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Vegetation and Stakeholder Analysis of The Mangrove Forest Ecosystem in The Coastal Area of Bazartete, Timor-Leste

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Abstract

Mangroves are important ecosystems that provide a range of ecosystem functions and services that support livelihoods and the environment. This study aimed to analyse mangrove vegetation and stakeholders based on their interest and influence on the mangrove forest ecosystem in Bazartete, Timor-Leste.The research was conducted at two research stations: Tibar Village (Station I) and Ulmera Village (Station II). The mangrove vegetation data were obtained using a systematic sampling method based on the line transect. The analysis of mangrove vegetation consists of species frequency, population density, species dominance, and importance value index (IVI). The data collection methods used in this research are interviews and questionnaires with data analysis, including stakeholder identification, categorization and mapping, and stakeholder relationships. The analysis showed four mangrove species found at the research stations, namely *Sonneratia alba*, *Rhizophora apiculata*, *R. mucronata* and *R. stylosa.* The stand density at Tibar Village station is dominated by *S. alba*, with a density of 366.67 trees/ha, a species dominance level of 91.23 m^2/ha, and an IVI of 219.98. At the Ulmera Village station, *R. apiculata* exhibited a higher density (766 trees/ha). However, *S. alba* was the dominant species, possessing a species dominance level of 53 m^2/ha and an IVI of 116%. The Stakeholder matrix identifies the positions of various stakeholders, with the Minesterio de Agriculturae Pascas Timor-Leste (MAPTL), Mangrove Management Coordinator (MMC), and Diresaun Nasional Biodiversidade (DNB) being highly important and influential in mangrove forest management, while the United Nations Development Programme (UNDP) and Conservation International (CI) are considered subjects with high importance but low influence. This study provides information on mangrove species and vegetation analysis in the Coastal Area of Bazartete, Timor-Leste, aiding stakeholders in identifying species requiring conservation, protection, and rehabilitation.

Keywords: Mangrove ecosystem, Mangrove density, *Rhizophora apiculata, Sonneratia alba, Stakeholder analysis*

1. Introduction

Mangrove forests, characterized by their uniqueness and distinctiveness as forest ecosystems, have significant economic and ecological value; however, they are highly vulnerable to damage if they are not managed wisely [1]. Mangrove forest ecosystems serve complex functions, including physical and biological functions, such as spawning grounds, nurseries, feeding areas, germplasm, and genetic sources, along with socio-economic functions. As coastal ecosystems with high biological productivity, mangroves naturally harbor many fish species. A diverse array of mangrove species contributes to the richness and abundance of animal resources [2]. Moreover, mangroves are known to be carbon-rich ecosystems, storing four to eight times more carbon than terrestrial forests [3].

Mangrove forests cover a relatively limited expanse, amounting to 1,300 ha, within the coastal zone of Timor-Leste in 2013. These forests consist of fringing stands, primarily comprising a modest number of species, totalling 19 mangrove species. These mangroves thrive in sand-dominated deposits in small lagoons along the south coast and in sheltered embayments along the north coast [4][4]. Mangrove forests in Timor-Leste are also present in the coastal area of Bazartete, Liquisa District, particularly in the villages of Tibar and Ulmera, with mangrove land areas measuring 22 and 45 ha, respectively [5].

Despite their significance as ecosystems that contribute to various functions and services supporting livelihoods and the environment, mangrove forests in Timor-Leste have been subjected to exploitation since at least the 1940s, primarily attributed to land clearing for agricultural purposes, the utilization of mangrove wood, and the conversion of land for human settlements. Exploitation has led to the loss of almost 90% of the original mangrove forest in Timor-Leste, which was estimated to be around 9,000 hectares in 1940. Consequently, by 2013, only approximately 1,300 ha had remained [4]. Mangrove deforestation in Metirano, Timor-Leste, documented by Alongi [6], led to a reduction of 30–50% in the count of live stems and a decrease in aboveground biomass ranging from 46% to 86%. Richard and Friess [7] reported percentage mangrove loss 2000–2012 in Timor-Leste is 0.19%.

The Tibar and Ulmera communities in the Liquisa District of Timor-Leste are among the places where mangrove areas have been impacted. In 2017, efforts were made to restore mangroves; nevertheless, the programme's success was deemed subpar. The purpose of this study was to examine mangrove vegetation and identify and evaluate the stakeholders involved in the rehabilitation effort. The results of this study will be useful in the future for managing mangrove regions in Ulmera and Tibar villages.

2. Materials and Methods

2.1 Description of study area

The research was conducted from September to October 2021 in Tibar Village and Ulmera Village, located in the coastal area of Bazartete, Liquica District, Timor-Leste (Figure 1). The selection of the research location was based on purposive sampling, which was conducted after the initial survey. The research location represents the conditions of mangrove forests in the coastal area of Bazartete. The Ulmera observation station (Station I) is situated in Ulmera Village and is inhabited by 939 families, totalling 4,347 people. The Tibar observation station (Station II) is located in one of the coastal villages bordering Dili City and the Liquisa District, covering an area of approximately 42.25 km². The population of Tibar Village comprises 1,387 families, totalling 6,951 people.

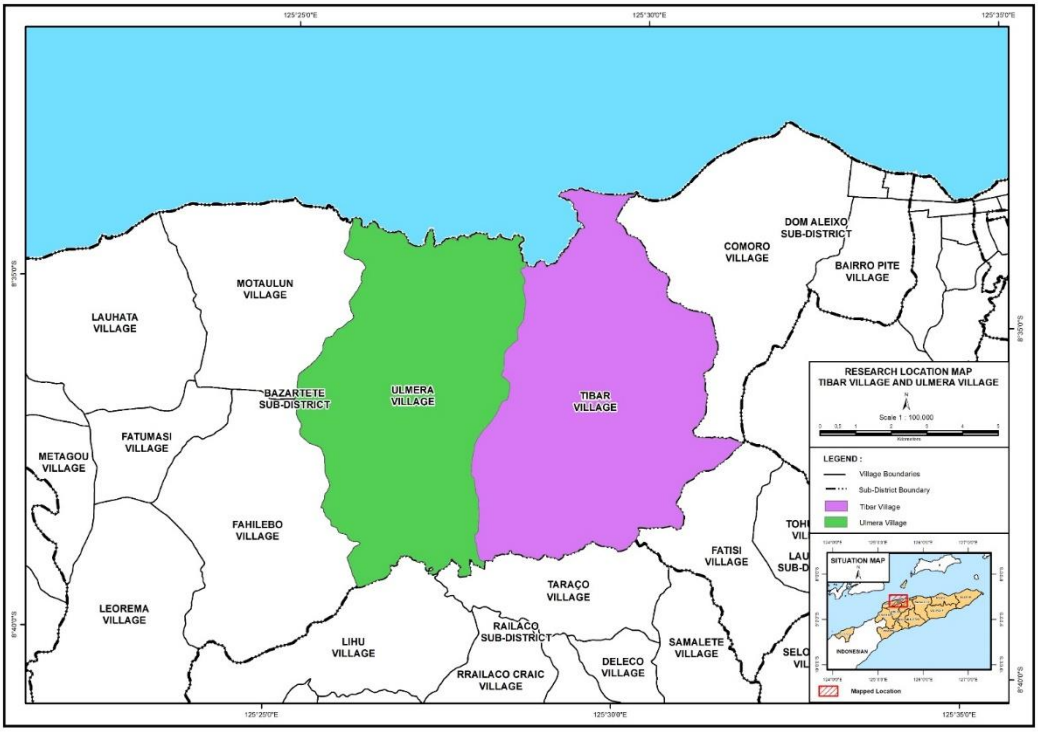

Figure 1. Research Location

Mangrove vegetation data, including the type and quantity of individuals, were acquired through observations and measurements conducted at each research station. The observations and measurements involved using three quadratic transects measuring 10 × 10 m for mangroves categorized as trees, a quadratic transect measuring 5 × 5 m for saplings, and a quadratic transect measuring 1 × 1 m for seedlings [8].

2.2 Analysis of Vegetation Data

The observed and calculated parameters for mangrove communities consisted of density (K), Relative Density (KR), Dominance (D), Relative Dominance (DR), Frequency (F), Relative Frequency (FR), Index of Important Value (IVI), Diversity Index (H'), and Dominance Index (C) [9][10]. Stem diameter measurements were conducted in both tree and sapling phases using the diameter at breast height (DBH) method.

1.1.1. Frequency

The species frequency (F) is the probability of finding an "i^{th}" species in all quadratics transects. During data collection, this calculation helped to identify the most common mangrove species in the quadrat transects, revealing the dominant species in the research area. The frequency species was determined as follows:

$$\text{Frequency (F)} = \frac{\sum \text{a sub plot is determined by a species}}{\sum \text{total of sub plot}} \quad (1)$$

The relative frequency (RF) is the ratio of the frequency of species "i" (F) to the total frequency of all species (∑F). RF was calculated using the following formula:

$$\text{Relative frequency (FR)} = \frac{\text{F of a spesies}}{\text{F of total of spesies}} \text{ x } 100\% \quad (2)$$

1.1.2. Population Density

The population density (PD) of each mangrove species was calculated by comparing the number of individuals found in the observation area. The population density was calculated using the following formula:

$$\text{Population Density (PD)} = \frac{\text{Number of individual species}}{\text{Total of plot area}} \quad (3)$$

Relative density (RPD) refers to the proportion or percentage of individuals of a particular species in the total population within a defined area or space.

$$\text{Relative Density (RD)} = \frac{\text{Number of individual species}}{\text{Total number of individual of all spesices}} \text{ x } 100\% \quad (4)$$

1.1.3. Dominance

Dominance provides information regarding the indication of a species' prevalence in a specific plot. It was calculated by determining the basal area of a species and dividing it by the total area of the plot. The dominance value was determined as follows:

$$\text{Dominance (D)} = \frac{\text{Total of basal area of each tree of species from all plots}}{\text{Total area of all observed plots}} \quad (5)$$

Relative dominance (RD) was used to determine the basal area of a particular species and was divided by the total basal area of all species present in a given area. Multiplying the result by 100 provides the percentage of relative dominance for that specific species

$$\text{Relative Dominace (RD)} = \frac{\text{Basal area of a species}}{\text{Total basal area of all species}} \text{x} 100\% \quad (6)$$

1.1.4. Importance Value Index

The Importance Value Index (IVI) is the sum of the values for species relative frequency (RF), species relative density (RPD), and relative dominance (RD). This calculation was conducted

to identify the key mangrove species for future planting initiatives [11]. The formula used to calculate the IVI is

$$\text{Impotance Value Index (IVI)} = \text{RF} + \text{RPD} + \text{RD} \quad (7)$$

The importance of a species ranges from 0% to 300% in the trees. The IVI value provides an overview of the role of mangrove species in mangrove communities.

2.3 Stakeholder Analysis in Mangrove Forest Management

The stakeholder analysis process comprises three phases: (a) identification, (b) categorization and mapping, and (c) evaluation of stakeholder relationships [12].

1.1.5. Stakeholder identification

Stakeholder identification was performed to ensure that individuals and entities managed mangrove forests within the Bazartete coastal area. This process involved verifying stakeholders associated with mangrove forest management through cross-referencing information obtained from primary sources, followed by on-site observations and interviews conducted with relevant stakeholders.

Table 1. Institutions involved in mangrove management.

Stakeholder	Background	Role in management
Minesterio de Agricultura e Pascas *Timor-Leste* (MAPTL)	Government	Permitting mangrove forest agroforestry and planting mangrove seedlings
Diresaun Nasional Biodiversidade (DNB)	Government	Responsible for protective areas and environmental permits
Mangrove Management Coordinator (MMC)	NGO	A group with its initiative was established to manage mangrove forests
United Nations Development Programme (UNDP)	NGO	Working with the government to plant mangroves
Conservation International (CI)	NGO	Carrying out mangrove management activities and publications

1.1.6. Stakeholder categorization and mapping

The categorization and mapping of stakeholders in mangrove forest management were accomplished by utilizing a matrix that considers their interests and influence. Assessment of their significance and impact relies on five key questions. Table 2 presents the stakeholder interest and influence scores.

Table 2. Stakeholder interest and influence score

Level of stakeholder interest			
Score	**Value**	**Criteria**	**Note**
5	21-25	Very high	Very interested in mangrove forest management
4	16-20	High	Interested in mangrove forest management
3	11-15	Enough	Quite interested in mangrove forest management
2	6-10	Low	Lack of interest in mangrove forest management
1	0-5	Very low	Has no interest in managing mangrove forests
Level of stakeholder influence			
Score	**Value**	**Criteria**	**Note**
5	21-25	Very high	Very influence in mangrove forest management
4	16-20	High	Influence in mangrove forest management
3	11-15	Enough	Quite an influence in mangrove forest management
2	6-10	Low	Less influence in mangrove forest management
1	0-5	Very low	Has affect mangrove forest management

The stakeholder mapping process involves aggregating interest and influence scores from each stakeholder and creating coordinates that illustrate their roles, as presented in Figure 2. Based on their influence and interests, the outcomes of stakeholder classification are categorized into four groups: key players, subjects, context setters, and crowds [12].

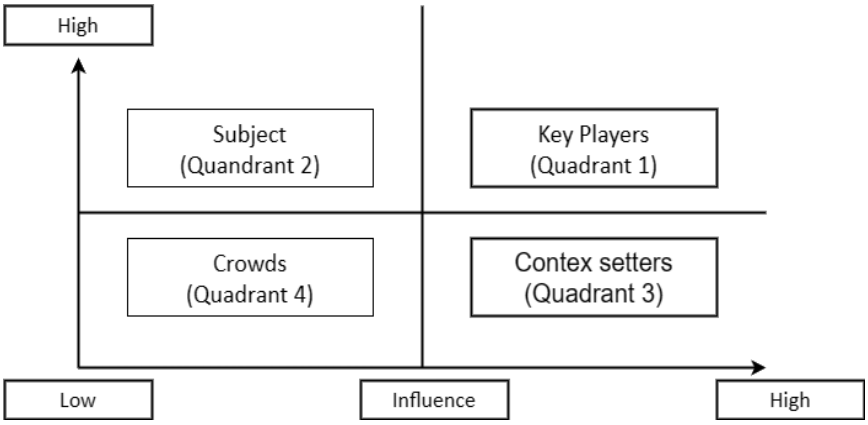

Figure 2. Matrix analysis of stake holder

1.1.7. Stakeholder relationship

Relationship data were collected through interviews, and the analyzed data included both realized and unrealized cooperative relationships among stakeholders. The interactions among stakeholders were delineated through a map illustrating the relationships involved in managing mangrove forests in the Bazartete coastal area.

3. Result dan Discussion

3.1 Mangrove vegetation

The vegetation analysis results showed that there were two species of mangrove vegetation at the Tibar village station, *Rhizophora apiculata* and *Sonneratia alba.* The total number of tree phases found at this station was 32, with 10 and 22 for *R. apiculata* and *S. alba*, respectively (Table 2). Sapling and seedling phases were also identified at this station, with a total of 3 saplings and 54 seedlings.

The mangrove vegetation community structure can be seen in the importance value index and diversity index of mangrove vegetation community constituents. The tree density at the Tibar village station indicates that *S. alba* has a density of 366.67 trees/ha compared to *R. apiculata,* which only has 166.67 trees/ha. This contributes to 533.33 trees/ha in the tree phase. The species dominance level was led by *S. alba* at 91.23 m^2/ha with an IVI of 219.98%. Based on vegetation analysis, it is evident that *S. alba* dominates in the tree phase. [13] documented a high density of *S. alba* along the Coast of Metinaro, Timor Leste. *S. alba* is recognized as a genuine mangrove species that can adapt to environmental change. According to [14], true mangroves exhibit salt exclusion or salt excretion through pneumatophores or aerial roots. They are exclusively found in tropical intertidal habitats and are adept at adapting to the prevailing environmental conditions. The condition of mangrove forests in the Bazartete area is currently degraded through several factors, one of which is that the phenomenon of erosion in coastal areas is still relatively high, so it is necessary to have physical protection to restore the condition of mangrove forests and maintain the quality of mangrove ecosystems as a life support system. Therefore, the government must work together with related institutions in the management of mangrove forests in the Bazarte Region, especially in Ulmera and Tibar Villages.

Table 3. Tree stage mangrove vegetation analysis in Tibar village station

Local Name	Latin	Number of Individual	PD	RPD	F	RF	D	RD	IVI	H'
Bakau	*Rhizophora apiculata*	10	166.67	31.25	0.67	40	0.09	8.77	80.02	0.36
Perepat / Pidada putih	*Sonneratia alba*	22	366.67	68.75	1	60	0.91	91.23	219.98	0.26
Total		32	533.33	100	1.67	100	1.00	100	300	0.62

Note: PD= Population density, RPD = Relative Population Density, F= Frequency, RF= Relative Frequency, D= Dominance, RD= Relative Dominance, IVI= Importance Vegetation Index, H' = Diversity Index

Table 4. Sapling stage mangrove vegetation analysis in Tibar village station

Local Name	Latin	Number of Individual	PD	RPD	F	RF	D	RD	IVI	H'
Bakau	*Rhizophora apiculata*	3	100	69	0.33	75	0.39	39.02	174.02	1.79
Perepat / Pidada putih	*Sonneratia alba*	2	66.67	40	0.11	25	0.61	60.98	125.98	0.18
Total		5	166.67	100	0.44	100	1	100	300	1.97

Four species of mangroves grow at the Ulmera village station: *R. apiculata, S. alba*, *R. mucronata*, and *R. stylosa.* Eighty-two trees was 82 trees in the tree phase. Meanwhile, 73 seedlings and 11 saplings were also found at this station. The tree density at the Ulmera village station revealed that *R. apiculata* had a higher density (511 trees/ha), followed by *S. alba* (277 trees/ha) and *R. stylosa* (88 trees/ha). A total of 82 trees/ha were identified in the tree phase within the sample plot. The highest importance value index was found in *R. apiculata* at 137.65 (Table 3).

The density level was dominated by *R. apiculata* because of the muddy substrate in the central zone. Meanwhile, in the outer zone directly facing the sea and consistently inundated by seawater, the predominant species is *S. alba.* The composition of flora in the *Sonneratia* and *Rhizophora* communities in the open zone was shaped by the soil substrate in that area. Specifically, S. alba was the dominant species in the sandy outer zone. Species that are dominant in an ecosystem and possess the highest IVI tend to excel in efficiently utilizing resources or display a greater capacity for adapting swiftly to their environment [15]. Mangrove growth and development can occur optimally under conditions of regular inundation, accompanied by continuous water and sediment circulation. This circulation can enhance nutrient concentrations and salinity levels, and neutralize sediment acidity [16]. *S. alba* is able to grow on relic mangrove habitats, which other mangrove species do not grow, especially on the southern coast, which is sandy, so this plant has the potential for restoration (rehabilitation) of degraded mangroves [17].

Table 5. Tree stage of mangrove vegetation analysis in Ulmera village station

Lokal Name	Latin	Number of Individual	PD	RPD	F	RF	D	RD	IVI	H'
Bakau	*Rhizophora apiculata*	46	766.67	56.10	1.00	42.86	0.39	38.69	137.65	0.32
Perepat / Pidada putih	*Sonneratia alba*	25	416.67	30.49	0.78	33.33	0.53	52.72	116.54	0.36

Lokal Name	Latin	Number of Individual	PD	RPD	F	RF	D	RD	IVI	H'
Bakau hitam	*Rhizophora mucronata*	3	50.00	3.66	0.11	4.76	0.01	0.53	8.95	0.12
Bakau kecil	*Rizophora stylosa*	8	133.33	9.76	0.44	19.05	0.08	8.05	36.86	0.23
Total		82	1366.67	100	2.33	100	1	100	300	1.03

Table 6. Saplings stage of mangrove vegetation analysis in Tibar village station

Local Name	Latin	Number of Individual	PD	RPD	F	RF	D	RD	IVI	H'
Bakau	*Rhizophora apiculata*	8	266.67	80	0.33	75	0.39	39.02	194.02	1.29
Perepat / Pidada putih	*Sonneratia alba*	2	66.67	20	0.11	25	0.61	60.98	105.98	0.32
Total		10	333.33	100	0.44	100	1.00	100	300	1.61

3.2 Stakeholder analysis

Stakeholders encompass internal and external entities capable of exerting direct or indirect influence and are subject to such influence [12]. [18] defined stakeholders as interconnected entities within the community, comprising community groups and individuals holding interests in an organization, company, or addressed issues.

Table 7. Stakeholder interest score result

No	*Stakeholder*	Interest					Mean
		K1	K2	K3	K4	K5	
1	United Nations Development Programme (UNDP)	4	4	4	5	4	4.2
2	Minesterio de Agriculturae Pascas Timor-Leste (MAPTL)	5	4	5	5	3	4.4
3	Mangrove Management Coordinator (MMC)	5	5	4	5	5	4.8
4	Diresaun Nasional Biodiversidade (DNB)	5	5	5	4	4	4.6
5	Conservation International (CI)	5	3	2	3	2	3

Note: 1= Very Low; 2=Low; 3= Moderate; 4= High; 5= Very High
K1: Stakeholders' involvement in mangrove forest management
K2: Stakeholders' benefits in mangrove forest management
K3: Stakeholders' authority in mangrove forest management
K4: Stakeholders' priority scale in mangrove forest management
K5: Stakeholders' level of dependence in mangrove forest management

The analysis of stakeholders in the management of mangrove forests in the coastal area of Bazartete, specifically in the villages of Tibar and Ulmera, is shown in Tables 4 and 5. The average value of stakeholder interest varies among stakeholders, ranging from 3 to 4.8. The MMC had the highest mean stakeholder interest. Meanwhile, the highest mean of stakeholder influence was for MMC and DNB.

Table 8. Stakeholder influence score result

Stakeholder	Influence					Mean
	P1	P2	P3	P4	P5	
United Nations Development Programme (UNDP)	3	4	1	2	3	2.6
Minesterio de Agriculturae Pescas Timor-Leste (MAPTL)	5	5	3	4	4	4.2
Mangrove Management Coordinator (MMC)	5	5	5	5	3	4.6

Stakeholder	Influence					Mean
	P1	P2	P3	P4	P5	
Diresaun Nasional Biodiversidade (DNB)	5	5	5	5	3	4.6
Conservation International (CI)	2	3	1	1	2	1.8

Note: 1= Very Low; 2=Low; 3= Moderate; 4= High; 5= Very High
P1: Stakeholders' roles in mangrove forest management in the coastal area of Bazartete
P2: Stakeholders' authority in interactions related to mangrove forest management in the coastal area of Bazartete
P3: Oversight and evaluation by stakeholders in mangrove forest management in the coastal area of Bazartete
P4: Policies and regulations in mangrove forest management in the coastal area of Bazartete
P5: Resource capacity provided by stakeholders to support mangrove forest management in the coastal area of Bazartete

Stakeholder analysis is a method of gathering information about those who affect or are affected by decisions or policies [19]. As noted by [20], stakeholders can assist in mobilizing local resources. According to [12], stakeholders are categorized into four groups: Key Players, who hold high importance and influence; subjects with increased importance but low influence; Context Setters, who possess high influence but moderate importance; and crowds, with moderate importance and low influence.

The results of the stakeholder analysis in the management of mangrove forests in the coastal area of Bazartete, especially in the villages of Tibar and Ulmera, revealed five Stakeholders: United Nations Development Programme (UNDP), Minesterio de Agriculturae Pascas Timor-Leste (MAPTL), Mangrove Management Coordinator (MMC), Diresaun Nasional Biodiversidade (DNB), and Conservation International (CI). The analysis results represented by the scores in the table of importance and influence levels indicate that MMC, as the coordinator of mangrove forest management, falls into the category of primary stakeholders. The MATL is a key stakeholder because of its high direct interest in a mangrove program. The DNB is a key stakeholder with a high authority score, suggesting that the DNB can make decisions and actions in a policy. Supporting Stakeholders include the CI and UNDP, which continue to influence mangrove management despite the low level of policies and regulations in mangrove forest management in the Coastal Area of Bazartete.

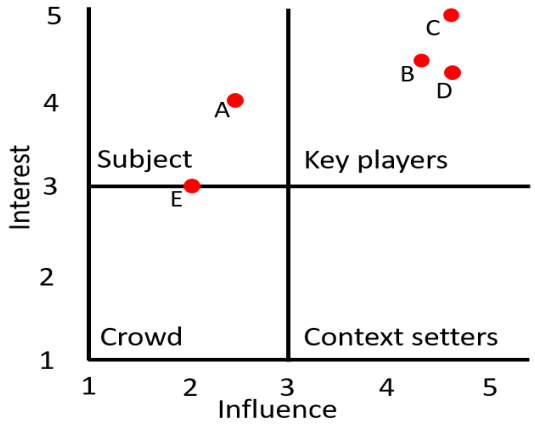

Figure 3. Stakeholder matrix

Note: A; United Nations Development Programme (UNDP), B; Minesterio de Agriculturae Pascas Timor-Leste (MAPTL), C; MMC, D; Diresaun Nasional Biodiversidade (DNB), and E; Conservation International (CI).

The Stakeholder matrix is important in determining where all stakeholders stand. In mangrove forest management, we can show stakeholders' positions in the key players' quadrant, occupied by MAPTL, MMC, and DNB. This indicates that these three stakeholders are highly important and influential. In contrast, UNDP and CI were categorized as subjects because they have high importance but low influence (Figure 3).

Until recently, mangrove management only involved planting mangroves; it has not been based on vegetation data. Data-driven mangrove management is anticipated to be built on

mangrove analysis. The findings of the analysis are expected to provide stakeholders with a thorough understanding of the mangrove ecosystem in the Bazartete coastal region, empowering them to utilize it as a foundation for management choices.

4. CONCLUSION

The coastal Area of Bazartete in Timor-Leste contains four mangrove species: *Sonneratia alba*, *Rhizophora apiculata, R. mucronata*, and *R. stylosa*. *S. alba* is the dominant tree found in Tibar village station, with 366.67 trees/ha and a dominance level of 91.23 m²/ha. The Ulmera village station has more *R. apiculata* (766 trees/ha). However, *S. alba* still dominated Ulmera, with a dominance level of 53 m²/ha. *S. alba* has the highest IVI in Tibar village station, whereas *R. apiculata* in Ulmera village station. The stakeholder matrix revealed the roles of different stakeholders, highlighting the significant importance and influence of MAPTL, MMC, and DNB in managing mangrove forests. On the other hand, UNDP and CI are noted as having high importance but relatively low influence.

Author Contributions

ERG: Data Collection, Software, Data Visualization, Writing- Original Draft & Editing**; NS:** Supervision, Conceptualization, Metodology, Review**; RS:** Supervision, Conceptualization, Metodology, Review**. NSO**: Writing - Review & Editing, Supervision; and **RSI**: Writing - Review & Editing, Supervision.

Conflicts of interest

"There are no conflicts to declare."

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The acknowledgements come at the end of an article after the conclusions and before the notes and references.

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