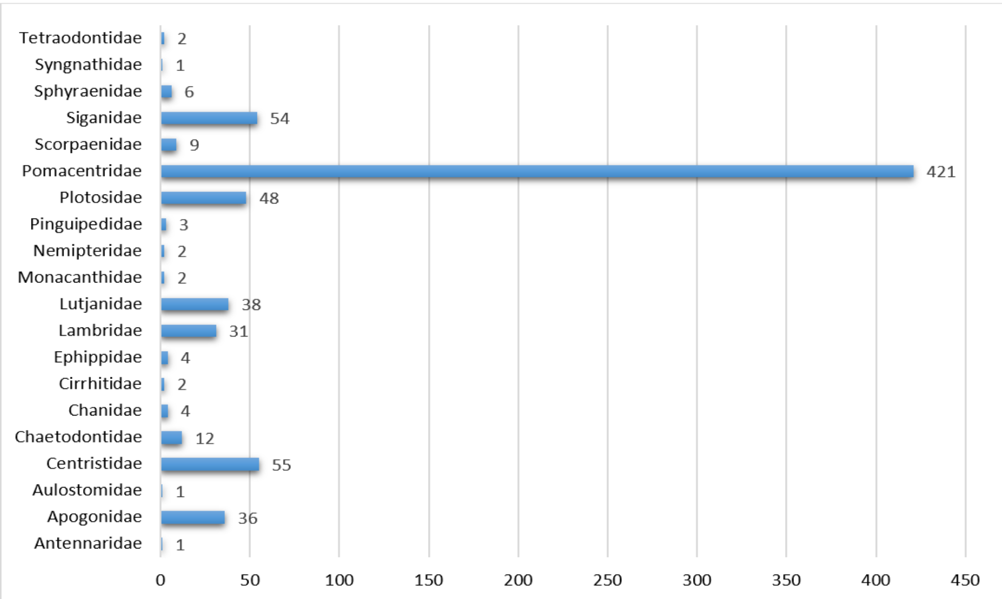

Figure 5: Abundance of Fish Families in Sumberkima Village Waters

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ISSN 1533-9211
DOI: 10.5281/zenodo.10931944

These families include Antennaridae, Apogonidae, Aulostomidae, Centristidae, Chaetodontidae, Chanidae, Cirrhitidae, Ephippidae, Lambridae, Lutjanidae, Monacanthidae, Nemipteridae, Pinguipedidae, Plotosidae, Pomacentridae, Scorpaenidae, Siganidae, Sphyraenidae, Syngnathidae, and Tetraodontidae. The Pomacentridae family was the most frequently encountered group, comprising 17 species of fish with 421 individuals. i.e. *Abudefduf vaigiensis, Acanthochromis polyacanthus, Amblyglyphidodon curacao, Chromis analis, C. Caudalis, C. margaritifer, C. ternatensis, Chrysiptera oxycephala, Dascyllus aruanus, D. melanurus, D. reticulatus, D. trimaculatus, Neopomacentrus azysron, Pomacentrus amboinensis, P. moluccensis, P. Reidi*, dan *Pomacentrus. sp.*

The presence of various fish families offers diverse underwater tourism experiences for visitors. For example, the Chaetodontidae family, known as butterflyfish, with their vibrant colors, can serve as a unique attraction for visitors interested in the beauty of the underwater world. Meanwhile, the Scorpaenidae family, which includes venomous fish, adds an exotic and unique value to the diving experience in the waters of Sumberkima Village.

The ecotourism potential offered by the biodiversity of fish also includes activities such as observation and understanding of the environment. Developing educational programs about marine biodiversity and environmental protection can be an additional attraction for visitors interested in gaining deeper insights into coral reef ecosystems and the importance of marine conservation. The management of coral reef-based ecotourism in Sumberkima Village needs to consider conservation and sustainability aspects. Efforts to protect coral reef ecosystems from physical damage, pollution, and destructive human activities are crucial to maintaining the sustainability of marine biodiversity.

Table 3: Fish Abundance in Sumberkima Village Waters during the research

Family	Scientific name	Frequency
Antennaridae	*Anntennarius pictus*	1
Apogonidae	*Apogon compressus*	4
	Apogon exostigma	32
Aulostomidae	*Aulostomus chinensis*	1
Centristidae	*Aeoliscus strigatus*	55
Chaetodontidae	*Chaetodon decussatus*	4
	Chaetodon modestus	8
Chanidae	*Chanos chanos*	4
Cirrhitidae	*Cirrhitichthys falco*	2
Ephippidae	*Platax teira*	4
Lambridae	*Coris gaimard*	5
	Halichoeres chrysus	9
	Thalossoma lunare	8
	Thalossoma lutescens	9
Lutjanidae	*Lutjanus biguttatus*	38
Monacanthidae	*Aluterus scriptus*	2
Nemipteridae	*Scolopsis trilineata*	2
Pinguipedidae	*Parapercis clathrata*	1
	Parapercis hexophthakma	1

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Family	Scientific name	Frequency
	Parapercis tetracantha	1
Plotosidae	*Plotosus lineatus*	48
Pomacentridae	*Abudefduf vaigiensis*	36
	Acanthochromis polyacanthus	26
	Amblyglyphidodon curacao	2
	Chromis analis	34
	Chromis caudalis	27
	Chromis margaritifer	26
	Chromis ternatensis	8
	Chrysiptera oxycephala	23
	Dascyllus aruanus	34
	Dascyllus melanurus	38
	Dascyllus reticulatus	31
	Dascyllus trimaculatus	26
	Neopomacentrus azysron	13
	Pomacentrus amboinensis	12
	Pomacentrus moluccensis	24
	Pomacentrus reidi	37
	Pomacentrus sp	24
Scorpaenidae	*Pterois anntennata*	3
	Pterois radiata	2
	Pterois volitans	2
	Scorpaenodes lictoralis	2
Siganidae	*Siganus argenteus*	9
	Siganus vermicularis	45
Sphyraenidae	*Sphyraena barracuda*	6
Syngnathidae	*Corythoichthys intestinalis*	1
Tetraodontidae	*Arothron hispidus*	1
	Arothron nigropunctatus	1
	TOTAL	**732**

The Pomacentridae family, commonly known as damselfishes, is indeed significant in coral reef ecosystems. A study on the marine fish fauna of the Redang Islands, Malaysia, identified Pomacentridae as one of the most speciose families (Du et al., 2019). Similarly, research on the lionfish diet in Cuba highlighted Pomacentridae as one of the most important fish families (Río et al., 2023). Furthermore, a study on reef fish biodiversity in Tunda Island, Indonesia, noted Pomacentridae for dominating the marine fish fauna (Mujiyanto et al., 2022). These findings emphasize the ecological importance and prevalence of Pomacentridae in various marine environments. Additionally, the Labridae family, which includes wrasses, was also found to be prevalent alongside Pomacentridae in different studies. Labridae was reported as one of the major families in the coral fish fauna of the Xisha Islands, China (S. Qiu et al., 2021)). Moreover, Labridae was highlighted as one of the dominant families in the reef fish species diversity of Mansinam and Lemon Island waters in Indonesia (Pranata et al., 2022). The co-occurrence of Pomacentridae and Labridae in these studies suggests a common presence and potential ecological interactions between these two fish families in reef ecosystems. The prevalence of Pomacentridae and Labridae in various marine environments indicates their

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importance in reef ecosystems and their potential significance for tourism activities such as snorkeling and diving, where these colorful and diverse fish families can enhance the experience for tourists interested in marine biodiversity.

Fishery Cultivation Activities

In Sumberkima Village, located in the Gerokgak District, Buleleng Regency, Bali Province, there are two types of seaweed:

1) *Gracilaria* sp. (Red Seaweed): This type of seaweed has high economic value and is used in various modern industries, both in the food and non-food sectors. The total production of seaweed in Sumberkima Village reaches 200-500 tons per month, with a selling price of around Rp6,000 per kilogram.
2) Cottonii (*Eucheuma cottonii*): This seaweed is green in color and has been cultivated in Sumberkima Village. Although it has only been running for 4 months, the production has reached approximately 5 tons. The success of cultivating cottonii seaweed in this village is remarkable.

Sumberkima Village has a total area of floating net cages of approximately 43.92 hectares. Fish farmers cultivate various types of fish. Some of the cultivated fish species include Grouper, Snapper and Ornamental fish. The presence of two types of seaweed, Gracilaria sp. and Cottonii, in Sumberkima Village highlights the importance of marine resources in the local economy. These seaweeds not only provide economic benefits but also contribute to the sustainability of coastal livelihoods. The high production of Gracilaria sp. and the remarkable success of cultivating Cottonii seaweed demonstrate the potential for seaweed farming as a lucrative venture in the village.

The cultivation of various fish species in floating net cages in Sumberkima Village reflects a diversification of aquaculture activities (Kade Kusuma et al., 2021). This practice not only provides an additional source of income for local communities but also contributes to food security and marine biodiversity conservation (Roos et al., 2019). The presence of species like grouper, snapper, and ornamental fish in these cages indicates the suitability of the marine environment in Sumberkima Village for aquaculture practices (Kade Kusuma et al., 2021). Moreover, the integration of seaweed farming along with fish cultivation in the village signifies a sustainable approach to marine resource utilization (Nie, 2022). Aquaculture activities, such as fish farming, have been shown to have a significant impact on local communities, especially in terms of nutrition and livelihood (Roos et al., 2019). The development of aquaculture in coastal areas has been crucial for economic growth and food production (Novianti et al., 2023). Additionally, the use of technologies like the Internet of Things (IoT) has modernized aquaculture farms, allowing for better monitoring and management of fish stocks (O'Donncha & Grant, 2019). Efforts to ensure the sustainability of aquaculture practices include the use of probiotics to enhance fish health and growth (Romanova et al., 2022). Furthermore, the implementation of organic fertilizers in aquaculture, as seen in some regions, aims to improve the cultivation of species like white leg shrimp and milkfish (Nur et al., 2021). These sustainable practices not only benefit the environment but also contribute to the economic

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development of local communities (Bhuiya et al., 2021). In conclusion, the cultivation of fish species in floating net cages in Sumberkima Village represents a multifaceted approach to aquaculture that not only boosts local economies but also addresses food security and marine conservation concerns. By integrating various species and sustainable practices, aquaculture in Sumberkima Village serves as a model for responsible marine resource utilization.

Coastal resources potential in Sumberkima village

Research on the potential of coastal resources in Sumberkima Village reveals diverse ecosystems with high ecological potential for development as ecotourism destinations. One of the main potentials is the presence of coral reef ecosystems rich in marine biodiversity. The coral reefs of Sumberkima Village are home to various fish species, mollusks, and other marine life, offering breathtaking snorkeling and diving experiences for visitors eager to explore the beauty of the underwater world.

In addition to coral reefs, the presence of seagrass beds, seaweed, and mangroves is also significant ecological potential in Sumberkima Village. Seagrass beds, with their species diversity, offer unique diving experiences and opportunities to observe diverse marine life.

Meanwhile, seaweed and mangroves play vital roles in maintaining coastal ecosystem balance, providing habitat for various marine species, and protecting the coastline from erosion. In addition to rich ecological potential, fish farming activities with floating net cage systems are also a distinctive feature and main potential of Sumberkima Village. This cultivation system provides opportunities for tourists to understand fish farming processes firsthand and enjoy fresh seafood products.

This presents an opportunity for developing ecotourism programs based on direct interaction between visitors and fish farming activities. The development of ecotourism programs based on ecological potential and fish farming activities can provide dual benefits for Sumberkima Village. Besides offering unique tourism experiences for visitors, these programs can also make a significant economic contribution to the local community through increased revenue from the tourism sector and marketing of local fishery products.

In the development of ecotourism, it is important to consider conservation and environmental sustainability aspects. Efforts to protect coastal ecosystems, such as coral reefs, seagrass beds, and mangroves, as well as wise management of fish farming activities, are key to maintaining the sustainability of this tourism destination in the long term. Active involvement of the local community in ecotourism management and development is also crucial.

Empowering the community in natural resource management, training as tour guides, and job opportunities related to the tourism industry can help increase their participation in maintaining environmental sustainability and gaining economic benefits from the ecotourism potential in Sumberkima Village. With sustainable management, effective promotion, and strong local community involvement, the coastal resource potential of Sumberkima Village for ecotourism development can serve as an example of sustainable tourism management and benefit all stakeholders involved.

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DOI: 10.5281/zenodo.10931944

CONCLUSION

The diversity of ecosystems in Sumberkima Village holds great ecological potential for developing as ecotourism destinations. The presence of rich coral reef ecosystems is a key attraction, offering exciting snorkeling and diving experiences for visitors interested in exploring the underwater beauty.

Additionally, the presence of seagrass beds, seaweed, and mangroves adds value by maintaining coastal ecosystem balance and providing habitats for various marine life. Fish farming activities with floating net cage systems are also a unique feature and main potential of Sumberkima Village.

This farming system not only allows visitors to understand fish farming processes directly but also provides access to enjoy fresh seafood products. The combination of ecological potential and fish farming activities lays a strong foundation for developing ecotourism programs based on direct interaction between visitors and coastal resources.

Acknowledgement

This research was funded by the Research and Innovation Funding Program for Advanced Indonesia organized by the National Research and Innovation Agency (BRIN).

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