Plant diversity in mangrove protection Forest Management Board, Ngoc Hien District Ca Mau Province

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ABBREVIATIONS

IUCN	International Union for Conservation of Nature
SNV	SNV Netherlands Development Organisation
DBH	Diameter at breast height ($D_{1,3}$)
GIS	Geographic Information System
GPS	Global Positioning System
H	Height (tree height)
ĐDSH	Biodiversity
RNM	Mangrove
FAO	Food and Agriculture Organization
BMU	Ministry of Environment, Natural Resources and Nuclear Safety (BMU) of the Federal Republic of Germany
NN-PTNT	Agriculture and Rural Development
PCA	Principal Component Analysis
CS	Collaborators
MDS	Non Metric multi – Dimensional Scaling

1 INTRODUCTION

1.1 Background

Mangroves of Ca Mau province has vast area more than the other provinces in the country and have an important role in the protection of erosion, river erosion, improve the microclimate, is habitat for live aquatic animals as well as nurseries for aquatic species reproduction, and support for coastal communities increase the income through aquaculture as some species such as shrimp, fish, oysters... in addition to the role of carbon stored in the biomass of mangrove trees to reduce greenhouse gas emissions.

Concentrated mangroves are natural forest of Protection Forest Management Board focused coastal regions is also strict protection forests of the province of Ca Mau only a narrow belt along the coastal forest with species *as Avicennia marina, Avicennia alba, Avicennia officinalis* with natural plant species and *Rhizophora apiculata* is main species for plantation, alternating growth on the banks of shrimp pond as *Lumnitzera racemosa, Ceriops zippeliana, Thespesia populnea*... since then has led to biodiversity mangrove decline in species composition, population and plant communities. Environment changed with the exploitation of natural aquatic resources has led to excessive fisheries decline in species composition and quantity. Currently, information on mangrove plant diversity is limited. Land formerly abundant mangroves, but most primitive plants have been destroyed in the past and then forests converted into shrimp ponds.

In the framework of the project "Mangroves and Markets (MAM)" in Ca Mau province of the Netherlands Development Organization (SNV) and the International Association for Conservation of Nature (IUCN) is the Ministry of Environment and Conservation nature and Nuclear Safety (BMU) of the Federal Republic of Germany sponsors interested in plant diversity of mangroves in the scope of the project, namely on the management areas of

protection forest management board but Cambodia to implement the Convention on biological Diversity (CBD) to encourage the parties' support improving the inventory and monitoring of biodiversity and ecosystem services at the appropriate scale to assess price threats and the potential impacts of climate change and the positive impacts and minimize negative of and adaptation to climate change on biodiversity and ecosystem services Status ", along with advice on the application of safeguards for REDD + (Decision XI \ 19, Hyderabad 2012).

1.2 Objectives

- Xác định thành phần thực vật rừng ngập mặn thông qua việc tính toán các chỉ số đa dạng sinh học nhằm xác định các loài thích hợp trên những điều kiện môi trường cụ thể để đề xuất các giải pháp sử dụng kết hợp với mô hình nuôi tôm sinh thái và quản lý rừng bền vững.
- Nâng cao năng lực cho cán bộ địa phương để tham gia trong công tác điều tra đa dạng thực vật rừng ngập mặn lần này và sẽ thực hiện các cuộc điều tra đa dạng thực vật trong tương lai.
- Đề xuất các giải pháp cho việc sử dụng và quản lý bền vững các nguồn tài nguyên thực vật rừng ngập mặn cũng như các loài cây trồng trong khu vực nuôi trồng thủy sản.

2 OVERVIEW OF RESEARCH

There are 54 true mangrove species (Tomlinson, 1986) belonging to 20 genus of 16 families, there are also 60 associated mangrove species belonging to 46 genus. In the list and criteria of species in the Red Book (Polidoro. BA et al, 2010) on the disappearance of species: risk of extinction mangroves and geographic areas according to the level of global concern, there are 70 species of mangrove belonging to 17 families.

Data from the Ministry of Agriculture and Rural Development shows that, mangrove area of Viet Nam is 400,000 hectares in 1943, decreased to 290,000 ha in 1996 and 279,000 ha in 2006 (MARD, 2008). Vietnam has 109

species including 37 true mangrove species and 72 mangrove associated species (Do Dinh Sam et al, 2005). The classification of true mangrove species and associated species dependent on classification of the authors, we follow the classification of FAO (2006) in this report. Ca Mau Province has many reports listed mangrove species but there are no specific studies are the most diverse plant mangroves on the basis of quantitative and documents are scattered in many places except Mui Ca Mau National Park has done research program biodiversity of the Park. Therefore, the investigation of mangrove plant diversity this time to set up the initial database as a basis for identification, monitoring biodiversity, the importance of coastal ecosystems, using as well as to prevent loss of species and enhance the understanding of the functions of forests and the impact of humans on fluctuations of plant diversity in mangroves.

3 CHARACTERISTICS OF STUDY AREA

3.1 Study area

Study area is defined as the jurisdiction of the Protection Forest Management Board, Ngoc Hien district. Focus measurement, research on the strictly protection forest in coastal areas.

3.2 Study subjects

Study subjects were mangrove species of 3 types of forest are strictly protection forests, forest protection and production forests under the jurisdiction of the Nhung Mien of Protection Forest Management Board, Ngoc Hien district, Ca Mau Province, including true mangroves and associated mangrove species as trees, shrubs, herbs, ferns, research focused diverse natural vegetation to find the distribution law and development of the natural species to apply on reforestation. Research focuses on the level of species and community diversity, not the study of genetic diversity.

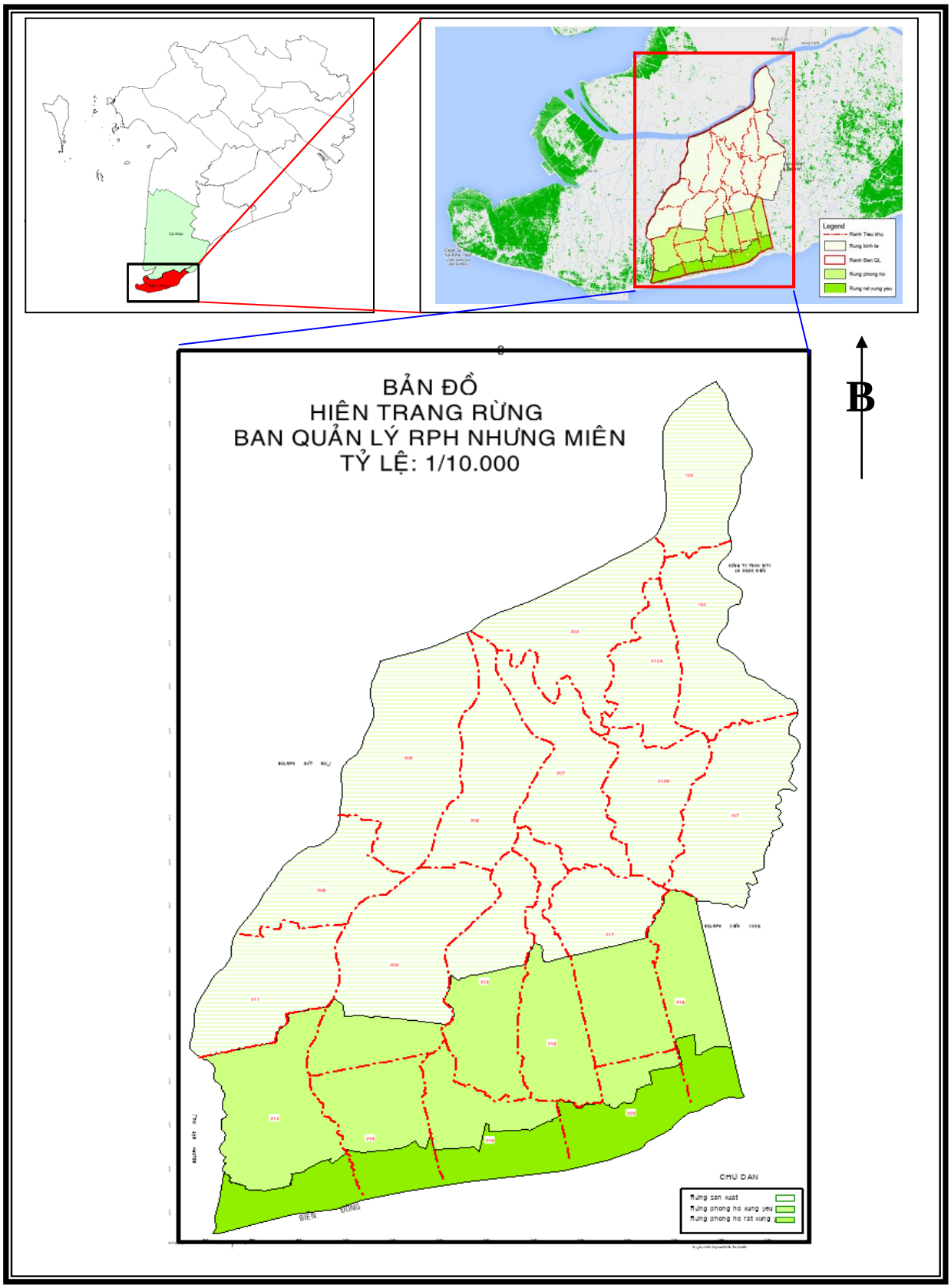


Figure 1. Location map of the forest compartment and 3 types of forest

4 CONTENTS AND METHODOLOGY

4.1 Contents of study

- Determination of mangrove species with habitats so that the proposed measures used and managed on a sustainable basis for the locality;
- Research and measurable component of woody plants; the number of individuals of each species of woody mangroves;
- Analyze and compare the biodiversity index of woody vegetation and relationship between species and between the plots in the study area.
- Identification of species, populations, communities woody plants that is rare and proposed solutions for use, conservation and sustainable management.
- Use the result of study by findings of the baseline data for monitoring and evaluation purposes in the future by building a long-term monitoring system for plant diversity of mangroves for the area.
- Proposal plant species to apply for planting mangroves in the future.

4.2 Research Methodology

4.2.1 Collect relevant data

- Gather information and data relating to biodiversity and research from the library, the Internet, consultation ...
- Collect topographic maps, administrative maps, forest status map, vegetation map, remote sensing and other data related to the study area.

4.2.2 Field survey

- Use the status map, Global Positioning System to field survey and identify areas of mangrove distribution, boundaries, location and position of the plots.
- Investigation on 10 transects, each transect has a length of 110 m and 3 plots on each transect, the plot 1 is far 10 m from the forest edge, pot 1 is apart 50 m from plot 2 and plot 3 is 50 m from plot 2 belonging to strictly protection forests.

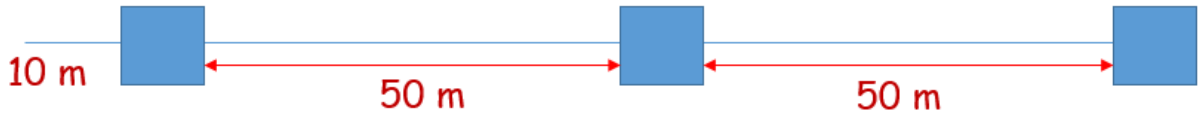


Figure 2 Layout of plots on a transect

- The size of plot is 100 m^2 (10 mx 10 m). The total of plots was 30 plots. Using the curve of number of species and area to check the number of plots necessary to ensure statistically.

- Measurement the number of individuals of tree species in the plot. Measure the diameter the trunk at breast height ($D_{1.3}$) and determine the name of the trees.

- Use a compass and tape measure around 50 meters to establish plots. Determine the number of trees in each plot and to be filled in the filed sheets.

- On the road in the area of production forests recognized mangrove trees that met on the transects survey.

- Use GPS Garmin 76 CSX to determine the position of the plots, rare and precious species.

- Use a digital camera to record the species, populations and communities mangroves.

- Identify and define the name of woody plants in the field through the mangroves of "Recognize mangroves through images" by Vien Ngoc Nam and Nguyen Son Thuy (1999); "Mangrove Guidebook for Southeast Asia" by Giesen et al (2006) published by FAO.

- Investigate the site classes, tidal regime according to Planting Technical Protocol, Forest maintenance and Protect the mangrove forests (*Rhizophora apiculata* Blume) in 1984 by former Ministry of Forestry.

Table 1 Types of mangrove sites

Type	**1a**	**1b**	**1c**	**1d**	**1e**	**1g**
Tidal height (m)	0 m	1 m	1,5 m	2 m	3 m	3,5 m
Inundation regime	Frequently flooded	Flooding by low tide	Flooding by average tide		Flooding by high tide	Flooding by unusually high tide
Inundation times/ month	56 - 62	45 - 59	20 – 45		3 - 20	2
Inundation days/ month	> 20 days	10 – 19	4 – 9 days		3 - 4	2 days
Soils		Soft mud	Tight mud	Soft clay	Hard clay	Compacted soil

4.2.3 Data Processing

On the basis of these data and documents collected in the field, using specialized software PRIMER 6 (Clarke and Warwick, 2006) processing, calculating the diversity index include:

+ The species richness (S), the number of individuals (N), Margalef richness index (d), Evenness (E), Shannon diversity index (H'), Simpson dominance index (D) , Pieloue (J), using index Caswell (V) to consider the change of environmental impacts to species diversity index Shannon.

+ Mangrove species and family have been recorded in the plots and survey transects.

+ Calculate the similarity matrix (Similarity matrices) on the basis of similarity of Bray - Curtis, drawing Cluster diagram. Use NMDS (Non Metric Multi - Dimensional Scaling) and PCA (Principal Component Analysis) to describe the relationship between the species and communities.

+ On the calculation results of the biodiversity index, conducting

comparative assessment of diversity and determine the relationship between woody plants and woody plant communities, the distribution law, species composition.

Figure 3 Board recorded transect and plot

Figure 4 Mark and measure girth of the trunk

5 RESULTS

5.1 Species composition

There are 34 species in the study area, in which is 18 true mangroves species (31%) and 16 associated mangrove species (69%) belonging to 24 families.

Table 2 Composition species by forests

No	Type	Production forest	Protection forest	Strictly Protection forest
1	True mangroves	15	11	16
2	Associated mangrove	13	10	14
	Total	28	21	30

Strictly Protection Forests area has number of true mangrove species and associated mangrove species greater than protection and production forests (Table 2) is due to the natural regeneration of forest production components more species than protection forests by planting several species in and around shrimp ponds and around the households with many species of mangroves.

5.2 Plant families

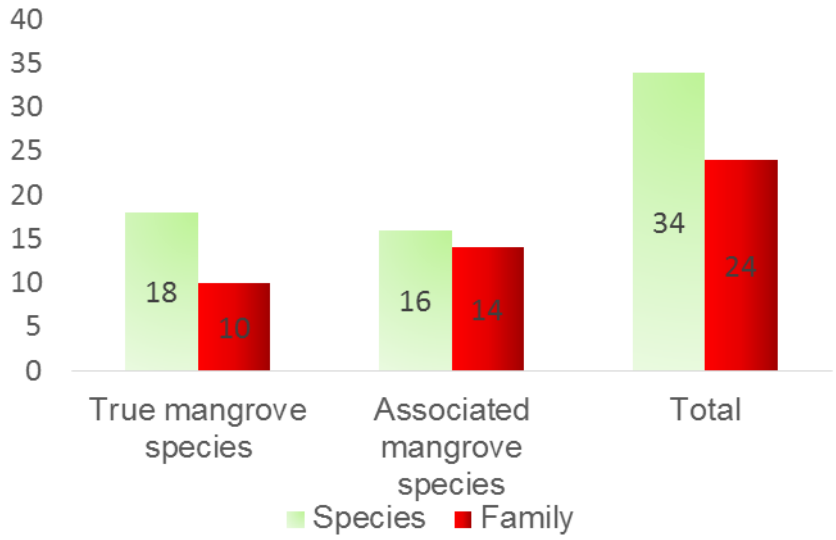


Figure 5 Number of families and species

In 18 true mangrove species belonging to 10 families accounted for 41.67% and 16 associated mangrove species belonging to 14 families accounted for 58.33% of them in the study area. Three tree families have occupied many individuals (Figure 5), in which Rhizophoraceae has the most number of trees, then Avicenniaceae and Euphorbiaceae (Figure 6).

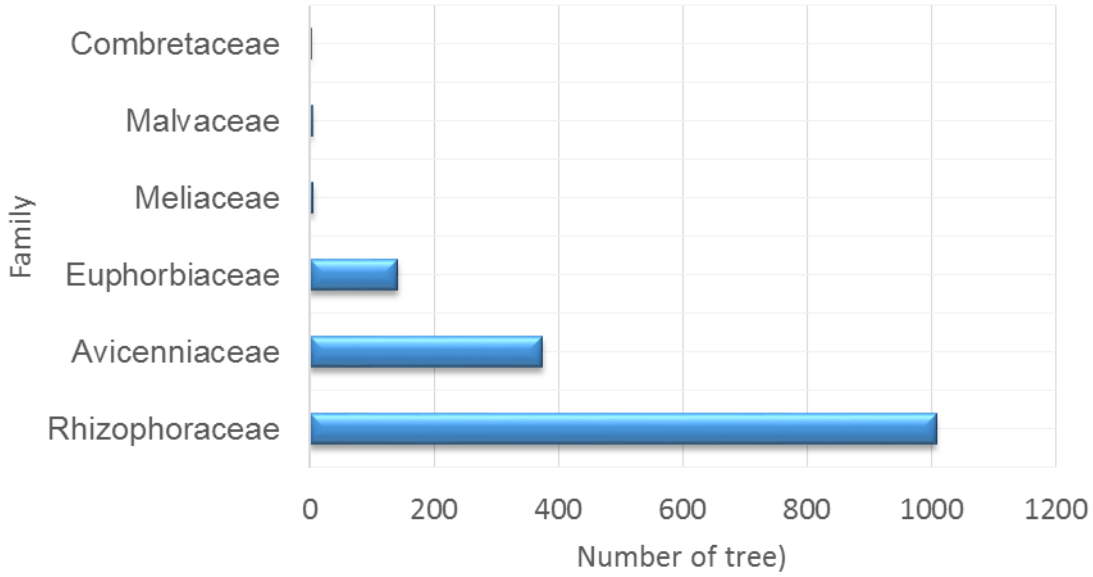


Figure 6 The number of trees by family

5.3. The Importance value index

The Importance value index (IV%) of the mangrove species showed that *Rhizophora apiculata* is highest IVI (50.39%), *Avicennia officinalis* is 11.87%, *Avicennia alba* is 11.31%, *Ceriops decandra* is 8.63%, *Avicennia marina* is 7.27%, *Excocaria agallocha* is 7%, which is 6 ecologically dominant species in the study area (Figure 7), four species have IVI value from 0, 47 to 1.02% including *Thespesia populnea, Xylocarpus moluccensis, Bruguiera cylindrica* and *Lumnitzera racemosa*. The total value of the most valuable species accumulated only 50% of mangrove species is *Rhizophora apiculata* (Appendix 5), the total IVI of important ecological dominant species are those species is 96.51% which live in the regularly inundated, *Thespesia populnea, Xylocarpus moluccensis, Bruguiera cylindrica* and *Lumnitzera racemosa* that live in areas with high elevated area, low tidal in mangrove.

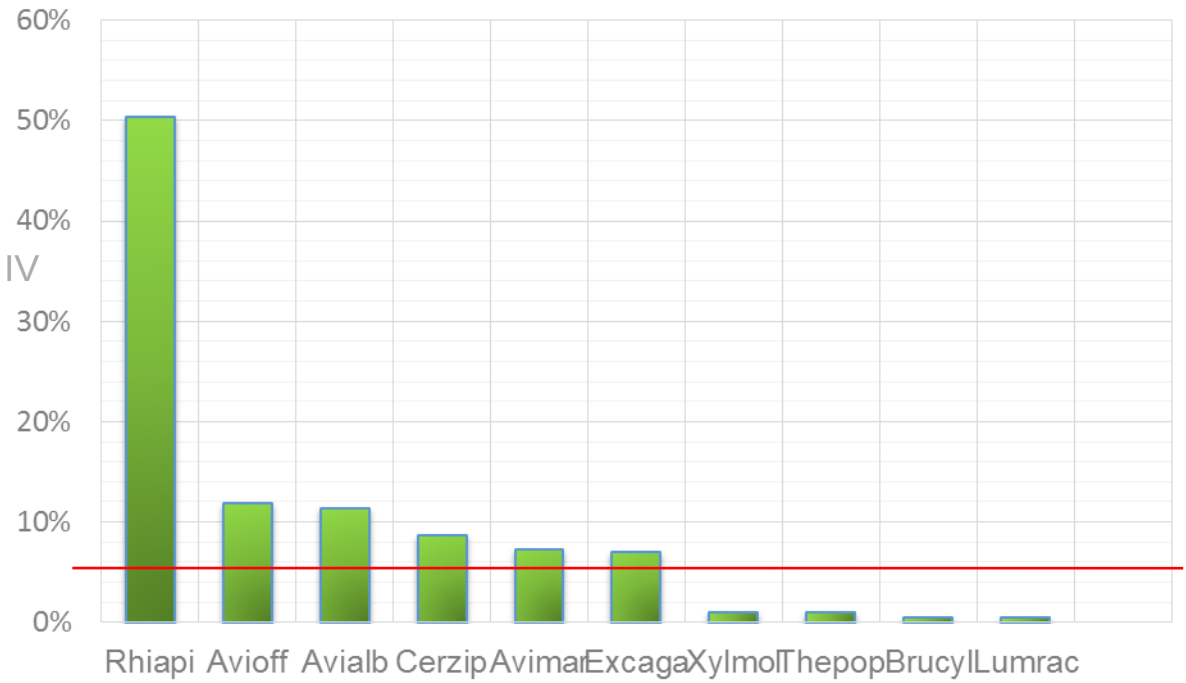


Figure 7 The Importance Value Index (IVI%) of the species

Formula of the species composition

0,504 Rhiapi + 0,119 Avioff + 0,1131 Avialb + 0,0863 Cerzip + 0,0727 Avimar + 0,0349 other species

5.4 The relationship between the number of species with plots

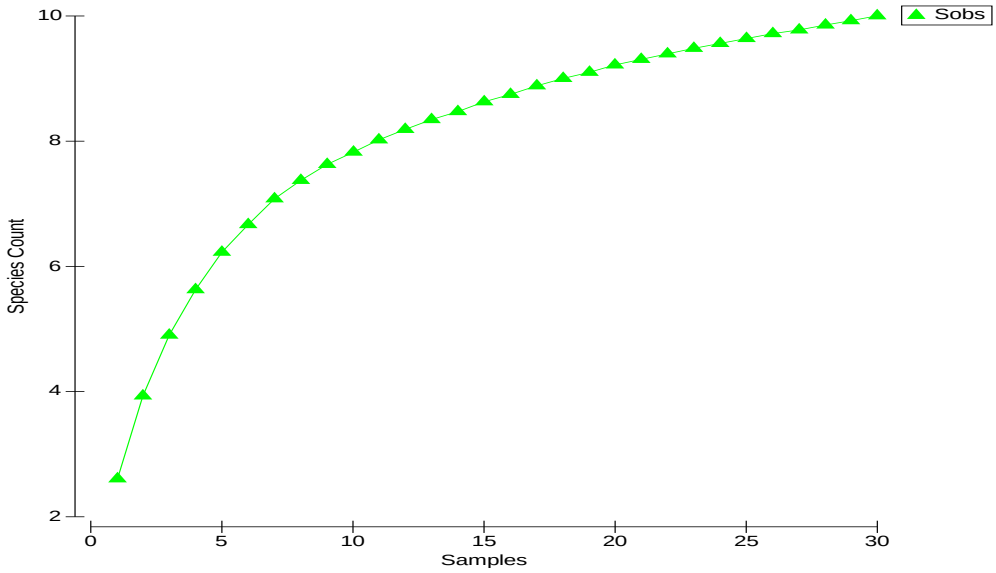
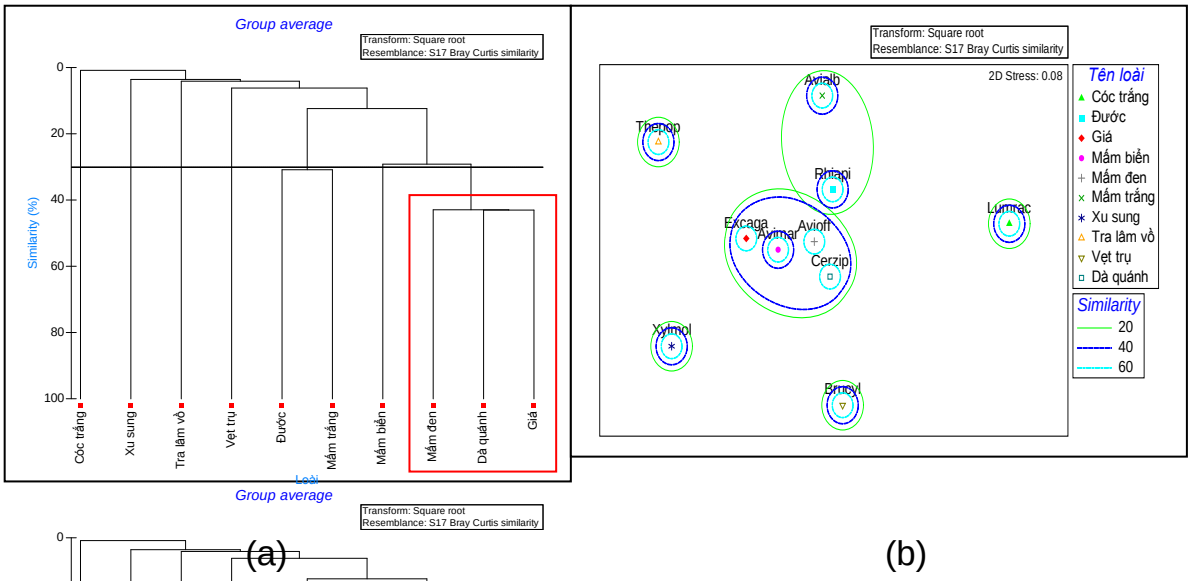


Figure 8 Plot curve with species

Over the curve of Figure 8, the species and plots showed that some species increased rapidly in the first 10 plots and increases from 11 to 27 plots and

stability progress for 10 species when the number of plots reached 30 with deviations 0. Thus the 30 plots is satisfactory in the choice of the number of plots with some species.

5.5 The relationship between species



(a) (b)

Figure 9 Cluster diagram (a) and MDS of species (b)

There are 10 species in 30 plots, of which there are eight true species and two associated species participate in mangrove are Price and *Thespesia populnea*. In each plot has averaged 2.6 ± 0.45 species, one species is lowest in plot 8 and a maximum of five species in plot 3, 18 and plot 22). According to the graph in Figure 9 shows *Lumnitzera racemosa*, *Thespesia populnea*, *Avicennia alba, Xylocarpus moluccensis, Bruguiera cylindrica* are the species that appear but the inviduals is not much, no relationships with other species, are separate species, these species are on the high elevated are of the mangroves. There are average of 10 ± 1 inviduals in plot, the highest is 19 individuals and lowest is 5 individuals per plot.

At the level of similarity of 30%, there are seven species groups in which group has the most species including 3 species on the high elevation of the mangroves, there are 6 other in which 1 group has 2 species and 5 groups have 1 species. At this similarity shows *Rhizophora apiculata* and *Avicennia alba* in a group together. *Avicennia officinalis*, *Ceriops zippeliana* and

Excocaria agallocha in a group. The species of the same group may consider for mixed species plantations.

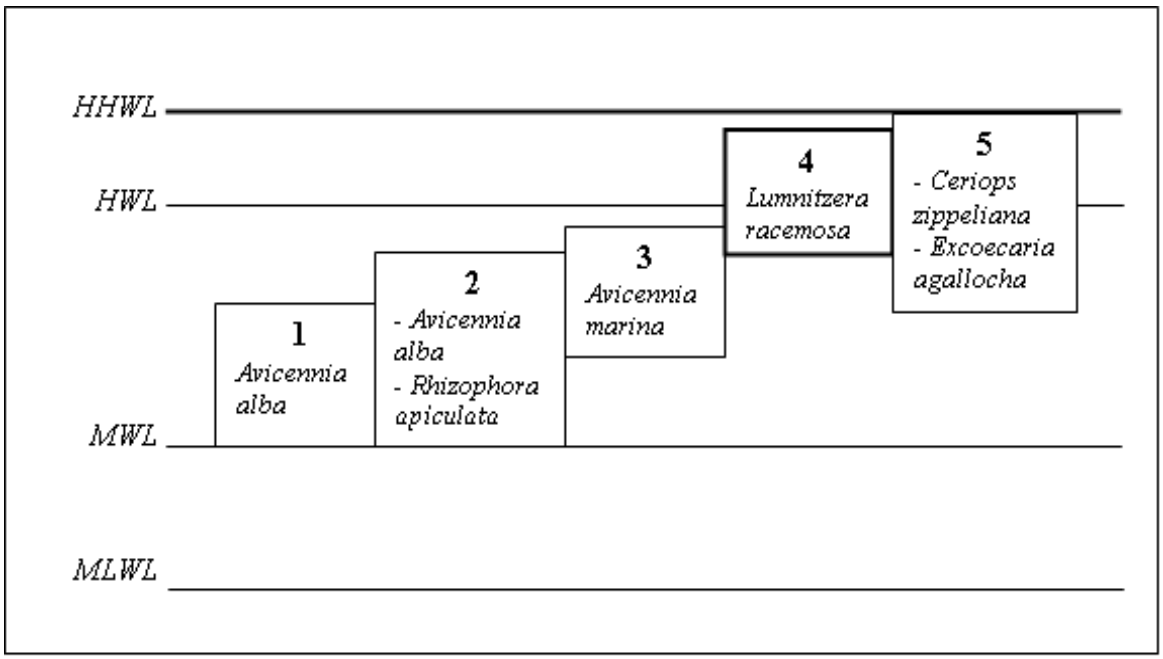


Figure 10 Distribution of the species in topography

The results showed that the species of the same group together that has the ability to grow mixed together like *Avicennia alba* with *Rhizophora apiculata. Ceriops zippeliana, Avicennia officinalis* with *Excoecaria agallocha*. *Avicennia marina, Lumnitzera racemosa* and *Bruguiera cylindrica* can not be mixed with other species due to the distribution on different high elevated area of the region.

5.5 The distribution of the species in the study area

Regarding the distribution of the species of mangroves in the coastal areas of Nhưng Mien Protection Forest Management Board showed that 10 species in which one *Lumnitzera racemosa* species is random distribution, accounting for 10% (Table 3), the remaining species are aggregated distribution, accounted for 90%.

Table 3 Distribution of the species in the study area

Species	Variance	Average	Chi-sq	Degree of freedom	Probability	Distribution
Lumnitzera racemosa	0.03	0.03	29	29	0.46512	Random
Ceriops zippeliana	70.02	4.33	468.62	29	0.00000	Aggregated
Rhizophora apiculata	455.09	29.13	453.00	29	0.00000	Aggregated
Excoecaria agallocha	197.86	4.73	1212.23	29	0.00000	Aggregated
Avicennia marina	26.34	2.07	369.61	29	0.00000	Aggregated
Avicennia officinalis	108.00	4.73	661.66	29	0.00000	Aggregated
Avicennia alba	120.56	5.7	613.39	29	0.00000	Aggregated
Xylocarpus moluccensis	0.28	0.17	49	29	0.01160	Aggregated
Thespesia populnea	0.33	0.13	71	29	0.00002	Aggregated
Bruguiera cylindrica	0.53	0.13	116	29	0	Aggregated

Type aggregated distribution is common in mangroves because the species are impacted by salinity, tidal, topography, soil... These species have adapted to specific environmental conditions and in appropriate conditions, they will grow into group, randomly distributed species are species not adapted to the new environment by joining the environment so it should take time to adapt to these species.

5.6 Relations between communities

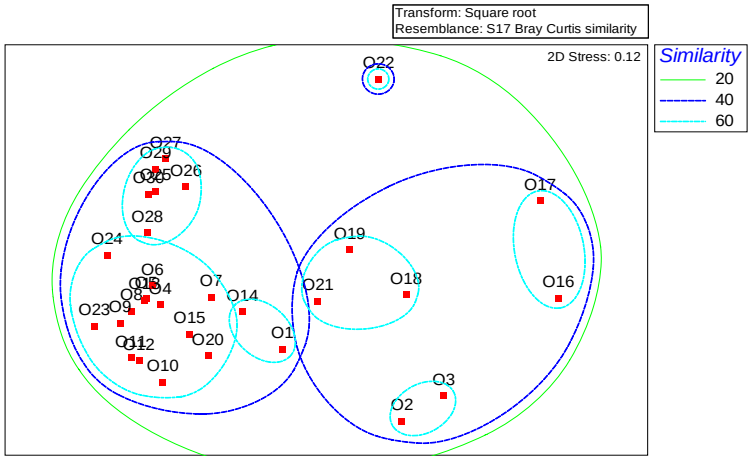


Figure 11 MDS diagram of species

Use NMDS (Non Metric Multi - Dimensional Scaling) to describe the relationship between the communities together through the distance between the communities.

At 20% similarity with one group, at 40% similarity showed three community groups, of which community 22 is separate.

Group 2 consists of 07 communities (2, 3, 16, 17, 18, 19 and 21), the majority of the communities are in little flooded in mangrove such species as the appearance of *Ceriops zippeliana* and *Excoecaria agallocha*

Group 3 includes the remaining communities, including community 11 appear more *Rhizophora apiculata.* This similarity level has communities 22 which *Avicennia alba* appear more; When considering the similarities at 60% appearance 7 groups to comply with more detailed habitat (Figure 11).

5.7 The relationship between species, communities

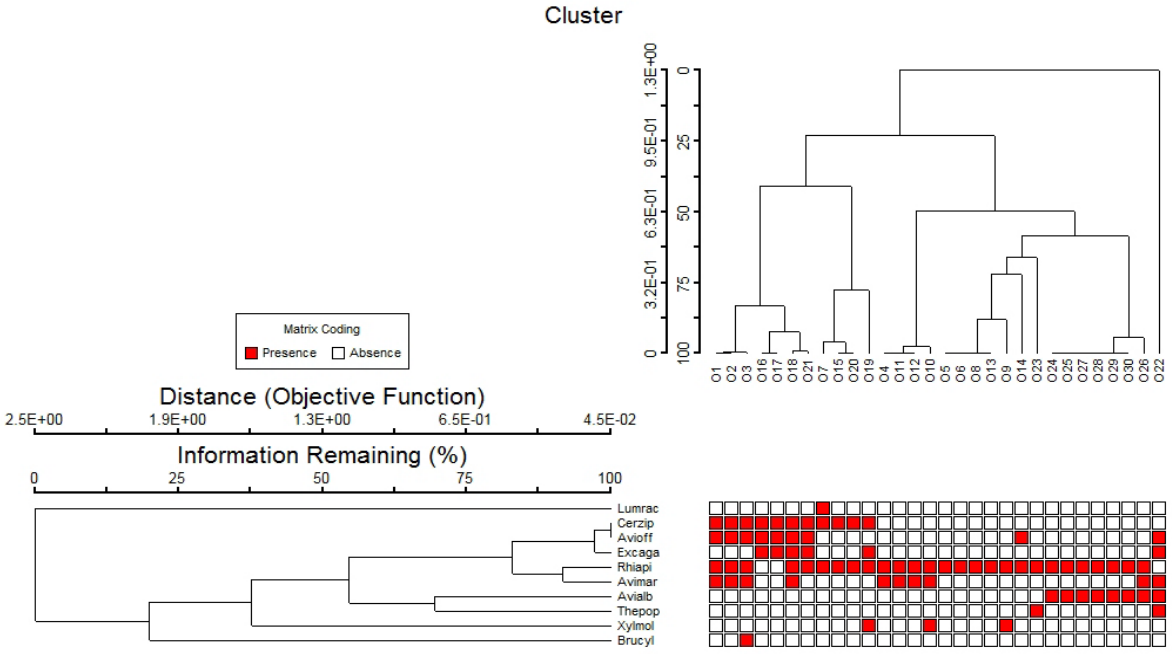


Figure 12 Diagram the relationship between species and communities

Figure 12 shows *Rhizophora apiculata* appeared in 27 plots, whereas *Lumnitzera racemosa* distribution in communities O7, *Bruguiera cylindrica* also distributed in communities O3. The gradually topography from the coast to

inland, there is *Ceriops zippeliana* appear in 11 plots occupied 36.7% of the total plots. Through the above diagram shows the species groups appear in the terrain with the indicator plant.

5.8 Caswell index

Use the Caswell index to diagnose level of environmental disturbance that may impact on the biodiversity of plant communities. Through calculations showed that Caswell (V) ranged from -1.37 to 1.86, the plots values in the range of - 2 to + 2 should not change the environment in the plot to increase or decrease diversity.

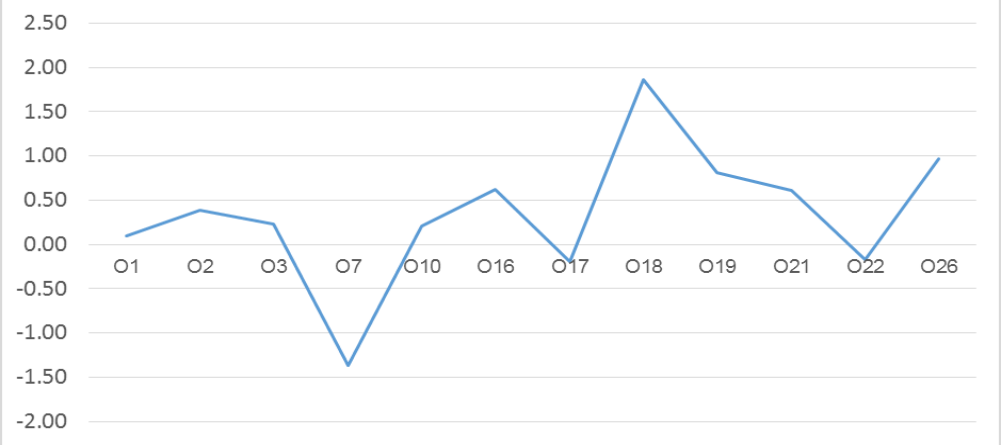


Figure 13 The graph of Caswell index

5.9 The biodiversity index

Use of biodiversity indicators to calculate and compare the level of richness of species, number of individuals, Margalef richness, Pielou, Simpson dominance index and Shannon diversity index in the study area (Appendix 4).

The average of Margalef index (d) is 1 0.66 ± 0.16, the lowest was 0.00 in the plot O5, O6, O8 and O13 has a species and the highest value is 1,54 in plot O22. There are 12 plots of 30 plots that value Margalef is higher than the average value (40%) and 18 plots is at below average.

The average Pielou index (J ') value is 0.74 ± 0.12, the highest is 1.00 in plots 25, 29 and 30, the lowest is 0.00 in the plot O5, O6, O8 and O13. Number of plots with Pielou index (J ') is greater than the average index (70%). This

indicates the Pielou index in plots are above average.

The average D Simpson dominance index value was 0.51 ± 0.09, the highest is 1 in the plots that has only one species, and the lowest is 0.17 in plot O18, the number of plots that have Simpson dominance index greater than the average value is 12 plots (40%), the number of plots that D value less than the average value is 18 plots occupied (60%), so the plots in areas is high diversity. Simpson dominance index is smaller the higher level of diversity.

The average value of Shannon diversity index - Weiner (H ') is 0.16 ± 0.73, the highest is 1.58 in plot O2 and lowest in plots O5, O6, O8 and O13. There are 10 plots that Shannon diversity index - Weiner (H ') was higher than the mean (accounting for 33.3%). This shows that the diversity index in the plots is less uniform. These plots have a high diversity in this region are O21, O2, O3, O18, O22 and O19.

The average of Species richness (S) is 2.6 ± 0.45, the highest (S) in plot O18 with 5 species and the lowest is one species in plots O5, O6 and O8, the number of plots that species is larger than average value is 9 plots (30%), the number of plots is less than the average value is 21 plots occupied (70%), so the plots have the number of high species.

The number of individuals (N) with an average value of 10 ± 1, the highest in 19 individual cells and measure o18 low as 5 individual cell O6 measure, the number of cells can be measured in the number of individual cells greater than the average value of 17 cells (accounting for 56.7%), the number of cells measured value is less than the average value is 13 plots occupied (43.3%), the cells can be measured in the number of individuals less than the average.

Vegetation in the study area had low diversity index. This reflects the characteristics of the diversity of mangrove have fewer species than on the inland. Moreover, mangrove area is not pristine natural forests but which are natural regeneration and replanting mangrove.

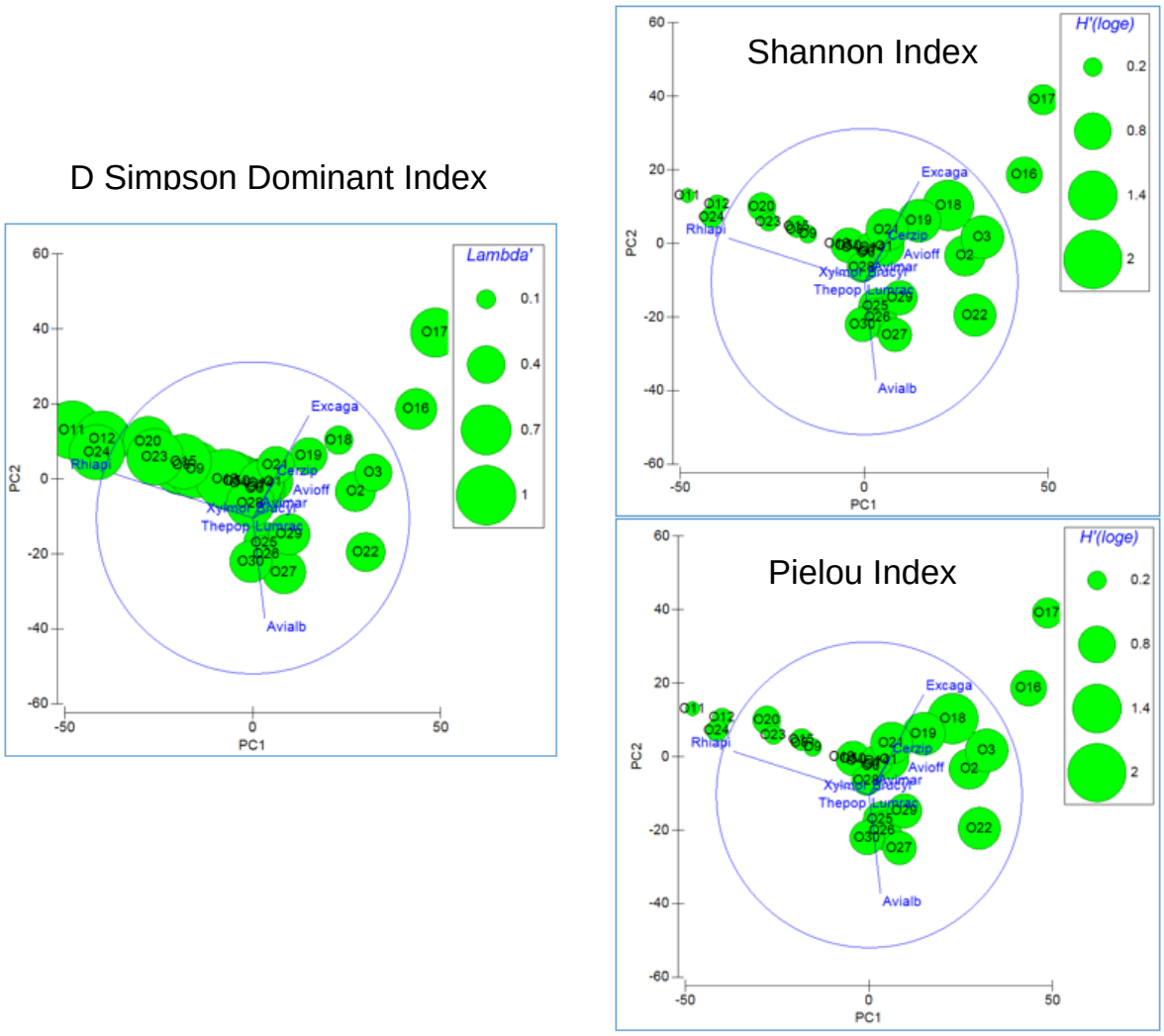


Figure 14 The level of the diversity index varied in communities

The Figure 14 shows the relationship between the Pielou and Shannon index, the plots that is high Pielou index, the Shannon index is higher but Simpson dominance index (D) is opposed to two Pielou and Shannon index.

5.10 K Dominance Curve

The Figure 15 shows the abundances of the species of plots is different. Plot O18 is highest diversity and the lowest are in the plot O5, 6, 8 and 13, which are plots in the plantation with *Rhizophora apiculata* is the main species.

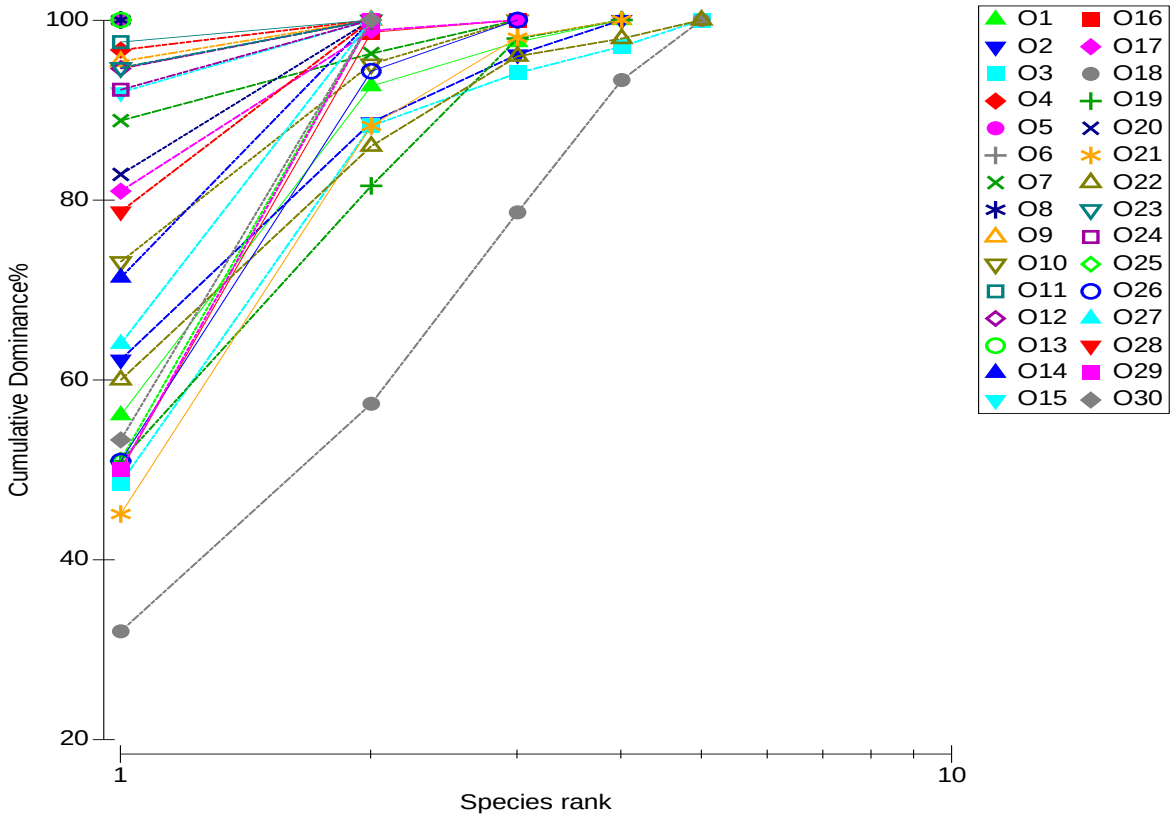


Figure 15 K Dominated curve

5.11 The Principal Component Analysis (PCA)

The relationship of the species, between species and plots or the environment are shown in the graph PCA (Figure 16) and indicates the relationship between species and plots in the study area and it was divided into the following groups:

- Group 1: Includes *Ceriops zippeliana*, *Avicennia officinalis,* this is the species group that related together that distributes on slightly higher elevation of the mangroves.

- Group 2: Includes *Bruguiera cylindrica* and *Excoecaria agallocha* is a group of species distribution on the high ground of the mangroves, higher elevated soil of group 1.

- Group 3: Includes *Lumnitzera racemosa*, *Avicennia alba, Xylocarpus moluccensis, Thespesia populnea.*

- Group 4: *Rhizophora apiculata* and *Avicennia mariana*

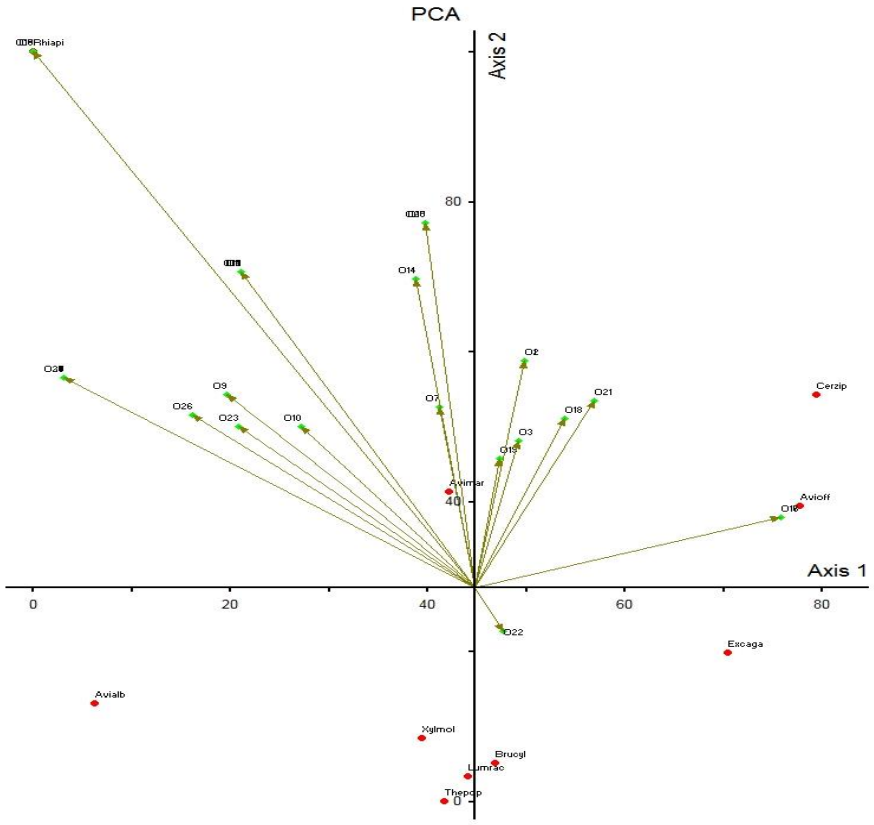


Figure 16 PCA plot of species and plant communities

Based on the results of PCA analysis can arrange in mixed planting with the same group of species, on the environment in which it appears many species.

5.12 Status of conservation of biodiversity, pressures, challenges to biodiversity

Mangrove vegetation of the study area is not high diversity, on the part of the natural forest is interspersed with *Rhizophora* planting. On the strictly protection forests earlier, the forest were converted into shrimp culture then this areas convert into strictly protective forests, so the area planted with *Rhizophora apiculata*, and the small piece of land have been for natural regeneration. Forest area has been cut by taken as mangrove poles to plug the boundary line and inshore fishing. Lack of forest protection force and also limited in the protection of forests.

In the area of productive forest, there are many tree species but scattered and

planted on the banks of shrimp ponds, *Rhizophora apiculata,* a single mangrove species are planted in shrimp ponds in of habit and fear impact of shrimp farming has affecting diverse species of mangroves in planting.

The coastal forests are strongly eroded, which is why reducing species diversity when soil erosion leading to disappearance of species.

5.13 Proposed solutions for the use and sustainable management of natural resources mangrove vegetation

5.13.1 Conservation

The main current conservation measures is to protect existing forests and in situ conservatio. In the area of strictly protection forests has some big trees need preserved to serve as seed source (genetic conservation) as well as study tours.

Figure 17 *Avicennia marina* remains to preserve

Promote exsitu conservation with the presented previous species, but they now rare as *Bruguiera gymnorhiza, Bruguiera sexangular, Rhizophora mucronata, Rhizophora stylosa*… and two species as *Lumnitzera littorea, Azima sarmentosa* listed in the Red Data Book of Vietnam.

5.13.2 Use and management of mangrove vegetation biodiversity

The utilization of mangroves in the area mainly planting *Rhizophora apiculata*

are concentrated in the current work of planting mangrove, not species diversity in forest plantations. Propaganda understanding and communication about plant diversity of the local communities in the area are limited, not much activity is due to lack of interest. The management of forest is mainly Rhizophora species. The situation of coastal erosion has impacts on reduce plant diversity.

To use and good management of plant diversity of mangroves, there should be community involvement in the implementation steps of planning, extensive propaganda and education about the benefits and value of mangroves as well as mixed planting within the family through in-situ conservation.

Raising awareness about biodiversity, forest protection legislation for communities in the region. Strengthen advocacy and education to communities in mangrove areas to understand the value, importance of biodiversity to people's lives.

Capacity building for local forest rangers on law enforcement to be effective. Organize training capacity by use equipments, machinery, GIS (Google Earth) in the management of forest resources.

Solutions related to science and technology: Strengthening the scientific research, monitoring biodiversity and rare genetic resources toward building permanent plots to monitor the long-term.

5.13.3 Proposed species plaanting in ecological shrimp area

Because of habit, so the only *Rhizophora* species selected for planting in the shrimp ponds. Because there are many ideas that other species will affect the shrimp culture, in addition to economic value of *Rhizophora* trees are high and facilitate the purchase and sale of products of thinning or exploitation. To diversity of plant species in shrimp ponds by planting some species such as *Rhizophora mucronata, Rhizophora stylosa* are same family (Rhizophoracea). Need assistance programs of seed supply and training on biodiversity and forests.

On the high embankment planted some trees such as *Tamarindus indica, Thesespia populnea* that regenerated coppices, lower elevated area plant *Lumnitzera racemosa, Bruguiera parviflora, Bruguiera cylindrica, Xu sung Xylocarpus moluccensis*.

Need to establish a nursery to prepare trees for planting which had previously appeared as *Bruguiera gymnorhiza, Bruguiera sexangula*, species in Red List Book of Vietnam as *Lumnitzera littoreaand Azima sarmentosa. Agieceras floridum.*

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The situation of plant in this area is not high diversity. No rare species in the Viet Nam Red Book. Rhizophora are predominant species in 3 forest type is due to planting. *Avicennia mariana, Avicennia alba, Avicennia officinalis* and *Rhizophora* play important role in protection. Distribution of mangrove trees on terrain is very clear. In addition to strictly protection forests, protection forests there are more species in production forest by planting several species close to home. Forests affected by natural disasters such as landslides, erosion happening strong. There is still illegal cutting trees in coastal forests.

6.2 Recommendations

- To set up permanent plots to monitoring plant diversity in the future, according to the given time to examine plant diversity through a variety of indicators to measure the impact to increase biological diversity.
- Set up a Mangrove Arboretum to collect, store the plant genome to serve for guests, tourists, students for study and study tours.
- Conduct research on the genetic diversity of plant of endangered, rare to conserve genetic resources inherent in this area.
- It should have the awareness program, training on diversity of plants and animals for people to improve the conservation of biological diversity.
- Strengthen the protection of strictly protection forests and has restrictive measures to limit erosion declining area and mangrove species composition.
- Encourage people to plant more trees species to increase the diversity of plant mangroves.
- Use and widely disseminated the results of the report, biodiversity information, images species, communities in the study area to cater for the propagation, conservation education and ecological tourism in future.

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Appendix 1 Coordinates of plots

Plot	VN2000		UTM
O 1	25574052	8986974	48 P 496790 950274
O 2	25573696	8987162	48 P 496744 950312
O 3	25573536	8987296	48 P 496726 950334
O 4	25572931	8982428	48 P 496357 949892
O 5	25572582	8982625	48 P 496313 949931
O 6	25572151	8982785	48 P 496253 949971
O 7	25568165	8974593	48 P 495161 949393
O 8	25567923	8974954	48 P 495142 949442
O 9	25567637	8975346	48 P 495119 949497
O10	25561537	8968389	48 P 493760 949158
O11	25561213	8969091	48 P 493748 949245
O12	25560962	8969511	48 P 493731 949300
O13	25547970	8955842	48 P 490899 948691
O14	25547765	8956400	48 P 490898 948757
O15	25547563	8956884	48 P 490893 948816
O16	25574058	8989766	48 P 496947 950546
O17	25574072	8989308	48 P 496924 950500
O18	25574059	8988702	48 P 496888 950442
O19	25570091	8991125	48 P 496394 950901
O20	25570237	8990627	48 P 496389 950844
O21	25570407	8990334	48 P 496399 950806
O22	25568075	8984510	48 P 495702 950368
O23	25568209	8984051	48 P 495698 950315
O24	25568384	8983540	48 P 495697 950256
O25	25538113	8944701	48 P 488706 948152
O26	25538008	8945237	48 P 488719 948210
O27	25537957	8945975	48 P 488752 948286
O28	25540982	8947951	48 P 489345 948310
O29	25540857	8948503	48 P 489356 948371
O30	25540651	8949121	48 P 489358 948443

Appendix 2 List of mangrove species

No	Scientific name	Vietnamese name	Family	Production forest	Protection forest	Strictly Protection forest
True Mangrove Species				**15**	**11**	**16**
1	*Sesuvium portulacastrum* L.	Sam biển	Aizoaceae	x	x	x
2	*Nypa fruticans* Wurmb.	Dừa nước	Palmae	x	x	x
3	*Avicennia alba* Blume	Mấm trắng	Avicenniaceae	x	x	x
4	*Avicennia marina* (Forssk.)	Mấm biển	Avicenniaceae			x
5	*Avicennia officinalis* L.	Mấm đen	Avicenniaceae	x	x	x
6	*Excoecaria agallocha* L.	Giá	Euphorbiaceae	x	x	x
7	*Xylocarpus moluccensis* (Lam.).	Xu sung	Meliaceae	x	x	x
8	*Acrostichum aureum* L.	Ráng đại	Pteridaceae	x	x	x
9	*Bruguiera sexangula* (Lour.) Poir.	Vẹt đen	Rhizophoraceae	x		x
10	*Bruguiera cylindrica* (L.) Blume	Vẹt trụ	Rhizophoraceae			x
11	*Bruguiera parviflora* (Roxb.)	Vẹt tách	Rhizophoraceae	x		x
12	*Ceriops zippeliana* Blume	Dà quánh	Rhizophoraceae			
13	*Rhizophora apiculata* Blume	Đước đôi	Rhizophoraceae	x	x	x
14	*Rhizophora mucronata* Lamk.	Đưng, Đước bộp	Rhizophoraceae	x		
15	*Sonneratia ovata* Backer	Bần ổi	Sonneratiaceae	x		x
16	*Sonneratia alba* J. Smith	Bần trắng	Sonneratiaceae	x	x	x
17	*Acanthus ilicifolius* L.	Ô rô (hoa tím)	Acanthaceae	x	x	x
18	*Lumnitzera racemosa* Willd	Cóc trắng	Combretaceae	x	x	x
Associated Mangrove Species				**13**	**10**	**14**
1	*Gymnanthera nitida* R. Br.	Lõa hùng	Asclepiadaceae	x	x	x
2	*Pluchea indica* (L.) Lees.	Lức, Cúc tần	Asteraceae			x
3	*Wedelia biflora* (L.) DC	Sơn cúc hai hoa	Asteraceae	x	x	x
4	*Derris trifoliata* Lour.	Cóc kèn	Papilionoideae	x	x	x
5	*Thespesia populnea* (L.)	Tra lâm vồ	Malvaceae	x	x	x
6	*Psychotria serpens* L.	Lìm kìm	Rubiaceae	x	x	x
7	*Clerodendrum inerme* (L.)	Ngọc nữ biển	Verbenaceae	x	x	x
8	*Phoenix paludosa*	Chà là biển	Arecaceae	x		x

9	*Nypa fruticans* Wurmb.	Dừa nước	Arecaceae	x	x	x
10	*Cayratia trifolia* (L.)	Dây vác	Vitaceae	x		x
11	*Premna serratifolia* (L.)	Vọng cách	Verbenaceae			x
12	*Ipomoea pes-caprae* (L.)	Muống biển	Convolvulaceae	x	x	x
13	*Hibiscus tiliaceus* (L.)	Tra làm chiếu	Malvaceae		x	x
14	*Acrostichum aureum (*L.)	Ráng đại	Pteridaceae	x	x	x
15	*Tamarindus indica* (L.)	Me	Caesalpiniacea	x		
16	*Morinda citrifolia* (L.)	Nhàu	Fabaceae	x		
	Total			**28**	**21**	**30**

Appendix 3 The survey data of plots

No	Species	**Abbreviations**	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10
1	*Lumnitzera racemosa*	Lumrac	0	0	0	0	0	0	1	0	0	0
2	*Ceriops zippeliana*	Cerzip	1	2	27	0	0	0	2	0	0	0
3	*Rhizophora apiculata*	Rhiapi	23	4	2	29	31	24	24	46	42	30
4	*Excoecaria agallocha*	Excaga	0	0	0	0	0	0	0	0	0	0
5	*Avicennia marina*	Avimar	2	14	2	1	0	0	0	0	0	9
6	*Avicennia officinalis*	Avioff	15	33	33	0	0	0	0	0	0	0
7	*Avicennia alba*	Avialb	0	0	0	0	0	0	0	0	0	0
8	*Xylocarpus moluccensis*	Xylmol	0	0	0	0	0	0	0	0	2	2
9	*Thespesia populnea*	Thepop	0	0	0	0	0	0	0	0	0	0
10	*Bruguiera cylindrica*	Brucyl	0	0	4	0	0	0	0	0	0	0

No	Species	**Abbreviations**	O11	O12	O13	O14	O15	O16	O17	O18	O19	O20
1	*Lumnitzera racemosa*	Lumrac	0	0	0	0	0	0	0	0	0	0
2	*Ceriops zippeliana*	Cerzip	0	0	0	0	4	1	15	19	25	12
3	*Rhizophora apiculata*	Rhiapi	79	70	33	25	46	0	0	11	15	58
4	*Excoecaria agallocha*	Excaga	0	0	0	0	0	36	68	16	8	0
5	*Avicennia marina*	Avimar	2	4	0	0	0	0	0	24	0	0
6	*Avicennia officinalis*	Avioff	0	0	0	10	0	35	1	5	0	0
7	*Avicennia alba*	Avialb	0	0	0	0	0	0	0	0	0	0
8	*Xylocarpus moluccensis*	Xylmol	0	0	0	0	0	0	0	0	1	0
9	*Thespesia populnea*	Thepop	0	0	0	0	0	0	0	0	0	0
10	*Bruguiera cylindrica*	Brucyl	0	0	0	0	0	0	0	0	0	0

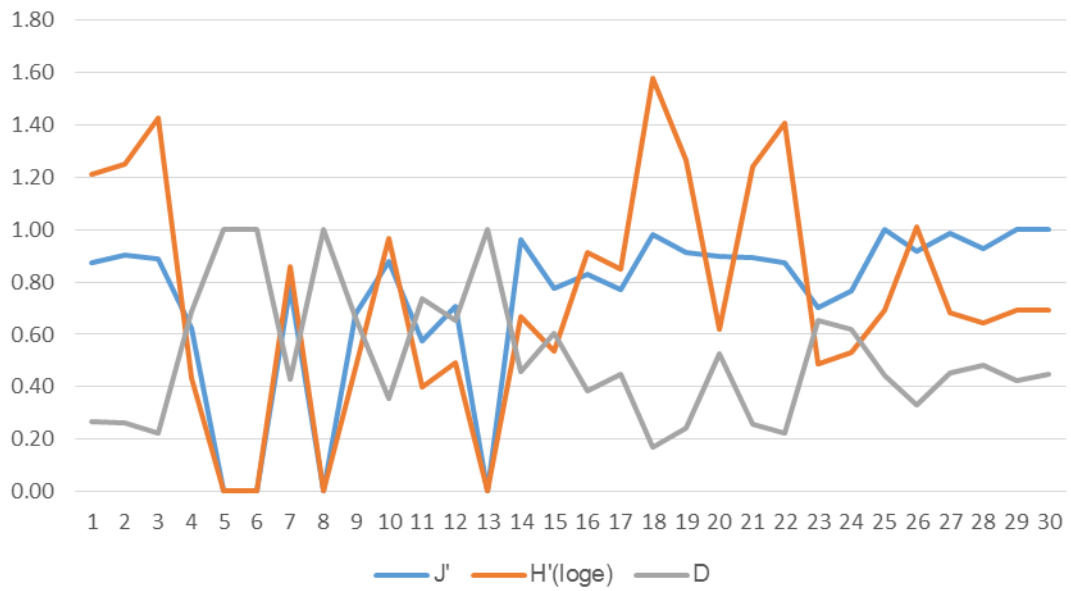
No	Species	**Abbreviations**	O21	O22	O23	O24	O25	O26	O27	O28	O29	O30
1	*Lumnitzera racemosa*	Lumrac	0	0	0	0	0	0	0	0	0	0
2	*Ceriops zippeliana*	Cerzip	22	0	0	0	0	0	0	0	0	0
3	*Rhizophora apiculata*	Rhiapi	23	0	54	72	23	23	18	26	15	28
4	*Excoecaria agallocha*	Excaga	1	13	0	0	0	0	0	0	0	0
5	*Avicennia marina*	Avimar	0	1	0	0	0	3	0	0	0	0
6	*Avicennia officinalis*	Avioff	5	5	0	0	0	0	0	0	0	0
7	*Avicennia alba*	Avialb	0	30	0	6	22	27	32	7	15	32
8	*Xylocarpus moluccensis*	Xylmol	0	0	0	0	0	0	0	0	0	0
9	*Thespesia populnea*	Thepop	0	1	3	0	0	0	0	0	0	0
10	*Bruguiera cylindrica*	Brucyl	0	0	0	0	0	0	0	0	0	0

Appendix 4 The diversity index of plots

Plot	S	N	d	J'	H'(loge)	D Simpson
O1	4	11	1.25	0.87	1.21	0.27
O2	4	13	1.17	0.90	1.25	0.26
O3	5	16	1.45	0.89	1.43	0.22
O4	2	6	0.54	0.63	0.43	0.69
O5	1	6	0.00	0.00	0.00	1.00
O6	1	5	0.00	0.00	0.00	1.00
O7	3	7	1.01	0.78	0.86	0.43
O8	1	7	0.00	0.00	0.00	1.00
O9	2	8	0.48	0.68	0.47	0.66
O10	3	10	0.87	0.88	0.97	0.35
O11	2	10	0.43	0.58	0.40	0.74
O12	2	10	0.43	0.71	0.49	0.66
O13	1	6	0.00	0.00	0.00	1.00
O14	2	8	0.48	0.96	0.67	0.46
O15	2	9	0.46	0.77	0.54	0.60
O16	3	13	0.78	0.83	0.91	0.38
O17	3	13	0.78	0.77	0.85	0.45
O18	5	19	1.36	0.98	***1.58***	0.17
O19	4	13	1.18	0.91	1.26	0.24
O20	2	11	0.42	0.90	0.62	0.53
O21	4	13	1.18	0.90	1.24	0.26
O22	5	13	1.54	0.87	1.41	0.22
O23	2	9	0.45	0.70	0.49	0.65
O24	2	11	0.42	0.77	0.53	0.62
O25	2	9	0.44	1.00	0.69	0.44
O26	3	12	0.81	0.92	1.01	0.33
O27	2	10	0.44	0.99	0.68	0.46
O28	2	8	0.49	0.93	0.64	0.48
O29	2	8	0.49	1.00	0.69	0.43
O30	2	11	0.42	1.00	0.69	0.45
Mean	***2.6 ± 0.45***	***10 ± 1***	***0.66 ± 0.16***	***0.74 ± 0.12***	***0.73 ± 0.16***	***0.51 ± 0.09***

Appendix 5 The Important value (IV)

No	Species	Abbreviations	N%	F%	G%	IV%
1	*Rhizophora apiculata*	Rhiapi	56.95%	34.62%	59.61%	50.40%
2	*Avicennia officinalis*	Avioff	9.25%	11.54%	14.90%	11.90%
3	*Avicennia alba*	Avialb	11.14%	10.26%	12.54%	11.31%
4	*Ceriops zippeliana*	Cerzip	8.51%	14.10%	3.32%	8.63%
5	*Avicennia marina*	Avimar	4.04%	12.82%	4.96%	7.27%
6	*Excoecaria agallocha*	Excaga	9.26%	7.69%	4.05%	7.00%
7	*Xylocarpus moluccensis*	Xylmol	0.26%	3.85%	0.21%	1.44%
8	*Thespesia populnea*	Thepop	0.26%	2.56%	0.25%	1.02%
9	*Bruguiera cylindrica*	Brucyl	0.26%	1.28%	0.08%	0.54%
10	*Lumnitzera racemosa*	Lumrac	0.07%	1.28%	0.08%	0.48%
	Total		100.00%	100.00%	100.00%	100.00%



Appendix 6 Relationship between indices: Pielou (J), Shannon (H'e) and dominance (D)

Appendix 7 Forest Inventory Team

PICTURE OF SPECIES

Sam biển (*Sesuvium portulacastrum* L.)

Dừa lá (*Nypa fruticans* Wurmb,)

Mấm trắng (*Avicennia alba* Blume)

Mấm biển (*Avicennia marina* (Forssk.))

Mấm đen (*Avicennia officinalis* L.)

Giá *(Excoecaria agallocha* L.)

Xu sung *(Xylocarpus moluccensis* (Lam.))

Ráng đại (*Acrostichum aureum* L.)

Vẹt đen (*Bruguiera sexangula* (Lour.) Poir.)

Vẹt trụ (*Bruguiera cylindrica* (L.) Blume)

Vẹt tách (*Bruguiera parviflora* (Roxb.))

Dà quánh (*Ceriops zippeliana* Blume)

Đước (*Rhizophora apiculata* Blume)

Đưng (*Rhizophora mucronata* Lamk.)

Bần ổi (*Sonneratia ovata* Backer)

Bần trắng (*Sonneratia alba* J. Smith)

Ô rô tím *(Acanthus ilicifolius* L.)

Cóc trắng *(Lumnitzera racemosa* Willd)

Lõa hùng (*Gymnanthera nitida* R. Br.)

Lức (*Pluchea indica* (L.) Lees.)

Sơn cúc 2 hoa (*Wedelia biflora* (L.) DC)

Cóc kèn 3 lá (*Derris trifoliata* Lour.

Tra lâm vồ (*Thespesia populnea* (L.))

Lìm kìm *Psychotria serpens* L.

Ngọc nữ biển (*Clerodendrum inerme* (L.)

Chà là (*Phoenix paludosa)*

Cách (*Premna serratifolia* (L.))

Dây vác (*Cayratia trifolia* (L.))

Muống biển (*Ipomoea pes-caprae* (L.))

Bình bát (*Annona glabra* L.)

Appendix 8 Position of plots and transects in Strictly protection forest areas