

**INVENTORY ON THE BIODIVERSITY OF MANGROVE FLORA IN
ORDER TO FIND OUT WHICH SPECIES THRIVE IN PARTICULAR
ENVIRONMENTS AND PROPOSE SOLUTIONS FOR SUSTAINABLE
USE AND MANAGEMENT OF THESE
COASTAL RESOURCES IN BAC LIEU PROVINCE**



VIEN NGOC NAM, PhD.
University of Agriculture and Forestry. Ho Chi Minh City

May 2010

**INVENTORY ON THE BIODIVERSITY OF MANGROVE FLORA IN
ORDER TO FIND OUT WHICH SPECIES THRIVE IN PARTICULAR
ENVIRONMENTS AND PROPOSE SOLUTIONS FOR SUSTAINABLE
USE AND MANAGEMENT OF THESE
COASTAL RESOURCES IN BAC LIEU PROVINCE**

Prepared by: **Vien Ngoc Nam. PhD**

Nong Lam University, Thu Duc
Ho Chi Minh City



Bac Lieu
May 2010

Collaborators Conducted Research

Name	Academic	Duty	Organization
Viên Ngọc Nam	PhD	Leader	Nong Lam University, Thu Duc, Ho Chi Minh City
Huỳnh Thanh Tú	Master Student	Field data collection and primary analysis	Master Student K2008, Forestry Faculty Nong Lam University, Thu Duc, Ho Chi Minh City
Viên Ngọc Tuấn Anh	Forestry Student	Field data collection	Nong Lam University, Thu Duc, Ho Chi Minh City
Lê Hoàng Vũ	Forestry Engineer	Field data collection	Bac Lieu Forest Protection Department
Nguyễn Văn Hội	Forestry Engineer	Field data collection	Bac Lieu Forest Protection Department
Nguyễn Xuân Bình An	Intermediate	Field data collection	Bac Lieu Forest Protection Department

ACKNOWLEDGMENT

To complete this study we would like to thank to:

Leaderships and staffs from the Forest Protection Sub-Department of Bac Lieu province, Technical Department officials who joined and supported in collecting and supplying data.

Staffs from the Project "Sustainable Management of Coastal Forest Ecosystems in Bac Lieu Province", including Mr. Phan Van Hoang, Dang Cong Buu and Ms Thao who supported in the implementation process.

Besides, in the process of data collection in the field we also received great help from the Forest Protection staffs in respective stations located in Bac Lieu Town, Dong Hai and Hoa Binh districts and several forest protection households who provided information regarding to location positioning and species identifying as well as the history of the forest.

On behalf of the team.

Vien Ngoc Nam, PhD.

ABBREVIATIONS

ĐDSH	Biodiversity
RNM	Mangrove
FAO	UN Food and Agriculture Organization
BMU	German Federal Ministry of Environment (BMU)
GPS	Global Position System
NN-PTNT	Agriculture and Rural Development
PCA	Principal Component Analysis
CS	Counterpart
MDS	Non Metric multi – Dimensional Scaling
TX	Town

APPENDIX

Appendix 1: Important Value Index (IVI) of coastal plants in Bac Lieu

Appendix 2: List of mangrove plants in Bac Lieu Province

Appendix 3: The data measured in the plots

Appendix 4: Location and environmental conditions of plots

Appendix 5: Distribution pattern of mangrove trees

Appendix 6: Caswell index of plots

Appendix 7: Biodiversity index of plots

Appendix 8: Biodiversity index of plots in Bac Lieu Town

Appendix 9: Biodiversity index of plots in Hoa Binh District

Appendix 10: Biodiversity index of plots Dong Hai District

Appendix 11: The result of PCA

LIST OF FIGURES

- Mangrove tree sample in coastal of Bac Lieu Province

- Pictures of mangrove biodiversity activities in Bac Lieu

Figure 5.1: Location of study area

Figure 5.2: The rate of plant life forms

Figure 5.3: MDS of dominant mangrove species in bubble plots

Figure 5.4: % Rate of abundance of Family

Figure 5.5: Species and Plots curve

Figure 5.6: Cluster of coastal species in Bac Lieu

Figure 5.7: MDS of plots

Figure 5.8: Graph of Caswell index

Figure 5.9: Graph of biodiversity indexes of areas

Figure 5.10: Graph of Hill index of areas

Figure 5.11: Graph of dominant species in 3 study areas

Figure 5.12: Graph of dominant species in Bac Lieu

Figure 5.13: PCA chart of coastal Bac Lieu

Figure 5.14: Shrimp embankments obstructing trees biodiversity in mangrove

Figure 5.15: Raised bed for *Casuarina* sp. plantation

Figure 5.16: (A) Multi stem of *Rhizophora*, (B) Self thinning of high density of
Rhizophora apiculata

Figure 5.17: *Lumnitzera racemosa* plantation on elevated area in dry season

Figure 5.18: Map, location, pictures for biodiversity management

LIST OF TABLES

Table 5.1: Site classes of plots

Table 5.2: Dominant species in coastal of Bac Lieu

Table 5.3: Species distribution in study area

Table 5.4: Biodiversity index of Bac Lieu

Table 5.5: Beta (H_β) diversity index of 3 study areas

Table 5.6: Rare index of species

TABLE OF CONTENTS

1. INTRODUCTION.....	3
1.1 Background.....	3
1.2. Objectives	4
2. STUDY REVIEW	4
3. SUBJECTS AND CHARACTERISTICS OF STUDY AREA	5
3.1. Study subjects	5
3.2. Characteristics of the study area.....	5
4. CONTENTS AND METHODS	5
4.1. Study contents	5
4.2. Study Methods.....	6
4.2.1. Collect relevant data	6
4.2.2. Field measurement.....	6
4.3. Data analyzing	7
5. RESULTS	8
5.1. Location of plots.....	8
5.2. Site classes of plots in study areas.....	9
5.3. Species composition	10
5.4 Flora family	12
5.5 The relationship between species with areas, between species.....	13
5.6. Relationship between tree communities.....	16
5.7. Caswell index	17
5.8 Biodiversity index in Bac Lieu.....	18
5.9. Relationships between regions in the study area.....	19
5.9.1. Indicators of biodiversity by research area.....	19
5.9.2. Beta (H_{β}) diversity index	20
5.9.3. Dominance curve.....	21
5.10. Principal Component Analysis (PCA)	22
5.11. Situations of biodiversity conservation, pressure and challenge for biodiversity	24
5.12. The use and sustainable management of coastal resources.....	26

5.12.1. Conservation.....	26
5.12.2 Use and management of plant biodiversity of mangrove forest in Bac Lieu	27
6. CONCLUSION AND RECOMMENDATIONS.....	29
6.1. Conclusion	29
6.2. Recommendations	30

1. INTRODUCTION

1.1 Background

Though the area of Mangroves in Bac Lieu province cannot be compared to that in several neighboring provinces, it has an important role in environment protection and providing living and breeding habitat for aquatic species. Simultaneously, the coastal mangrove also provides coastal residents with increased income through aquaculture such as raising shrimp, fish, oysters. In addition, the mangrove forests play an essential role in carbon storage which help to reduce the greenhouse effects.

In the past, especially in the decade 1990, developing intensive shrimp culture areas in Bac Lieu Province has led to converse natural mangrove forests into shrimp ponds. Coastal forests of Bac Lieu province has only narrow belts of natural *Avicennia marina* forest along with the plantation mainly of *Rhizophora apiculata* species integrated with shrimp farms, Other planting species such as *Lumnitzera racemosa*, *Ceriops tagal*, *Thespesia populnea* and *Casuarina equisetifolia* are assigned on high elevation ground, which provide very little contribution to the richness of the mangrove forests. This, since then, leads to the decline of biodiversity in terms of species composition, population and plant community. Environmental degradation in association with over exploitation of aquatic natural resources has led to the reduction of aquatic species composition and quantity.

Adverse changes in ecological environment have undermined the resistance of mangrove forests to climate change as well as opportunities to generate income for the villagers in the coastal province of Bac Lieu.

Present information on plant diversity of mangroves is very limited. Formerly, land of mangrove forest was very rich, but most primitive plants had been destroyed in the past and the forests had suffered from conversion to shrimp farming and agriculture.

Within these situations, GTZ together with the People's Committee of Bac Lieu province have started to implement the project "Sustainable Management of Coastal Forest Ecosystems in Bac Lieu Province - Bac Lieu MCE" (Phase I) Sponsored by the Ministry of Environment, Resources and Nuclear Safety (BMU) of the Federal Republic of Germany. Mangrove biodiversity study is one of the project contents.

1.2. Objectives

- Determination of biological diversity through the calculation of biological indicators for mangrove plant species, including representatives of mangrove and introduced species
- Capacity building for local officials to participate in the survey of plant diversity on mangroves and will carry out surveys of plant diversity in future.
- Propose solutions for sustainable use and management of coastal resources in Bac Lieu

2. STUDY REVIEW

According to Tomlinson (1986) there are 54 true mangrove species belonging to the 20 genus, 16 families and 60 associate mangrove species belonging to 46 geniuses. According to the criteria list and the list of species in the Red Book of Polidoro. BA et al (2010) about the disappearance of species: the extinction risk of mangroves and geographical area according to the level of global interest, there are 70 mangrove species under 17 families.

Data from the Ministry of Agriculture and Rural Development (MARD) indicates that the mangrove area in Vietnam was over 400,000 ha in 1943 then it decreased to 290,000 ha in 1996 and to 279,000 hectares in 2006 (MARD, 2008).

According to Do Dinh Sam et al (2005), Vietnam has 109 species including 37 species of true mangrove species and 72 associate mangrove species. There are numerous ways applied by different authors to classify true mangrove and associate mangrove species. In this report we base on the FAO (2007) classification.

Previously, Bac Lieu and Ca Mau belonged to Minh Hai province so the two

places shared the same reports about mangrove plant investigation. After Minh Hai divided into Ca Mau and Bac Lieu provinces, there have not yet been any research on biodiversity of mangrove forests in Bac Lieu. Therefore, the investigation of diverse plant mangroves to build database to identify the importance of coastal forest ecosystems, use as well as to prevent loss of species and enhance understanding about the functions of forests and the effects of human impacts on forests.

3. SUBJECTS AND CHARACTERISTICS OF STUDY AREA

3.1. Study subjects

Study subject is the tree of the coastal province of Bac Lieu, including true mangrove trees and associate mangrove trees, shrubs, herbs, ferns, focusing on the diversity of natural trees to find the law of distribution and development of natural plants

3.2. Characteristics of the study area

Research areas identified as locations in the MCE project implementation including Bac Lieu town, Hoa Binh and Dong Hai district ... coastline is about 52 km.

4. CONTENTS AND METHODS

4.1. Study contents

- Determine the composition of mangrove plant species with specific habitat from which to propose measures to use and manage based on a sustainable for local.
 - o Research, measurable component of woody plants; number of individuals in each species of woody plants;
 - o Research on environmental factors as tidal regimes, soil, mangrove distribution in study area;.
- Analysis and comparison of the biodiversity index of mangrove plants and the relationship between species and between measured plots together environmental factors in the study area;

- Identification of species, populations, communities, rare mangrove plants species and proposed solutions use, conservation, sustainable management.
- Using results on the baseline data for monitoring and evaluation purposes in the future by developing a long - term monitoring system on plant diversity of mangroves for the project area.
- Propose solutions to apply to the plantations, planning and management of mangrove forests in the future.

4.2. Study Methods

4.2.1. Collect relevant data

- Collect information and data related to biodiversity and research from the library, the Internet, consult...
- Get topographic maps, administrative maps, forest status maps, maps of vegetation, remote sensing and other data relating to research area.

4.2.2. Field measurement

- Use the status maps, GPS device (Global Position System) and field surveys to determine areas, boundaries, location and area of plots.
- Transect surveying and layout typically plots on the study area. The size of plot is 100 m² (10 m x 10 m). The totals of 32 plots measured in three coastal districts are: Dong Hai (10 plots), Hoa Binh (8 plots) and Bac Lieu Town (14 plots).
- Using a compass and measure tape 50 meters to set up plots. Determine the number of plants in each plot by recording in the survey sheets.
- On the survey notes the trees that met on transects.
- Using a Garmin GPS 76 CSX to locate the plots, rare and precious species.
- Use digital camera to record the species, populations and mangrove communities.
- Identify and determine the name of plant species in the field through "Identification mangrove species by pictures" of Vien Ngoc Nam and Nguyen Son Thuy (1999); "Mangrove Guidebook for Southeast Asia" by Giesen and et al (2006) and "Handbook of Mangroves in Indonesia" by Shozo et al, 1997.

Site classes

Symbol	1a	1b	1c	1d	1e	1g
Inundated (m)	0 m	1 m	1,5 m	2 m	3 m	3,5 m
Tidal regime	Regularly flooding	Flooding by low tide	Flooding by mean tide		Flooding by high tide	Flooding by unusually high tides
Flood/Month	56 - 62	45 - 59	20 – 45		3 - 20	2
Food day/ Month	> 20 days	10 – 19	4 – 9 days		3 - 4	2 days
Soil		Soft mud	Tight mud	Soft clay	Hard clay	Solid soil

- Survey the site classes, tidal flooding regime under “Technical regulations for planting, maintenance and protection of mangrove forests (*Rhizophora apiculata* Blume)”, Ministry of Forestry (1984).

Simple classification of land types in the mangrove forest

Mud	Clay	Hard soil
- Black & Blue	- Blue	- Light Blue
- Discrete, less sticky	- Soft, sticky	- Hard, sticky little

Simple criteria for determining the soil in the field

1. **Soft mud:** As you step into soft mud, sunk to the knee and when moving it is down further 30 cm.
2. **Tight mud:** As you step down tight mud, sunk about 20-30 cm, hard to get leg up.
3. **Soft clay:** As you step into soft clay, sunk 10 - 20 cm
4. **Hard Clay:** Step away on the hard clay, legs sunk 5 cm.
5. **Hard soil:** Walking on ground, wet, not only in foot cushion.

4.3. Data analyzing

Diversity indices include

- Species richness (S), Number of individual (N), Abundance Margalef (d), Evenness (E), Shannon index (H'), Simpson index (D), Pielou index (J), Caswell index (V) to consider changes to the environmental impact of species diversity to Shannon index
- Calculate Similarity matrices on the basis of Bray - Curtis, draw diagrams Cluster. Using NMDS (Non Metric Multi - Dimensional Scaling) and PCA (Principal Component Analysis) to describe the relationship between species and communities
- Based on the results of the biodiversity index to conduct a comparison, assessing the level of diversity and determine relationships among species of plants, plant communities, distribution rules, and the species composition in each region.
- Comparative analysis of different indicators Beta diversity between the three study areas.

$$\text{Beta} = S/m$$

S : The total number of species and study areas

m: The average number of species in each area

- List of species, families that have been recorded in the plots and on transects.
- Rare Index: Follow by Taburno-Camposauro C, Napolitano. F (2006)

$$\text{IR} = 1 - \left(\frac{n}{N} \right) \times 100$$

IR: Rare Index

n : Number of plots in which the species was found

N : The total number of plots surveyed.

The index ranges from 0 to 100. A species is rare when the index is greater than or equal to 78.08 and lower than 95 (R); Very rare species (MR) when the value is between 95 and 97; extremely rare species (RR) when it is greater than 97.

5. RESULTS

5.1. Location of plots

The position of 32 measured plots in the coastal areas of three districts identified on the map (Annex Table 1) according to UTM coordinate system, Datum

WGS 84.

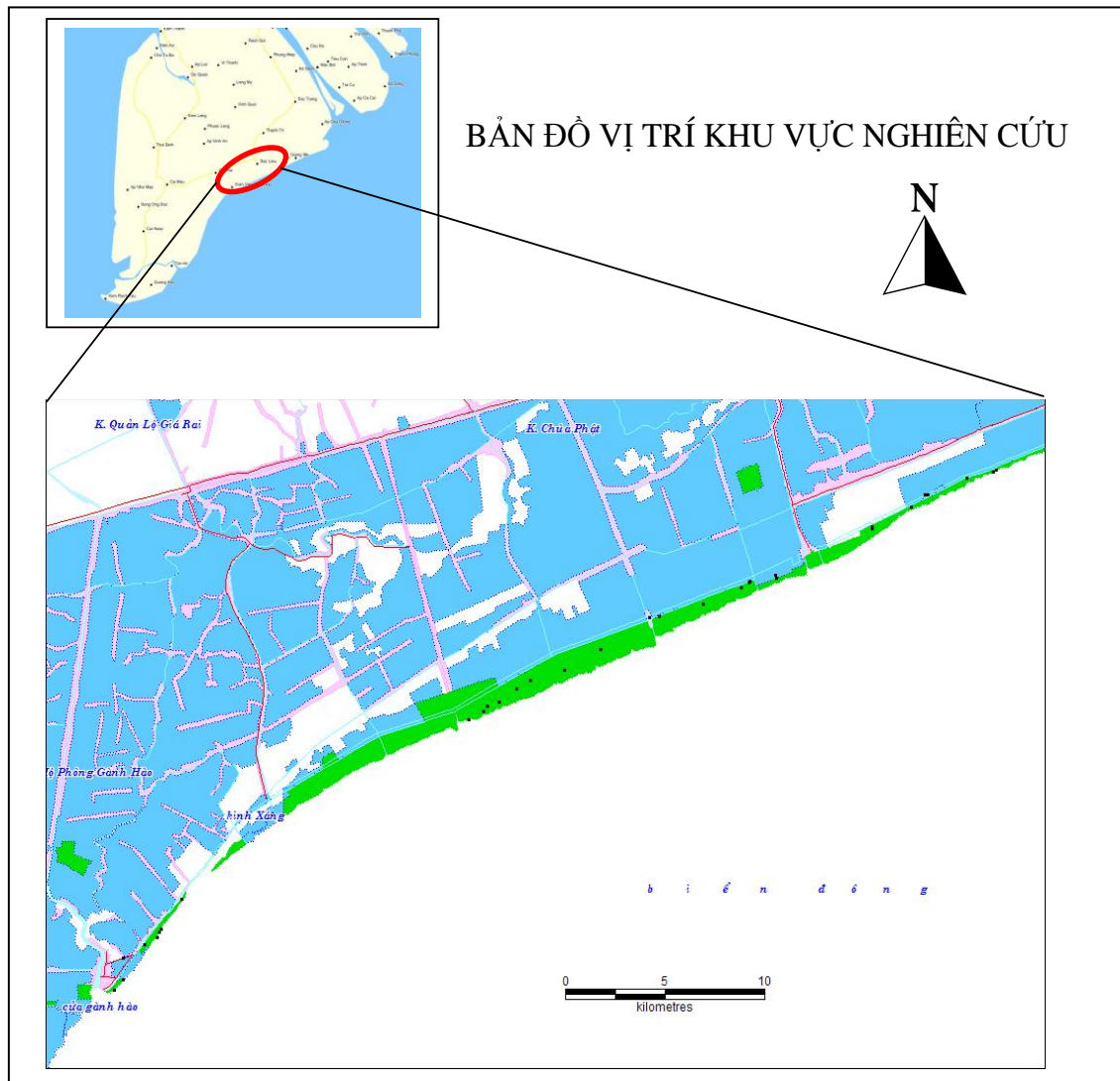


Figure 5.1: Location of study area

5.2. Site classes of plots in study areas

Through Table 5.1 show that the site class 1c is the predominant 71.9% of the total measured plots, class 1d has 5 plots (15.6%), class 1e has 4 plots (12.5%), that indicated that mangrove trees distributed naturally concentrated in three main site classes of 1c, 1d and 1e (Annex 2).

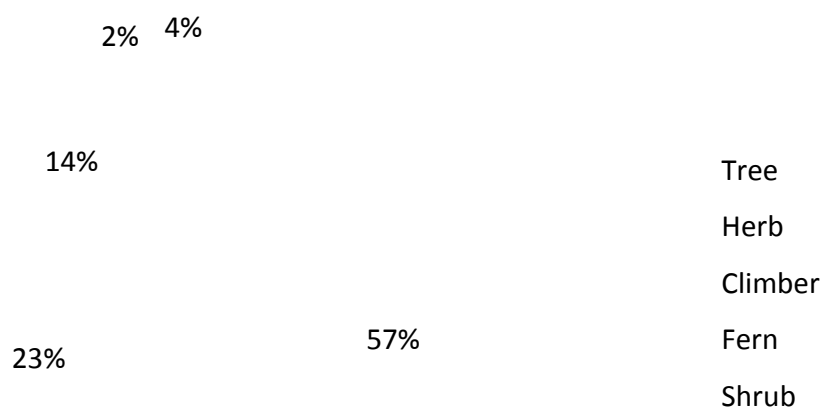
Table 5.1: Site class of plots

Site class	Number of plots	%
1c	23	71,9
1d	5	15,6
1e	4	12,5
Total	32	100,0

5.3. Species composition

On the survey transects identified 49 species, of which 15 species (31%) is true mangrove species and 34 species (69%) is associate mangrove species belonging to 27 families. In which (*Azima sarmentosa* (Blume) Benth. & Hook.f.) species is the only species in the mangrove forests of Bac Lieu in the list of Vietnam's Red Book.

About life forms, there are 56% of trees, herbaceous plants (24%), vines (14%), shrubs (4%) and 2% are ferns.



Hình 5.2: The rate of plant life forms

Measure 32 plots (area of 100 m²) with 2,205 trees, 33 species in 22 families. In which Rhizophoraceae has five species and Avicenniaceae has 3 species is two dominated families, the families have two species as Sonneratiaceae, Malvaceae, Leguminosae and Fabaceae, the 16 remaining families only have one species.

Table 5.2: Dominant species in coastal of Bac Lieu

TT	Local name	Scientific name	IV%
1	Mắm biển	<i>Avicennia marina</i> (Forssk.) Vierh.	12,06
2	Dừa vôi	<i>Ceriops tagal</i> (Perr.) C.B. Rob.	8,74
3	Lức	<i>Pluchea indica</i> (L.) Lees	7,58
4	Cóc kèn 3 lá	<i>Derris trifoliata</i> Lour	6,74
5	Đước	<i>Rhizophora apiculata</i> Blume	6,35
6	Rau muống biển	<i>Ipomoea pes-caprae</i> (L.)	5,24
7	Dừa quánh	<i>Ceriops zippeliana</i> Bl.	5,02

In the study area is dominated by seven species through IV index $> 5\%$ (Table 5.2) accounting for 51.72% of the species. Four common species are as *Avicennia marina*, *Ceriops tagal*, *Rhizophora apiculata* and *Ceriops zippeliana*. The shrubs are *Pluchea indica* and two vines species are *Derris trifoliata* and *Ipomoea pes-caprae*.

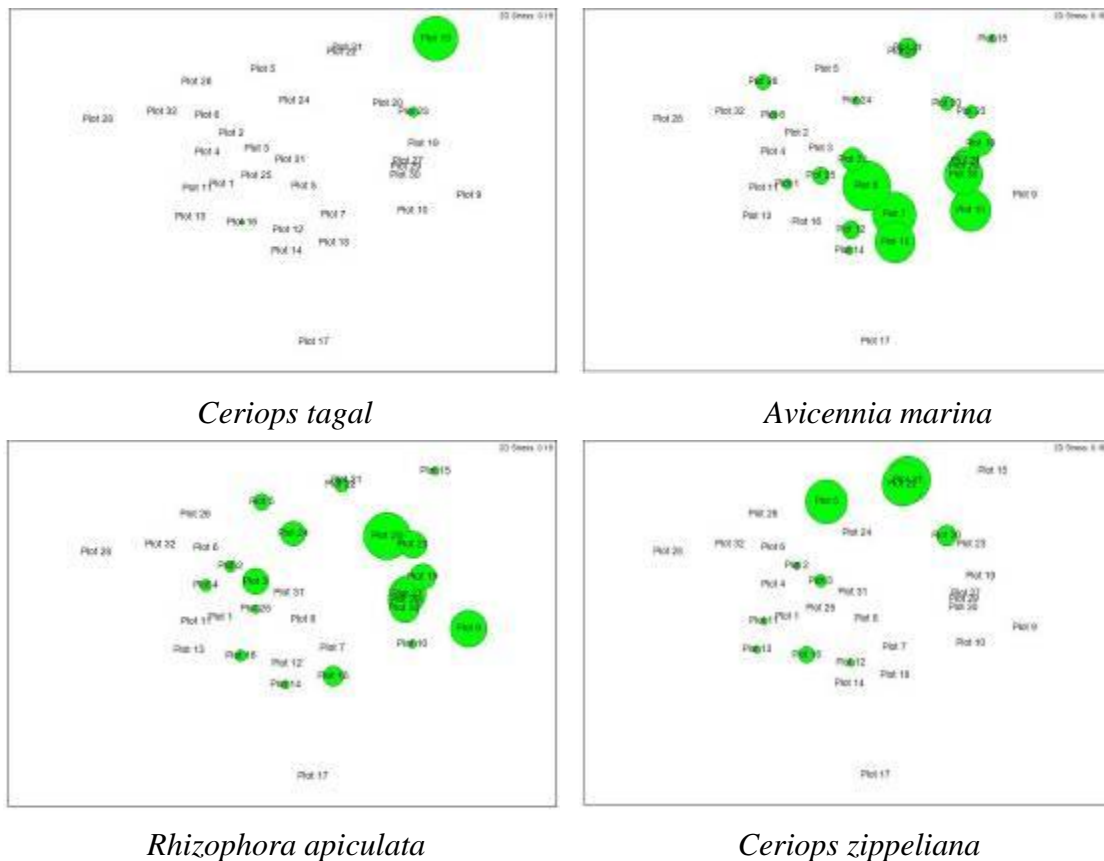


Figure 5.3: MDS of dominant mangrove species in bubble plots

Most species on elevated ground of mangrove areas, especially, *Avicennia marina* is only pioneer tree species, natural regeneration on relatively high elevated and tight soil.

On the high elevated ground, less humus, acidity, low nutrition composition, less inundated only 2 - 3 hours a day, or where unusual tide of the week, will meet species of the genus *Ceriops*, *Acanthus ilicifolius*, *Derris trifoliata* ...

The communities *Acanthus ilicifolius*, *Excoecaria agallocha*, *Phoenix paludosa*, *Lumnitzera racemosa* ... inundated by unusually high tide, on the upper layer appeared *Excoecaria agallocha*, *Lumnitzera racemosa* at the height of 4 – 6 m, under layer is *Acanthus ilicifolius* and *Phoenix paludosa* are two species that

difficult to clear, these communities are most common in the high coastal land in Bac Lieu.

Associate mangrove plant communities are communities which are a form stable phase with complex species composition. On forest land has been improved, flooded tidal time is at to minimum. The mixed species composition with other species is *Thespesia populnea*, *Excoecaria agallocha*, *Glochidion littorale*, *Gardenin floridaea*...

5.4 Flora family

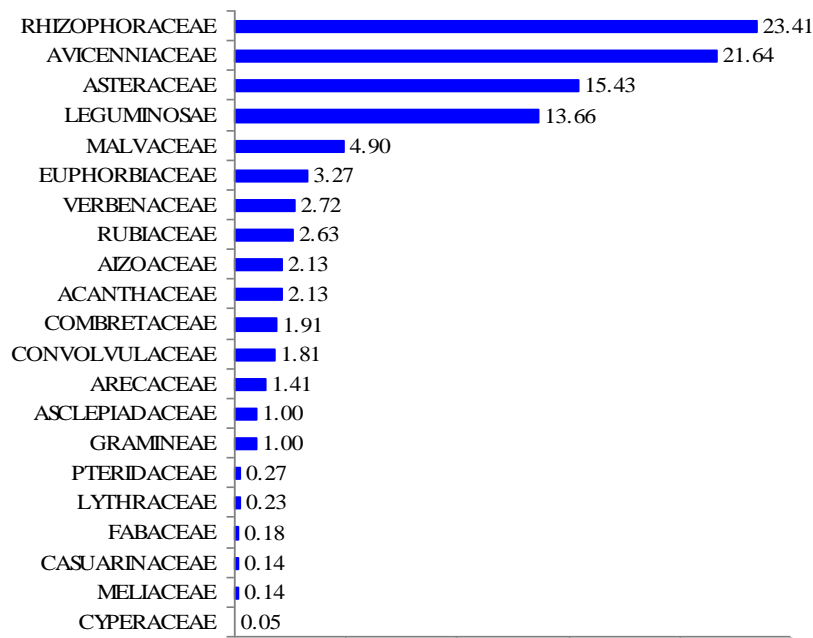


Figure 5.4: % Rate of abundance of Family

There are five families in which Rhizophoraceae has 516 individual accounts for 23.41% of the total individuals, followed by Avicenniaceae has 477 individuals (21.64%), Asteraceae has 340 individuals (15.43%), Fabaceae (Leguminosae) has 301 individuals (13.66%) and Malvaceae has 108 individuals (4.9%). The remaining families have less than 100 individuals, which Cyperraceae is only one individual. As the result indicate that the families have many species with big number of individuals. This affects to the diversity of plant families, so when they review plant diversity should be taken both in their number as well as number of individuals in each species.

5.5 The relationship between species with areas, between species

Number of species increased from plot 1 to 10 then from plot 11 to 30 slowly increased, species almost is not increase in the plot 30 and 32, and the number of plots measured for study species composition is acceptable.

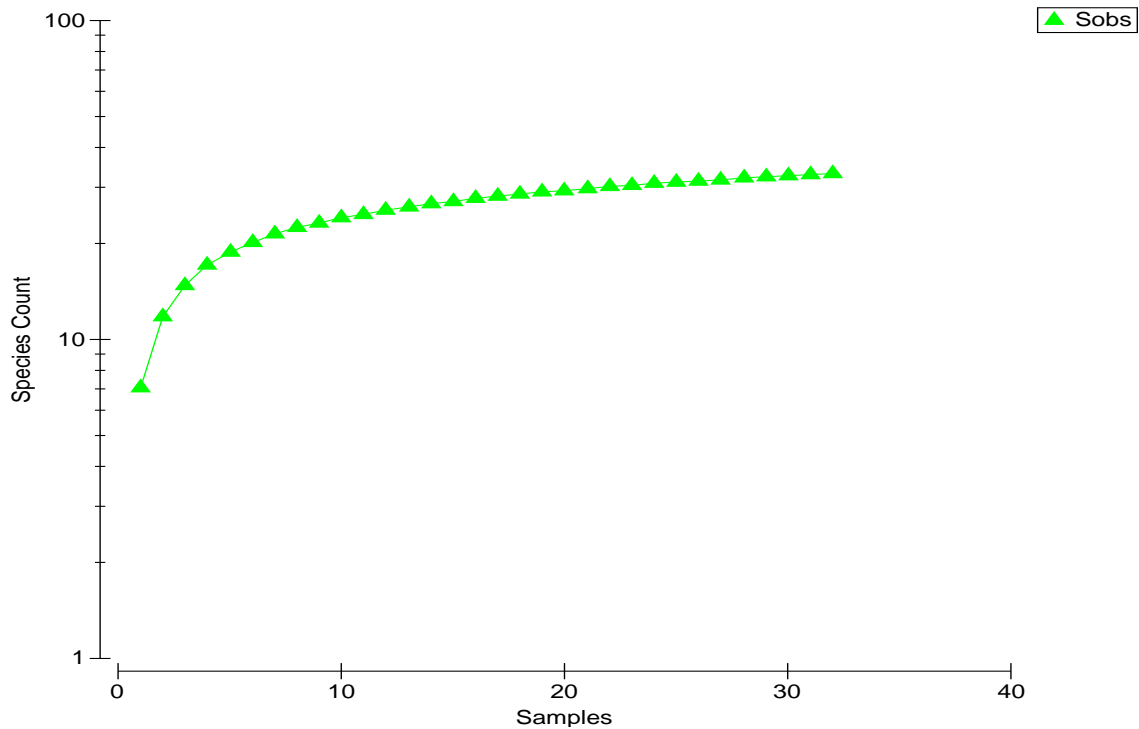


Figure 5.5: Species and plots curve

Regarding the distribution of tree species of mangroves in coastal areas shows that: Four species in 33 species are random distribution including *Sonneratia caseolaris*, *Avicennia officinalis*, and *Cyperus elatus* L. (12.12%). These remaining species are aggregated distribution.

Table 5.3: Species distribution in study area

Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
<i>Sonneratia caseolaris</i> (L.) Engler.	0.03	0.03	31.00	31	0.47	Random
<i>Sonneratia ovata</i> Backer.	0.50	0.13	124.00	31		Aggregated
<i>Lumnitzera racemosa</i> Willd.	6.03	1.31	142.38	31		Aggregated
<i>Ceriops zippeliana</i>	123.68	4.16	922.52	31		Aggregated
<i>Ceriops tagal</i> (Perr.) C.B. Rob.	692.71	4.94	4349.14	31		Aggregated
<i>Nypa fruticans</i> Wurm.	9.77	0.97	312.74	31		Aggregated
<i>Rhizophora mucronata</i> Lamk.	3.13	0.31	310.00	31		Aggregated
<i>Rhizophora apiculata</i> Blume	62.91	5.16	378.22	31		Aggregated
<i>Excoecaria agallocha</i> L.	21.55	2.25	296.89	31		Aggregated
<i>Avicennia marina</i> (Forssk.) Vierh.	440.90	13.56	1007.77	31		Aggregated
<i>Avicennia officinalis</i> L.	0.06	0.06	30.00	31	0.52	Random
<i>Avicennia alba</i> Blume	25.69	1.28	621.63	31		Aggregated
<i>Acanthus ilicifolius</i> L.	11.87	1.47	250.53	31		Aggregated
<i>Acrostichum aureum</i> L.	0.80	0.19	132.67	31		Aggregated
<i>Sesuvium portulacastrum</i> L.	28.45	1.47	600.49	31		Aggregated
<i>Bruguiera cylindrica</i> (L.) Blume	29.42	1.56	583.60	31		Aggregated
<i>Xylocarpus moluccensis</i> (Lam.)	0.15	0.09	50.33	31	0.02	Aggregated
<i>Hibiscus tiliaceae</i> L.	0.54	0.19	90.00	31		Aggregated
<i>Thespesia populnea</i> (L.)	39.19	3.19	381.14	31		Aggregated
<i>Clerodendron inerme</i> (L.) Gaertn	9.27	1.88	153.33	31		Aggregated
<i>Psychotria serpens</i> L.	12.87	1.81	220.07	31		Aggregated
<i>Derris trifoliata</i> Lour	118.19	6.25	586.24	31		Aggregated
<i>Deris indica</i> Blume	88.52	3.16	869.46	31		Aggregated
<i>Pluchea indica</i> (L.) Lees	176.56	7.34	745.29	31		Aggregated
<i>Gymnanthera nitida</i> R. Br.	2.74	0.69	123.45	31		Aggregated
<i>Wedelia biflora</i> (L.) DC	129.89	3.28	1227.11	31		Aggregated
<i>Casuarina equisetifolia</i> L.	0.15	0.09	50.33	31	0.02	Aggregated
<i>Paspalum vaginicum</i> Swort	4.16	0.69	187.45	31		Aggregated
<i>Cyperus elatus</i> L.	0.03	0.03	31.00	31	0.47	Random
<i>Cassia surattensis</i> Burm	0.03	0.03	31.00	31	0.47	Random
<i>Sesbania sesban</i> BL.	0.13	0.06	62.00	31		Aggregated
<i>Ipomoea pes-caprae</i> (L.)	50.00	1.25	1240.00	31		Aggregated
<i>Morinda citrifolia</i> L.	21.13	0.81	806.00	31		Aggregated

Aggregated distribution patterns are common in mangrove. Because species distribute by salinity, tidal flooding level, topography, soil... this species has adapted to certain environmental conditions and in appropriate conditions they will develop into the aggregated distribution (Table 5.3), the randomly distributed species are not yet adapt to new environments that are joined and habitats, it takes

time for the species to adapt to new environmental conditions.

Cluster of species

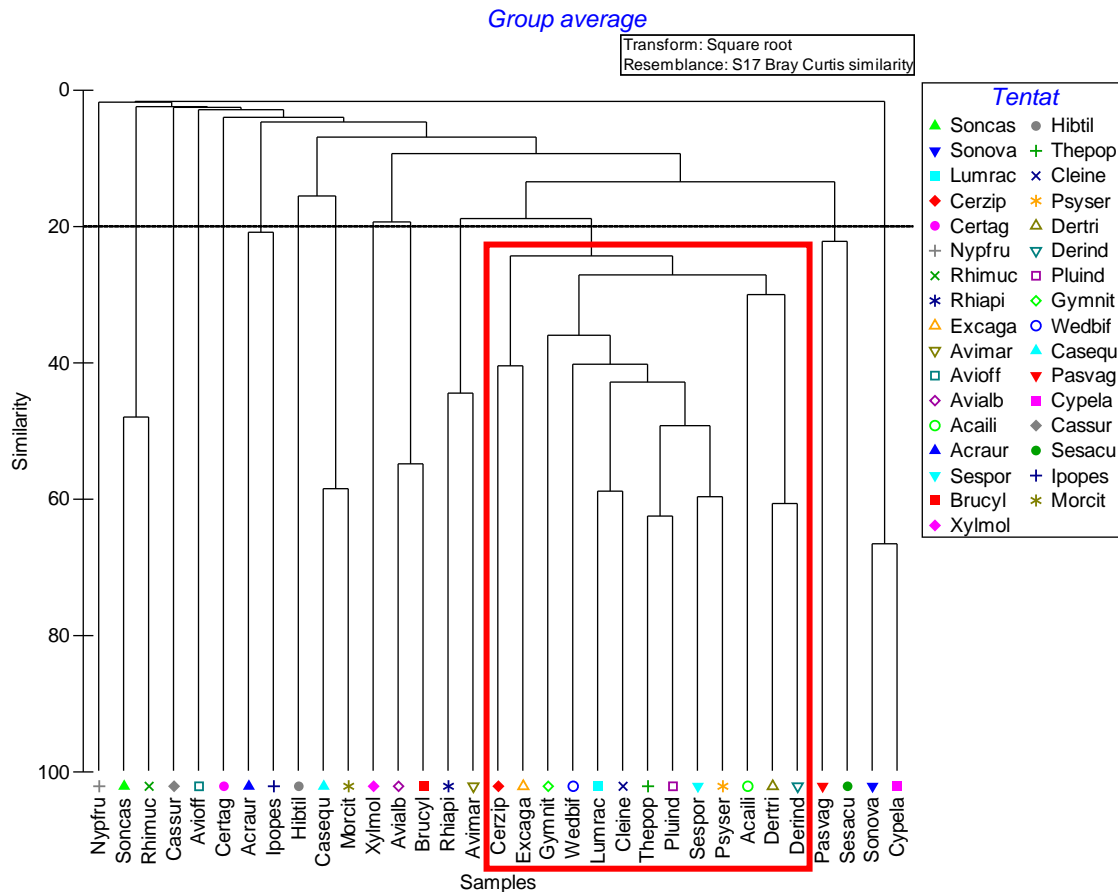


Figure 5.6: Cluster of coastal species in Bac Lieu

There are 33 species in 32 plots is measured, including 15 true mangrove species and 18 associate mangrove species. There is an average of 6.88 ± 1.28 species in each plot. The plot that has lowest is two species and highest 14 species. According to the graph (Figure 5.6) shows that *Nypa fructican*, *Ceriops zippeliana*, *Hibicus tiliaceus*, *Avicennia officinalis*, *Xylocarpus molucencis* are species which is not much and have less relationship with other species in the study area, these species on the high elevated area of the mangroves. The average is 69 ± 13 individuals in plots, 153 individuals are highest and the lowest was on 22 individuals in plots (Appendix 2).

At 20% similarity level, there are 13 group of species, in which group is most species including 13 true mangrove species and associate mangroves species that appear in the high elevated ground of the mangroves, while seven others group have two species and 6 group have a species. At this similarities shows that

Rhizophora apiculata and *Avicennia marina* are same group. *Avicennia alba* and *Bruguiera cylindrica* are in a group. The species of the same group may consider for mixed species planting.

5.6. Relationship between tree communities

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

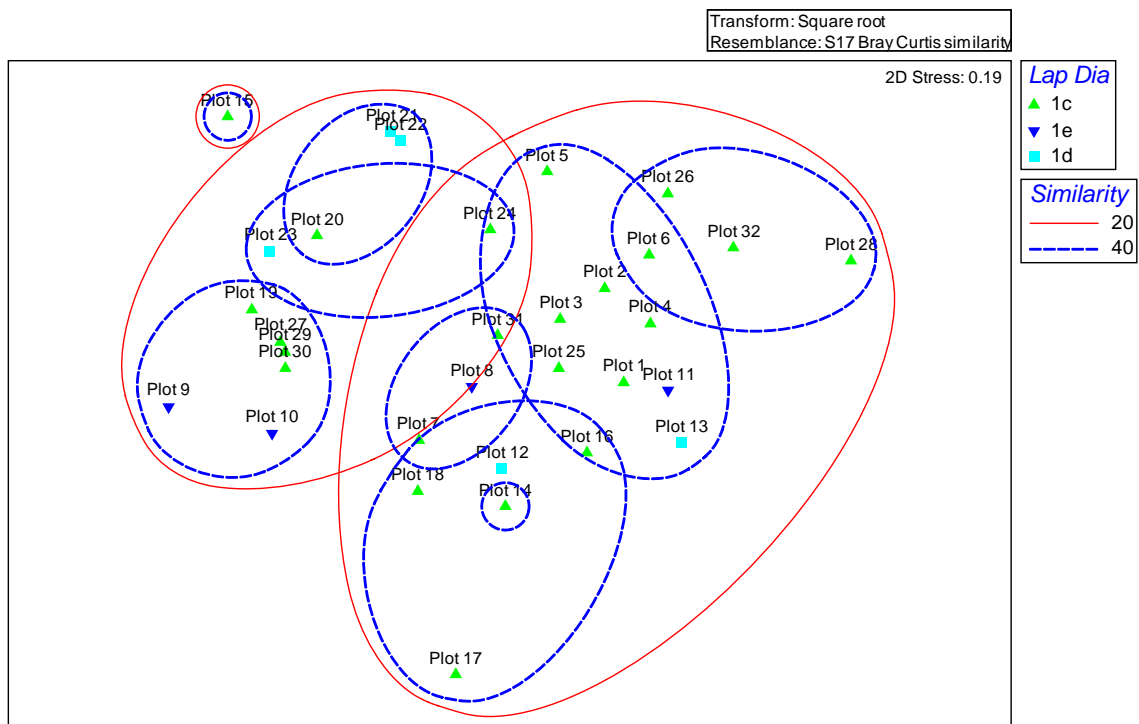


Figure 5.7: MDS of plots

At 20% similarity with three groups, in which plot 15 is separate group belonging to site class 1c with dominate *Ceriops tagal*, group 2 has 13 communities with species in site class 1c and 1d, the remaining group of 18 cells distributed in the site class 1c (16 plots) and 1e are two plots.

At 40% similar, there are 9 communities, in which community 15 standing separately with *Ceriops tagals*.

Group 2 consists of 12 communities (1, 2, 3, 4, 5, 6, 11, 13, 16, 24, 25, and 31) is the most site class 1c.

The group consists of communities 20, 21 and 22 belong to site class 1d in which community 20 appeared natural regeneration of *Rhizophora apiculata* and

Avicennia marina. The communities 21, 22 with species of high elevated area as *Ceriops zippeliana*, *Excocaria agallocha*... This similarity level is the popular species on the plot 14 on the high elevated land of brackish water as *Derris trifoliata*, *Acanthus illicifolius*, *Thespesia populnea*, *Xylocarpus mollucensis*... but relations with the communities 7, 12, 16 and 18.

Group including with 3 communities as 7, 8 and 31 are the trees on high elevated ground as *Pluchea indica*, *Clerodendron inerme*, *Xylocarpus mollucensis* and *Avicennia marina* appears on the near boundary of Soc Trang province.

5.7. Caswell index

Use Caswell index to consider the level of environmental disturbances that affect the biodiversity of plant communities. The results in (Appendix 7) shows the average value of Caswell V(N.D) of the plots is - 0.3, fluctuations between - 2.68 to 1.96, with 30/32 plots have value in the range + 2 and - 2 indicate that should not change the environment in the plots to increase or decrease diversity, whereas plot 7 (-2.24) and plot 8 (2.68) have values Caswell V(N.D) <-2 and >2 respectively. This mean that plots are not stable habitats (Figure 5.8), at the site class 1e, hard clay components, flooded only 3 - 20 times a month, the environment is changing in this area, affect biodiversity in the plots. It tended to reduce forest biodiversity by dominating *Avicennia marina* species are gradually move toward higher ground by digging up then appeared with a number of species such as *Clerodendron inerme*, *Pluchea indica*, *Gymnanthera nitida*...

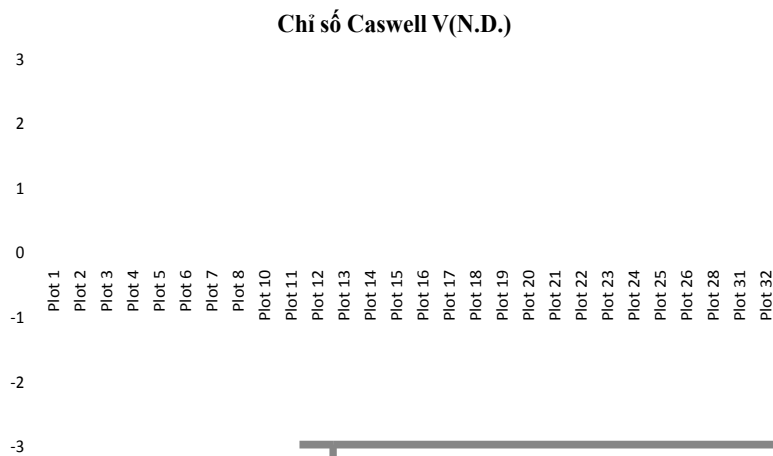


Figure 5.8: Graph of Caswell index

5.8 Biodiversity index in Bac Lieu

Use of biodiversity indicators to calculate and compare the level of species richness, abundance of species, number of individuals, Margalef richness, Pielou index, Simpson dominance index and Shannon index varied between study regions (Table 5.4).

Table 5.4: Biodiversity index of Bac Lieu

	S	N	d	J'	H'(loge)	Dominance D
All areas	6.88 ±1.28	68.91 ± 12.61	1.45 ± 0.33	0.76 ± 0.07	1.36 ± 0.21	0.36 ± 0.08
Bac Lieu Town	7.80 ± 2.36	55.80 ± 13.46	1.72 ± 0.63	0.72 ± 0.17	1.42 ± 0.50	0.38 ± 0.19
Dong Hai	8.50 ± 3.19	85.13 ± 38.69	1.84 ± 0.83	0.71 ± 0.21	1.50 ± 0.54	0.33 ± 0.23
Hoa Binh	5.29 ± 1.80	69.0 ± 20.2	1.03 ± 0.42	0.82 ± 0.07	1.23 ± 0.27	0.36 ± 0.09

Note:

S: Species

d: Margalef index

N: Number of individual

H_(e): Shananon – Weiner index

J': Pielou index

D: Dominance Simpson D

The average of Margalef index (d) in area is 1.45 ± 0.33 , the lowest is 0.24, 3.32 in plot 30 and highest in the plot 2. There are 14/32 plots have Margalef index higher than average (47.35%). Thus, the plots have Margalef index in below average.

The average value of Pielou index (J') is 0.76 ± 0.07 , the highest is 1.00 in plot 27, and lowest is 0.10 in plots 15. There are 21 plots have value Pielou index greater average value (65.63%). The Pielou index of plots are on average.

+ The average values of D Simpson dominance index is 0.36 ± 0.08 , 0.96 is the highest in plot 15 and the lowest is 0.09 in plot 2, the number of plots have Simpson dominance index greater than the average value is 13 plots (40.63%), the number of plots have value smaller than the average is 19 plots (59.37%) which indicate that plots in areas have high diversity. The smaller Simpson dominance index the higher diversity.

+ The average of Shannon index - Weiner (H') is 1.36 ± 0.21 , the highest is 2.37 in plot 2 and the lowest is 0.11 in plot 15, there are 16 plots have Shannon diversity index (H') higher than average values (50%). This shows that the diversity index in the plots in the region is relatively high and uniform. These plots are high diversity in this region is plot 1, plot 2, plot 11 and plot 25.

+ The average of species (S) is 6.88 ± 1.28 , Plot 11 is highest of 14 species and at least two species in plot 27, the number of plots have species larger average is 17 plots (53.13%), the 15 plots that number of species is smaller than the average is 15 plots (46.87%) the plots in areas is high number of species.

+ The average of number of individuals (N) is 68.91 ± 12.61 , the highest of 153 individuals measured in plot 26 and lowest is 22 individuals in plot 13, the number of plots are larger than average is 12 plots (37.5%), the 19 plots is under the average value (59.37%) such figures show the number of individual in regions is lower than average.

The plant communities in coastal area of Bac Lieu have no high diversity index. This reflects the diversity of characteristics of mangrove forests is fewer species than on land. In addition, mangrove areas in Bac Lieu are not natural forest which is regeneration with *Avicennia marina*. The area was prevented by the dikes, levees aquaculture and shrimp farming only using water pumps to get water from outside to the ponds was made to limit the distribution of mangrove species so plant biodiversity of mangrove forest is not high.

5.9. Relationships between regions in the study area

5.9.1. Indicators of biodiversity by research area

Figure 5.9 shows Margalef and Shannon-Wiener index descending from Bac Lieu Town, Hoa Binh and increased in the Dong Hai district, while Pielou index increased equally in the opposite direction from Bac Lieu Town to the Hoa Binh and decreases in the Dong Hoa district.

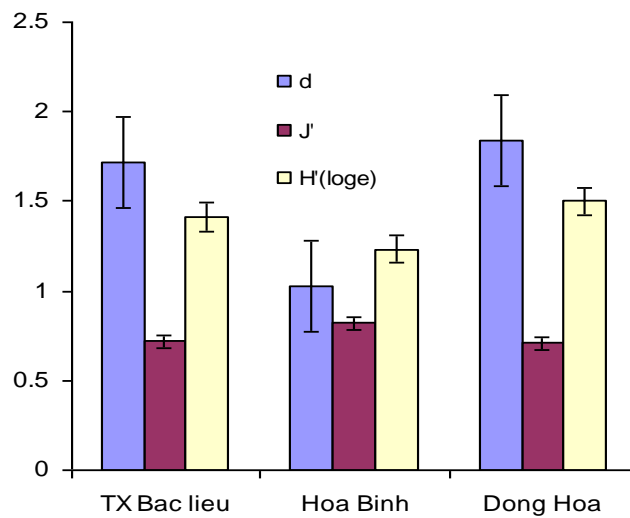


Figure 5.9: Graph of biodiversity indexes of areas

The diversity index showed Hill No, N1 and N2 decreased from the Bac Lieu town to Hoa Binh, but increased in Dong Hoa district while Ninf descending down from Bac Lieu Town to Hoa Binh and no increase in Dong Hoa.

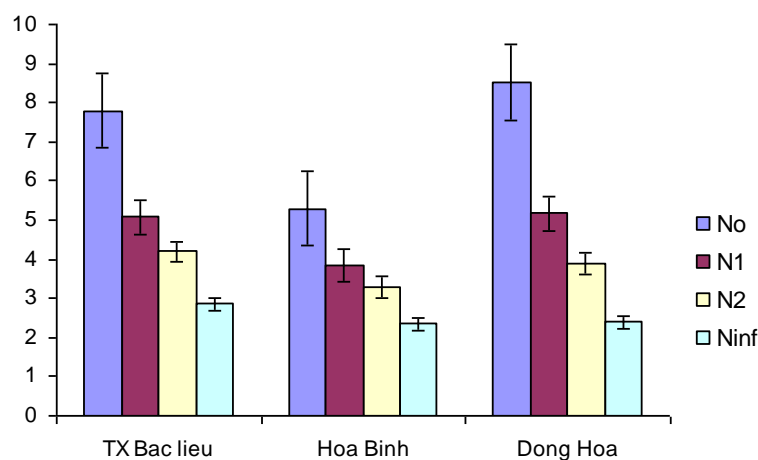


Figure 5.10: Graph of Hill index of areas

5.9.2. Beta (H_β) diversity index

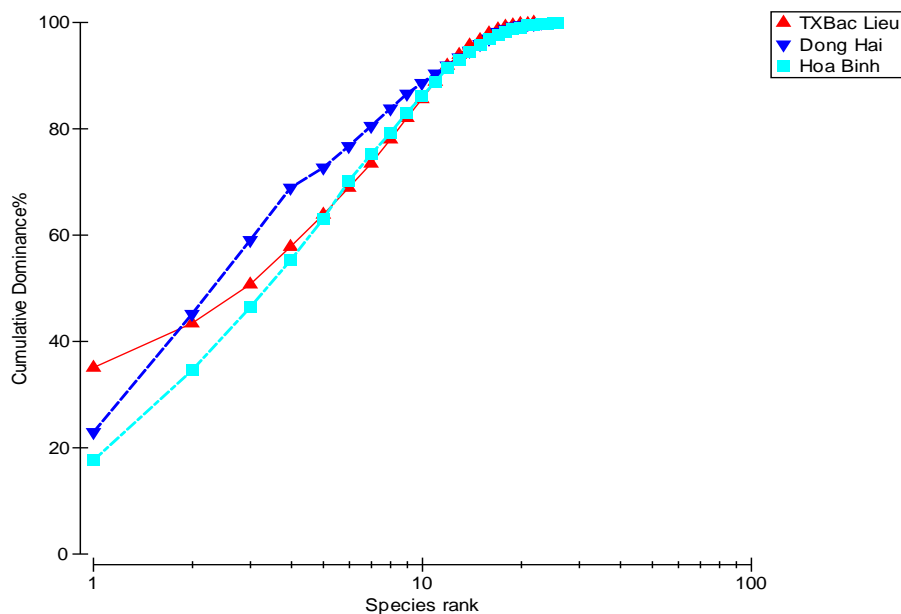
Using the diversity index Beta (H_β) to identify and evaluate differences in composition and structure of plant species between study areas, biodiversity indicators Beta (H_β) is larger that have the same number of species (common species) between the communities in areas, so that high diversity and vice versa when the diversity index Beta (H_β) under the same small number of species (common species) so low diversity. Through calculating beta diversity (H_β) in three study areas show the results in Table 5.5.

Table 5.5: Beta (H_β) diversity index of 3 study areas

No	Area	Beta (H_β) index
1	Bac Lieu Town	4.23
2	Hoa Binh	6.33
3	Dong Hoa	3.88

According to data in (Table 5.5) showed that Beta diversity indices (H_β) is the smallest in Dong Hoa ($H_\beta = 3.88$) which has the lowest diversity, followed in Bac Lieu Town ($H_\beta = 4.23$), finally the district Hoa Binh ($H_\beta = 6.33$) had the highest diversity. This is also reflected in the graph of dominant species in three study area (Figure 5.11).

5.9.3. Dominance curve

**Figure 5.11:** Graph of dominant species in 3 study areas

Through Figure 5.11 shows the level of dominance of Hoa Binh district is lowest and Dong Hai district is the highest. So where diversity is highest in Hoa Binh and Dong Hai is the lowest. Results analysis index beta (H_β) and dominant species graphs is similar in three coastal districts of Bac Lieu.

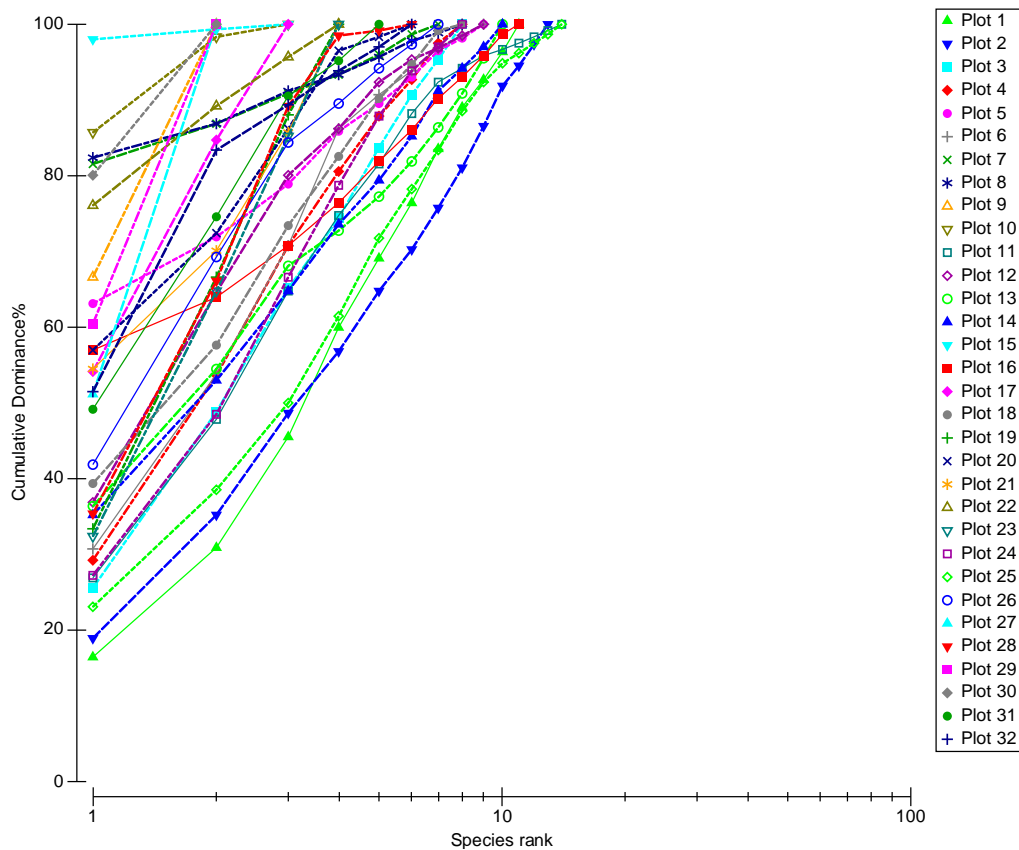


Figure 5.12: Graph of dominant species in Bac Lieu

- Comparison species of dominant between communities in the study area shows the level of dominance of species and species diversity has inversely relationships. In three study areas have 32 plots should take advantage of joint analysis in an area.
- Figure 5.12 shows results in 32 plots, the plot 1 and 2 have the lowest dominance in the plant communities so that high diversity, whereas the plot 10 and 15 is the high dominance so its is low diversity, only plot 15 separate and has only *Cerriops tagal* planting so plant diversity should not be higher.

5.10. Principal Component Analysis (PCA)

The relationship of species, between species and plots or the environment is reflected in the PCA graph (Figure 5.13) shows the relationship between species and plots in the study area was divided into following groups:

- Group 1: Including Bần ổi (Sonova), Xu sung (Xylmol), Cỏ nước mặn (Pasvag), Cỏ U du (Cypela), Muồng hoa vàng (Cassur), Diên điển (Sesese) và Nhàu (Morcit) this is a group of trees on high elevated land of mangroves have relations with each other.

- Group 2: Only species *Dà vôi* (*Certag*) plantation in plot 15, site class 1c, and tight mud mean inundation, elevation at 1.5 m and number days of flood varied from 4 – 9 days/month.

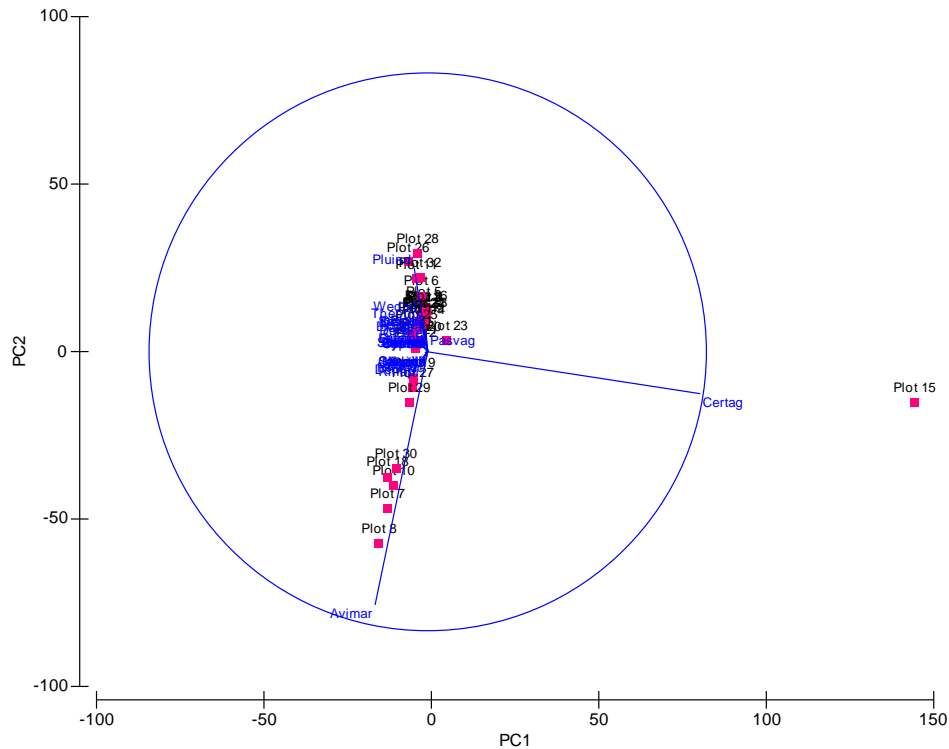


Figure 5.13: PCA chart of coastal Bac Lieu

- Group 3: Includes true mangrove species as *Bần chua* (*Soncas*), *Dừa nước* (*Nypfru*), *Đưng* (*Rhimuc*), *Đước* (*Rhiapi*), *Mắm biển* (*Avimar*), *Mắm đen* (*Avioff*), *Mắm trắng* (*Avialb*), *Ô rô tím* (*Acaili*), *Vẹt trụ* (*Brucyl*), *Cóc kèn 3 lá* (*Derind*). These plants have long-time flooding and soil composition of tight mud and hard clay.

- Group 4: Includes *Cóc trắng* (*Lumrac*), *Dà quánh* (*Cerzip*), *Giá* (*Excaga*), *Ráng* (*Acraur*), *Sam biển* (*Sespor*), *Tra nhót* (*Hibtil*), *Tra lâm vồ* (*Thepop*), *Ngọc nữ biển* (*Cleine*), *Lìm kìm* (*Psyser*), *Cóc kèn 3 lá* (*Dertri*). *Lức* (*Pluind*), *Loã hùng* (*Gymnit*), *Sơn cúc 2 hoa* (*Wedbif*), *rau muống biển* (*Ipopes*) are true mangrove trees and associate mangrove mixed with other species on the high ground of the mangroves.

- *Dà vôi* (*Cerriops tagal*) appear in plot 15 of site class 1c, tight mud, flood tide is the average level at 1.5 m height, number of days flooded from 4 - 9 days/month, number of time flooding from 56 to 62 times per month....

- *Mắm biển* (*Avicennia marina*) appears more and order in plot 8, 7, 10, 18, 30, 29,

27 and 19. This is a pioneer tree species in the coastal provinces of Bac Lieu in site class 1c and 1e, the composition of tight mud and hard clay, the average flood tide, flood time from 4 - 9 days per month.

Based on the results of PCA analysis can select species for mixed plantation with species in the same group, on the environment that the species appears more.

5.11. Situations of biodiversity conservation, pressure and challenge for biodiversity

The issue of plant biodiversity of coastal mangrove forests of the province of Bac Lieu shows limitation of natural conditions so the t distribution of mangroves species are also limited, in addition to problems in shrimp farming in the mangrove forests to obstruct the dispersal of mangrove seedlings or propagules by embankments enclosing the ponds and pump water into the shrimp pond, thus limiting the exchange of water and silt particles carried into the shrimp pond by the farmers do not want tree natural regeneration in breeding areas for reforestation to reduce rearing area.

In areas with high natural regeneration ability of many species but the embankments were prevented, in the forest is planted thick forests, multi stems, high canopy cover should not have any natural regeneration under trees. Environment in the area is disturbed by digging of land for shrimp ponds. The forests are highly diverse as the places not covered by the embankment, and seeds or propagules widely distributed on the development of suitable conditions.



Hình 5.14: Shrimp embankments obstructing trees biodiversity in mangrove

Plantation of *Casuarina* on raised bed failed because *Casuarina* tree has tap roots, at the first time roots develop well then touching underground water will rot the roots, leading to plant death.



Figure 5.15: Raised bed for *Casuarina* spp. plantation

Pressure on flora biodiversity of coastal mangroves is shrimp farming in Bac Lieu, obstructing natural regeneration and distribution of species composition by embankments. Seed sources in Bac Lieu are main species in mangrove forests as *Rhizophora mucronata*, *Bruguiera cylindrica*, *Ceriops tagal*... also lacking. The choice of suitable species has not been success as *Casuarina* spp, *Thespesia populnea*..., planted on the high elevated ground. Trees can not grow in dry season and deciduous then leading to die.



Hình 5.16: (A) Multi stem of *Rhizophora* (B) Self thinning of high density of *R. apiculata*

Shrimp farming is associated with people's lives so they tend to expand the area of culture. On the natural regeneration of *Avicennia mariana*, people were also using the net to make boundaries that hinder natural regeneration.



Figure 5.17: *Lumnitzera racemosa* plantation on elevated area in dry season

The direction of channels regular from East to West but from North to South or vice versa is less. *Lumnitzera racemosa* growing areas on high ground leading to so dry soil in dry season, cracked makes plants grow slowly or die.

Diversity index of mangrove flora in coastal Bac Lieu not high compared to other places such as Ca Mau, Can Gio, natural conditions have eroded in many areas, land is limited and divided in to small areas therefore it is difficult to develop in the mainland. *Avicennia marina* areas outside toward the sea, land required the time to increase gradually to replace other species. Firstly, immediate advantage of natural regeneration increases the biodiversity of species.

5.12. The use and sustainable management of coastal resources

5.12.1. Conservation

- Chum le (*Azima sarmentosa*) is the species recorded in Vietnam's Red Book (pages 327-328) of threatened endangered EN (A 1c, d) where the reduced distribution and habitats, distribution concentrated in Bac Lieu bird sanctuary, so it should insitu conservation of this species, is limited by dry season fires in this area will have adverse impacts on this species. Need propaganda presented to officials,

employees and visitors know to conserve this species.

- The number of rare plant species (IR) research in the area said the level of rare species in the study area, only rare cells depends on the capacity measure, the number of cells measured as much as the body the more rare accuracy index, calculated through analysis of data on only rare (Table 5.6) shows:

There are three extremely rare species of plants (MR) as *Sonneratia caseolaris* (L.) Engler, *Sonneratia ovata* Backer, *Rhizophora mucronata* Lamk in the study area, there are two species of rare plants (RR) in which species is *Avicennia officinalis* L., *Xylocarpus moluccensis* (Lam.) M Roem, very rare species usually only occur in a plot in the study area.

Table 5.6: Rare index of species

No	Local name	Scientific name	IR (%)	Symbol	
1	Bần chua	<i>Sonneratia caseolaris</i> (L.) Engler.	97	MR	Very rare
2	Bần ổi	<i>Sonneratia ovata</i> Backer.	97	MR	Very rare
3	Đưng	<i>Rhizophora mucronata</i> Lamk.	97	MR	Very rare
4	Mắm đen	<i>Avicennia officinalis</i> L.	94	R	Rare
5	Xu sung	<i>Xylocarpus moluccensis</i> (Lam.) M. Roem.	94	R	Rare

To conserve the rare species in Exsitu through the purchase seed from the nursery where the seed and planted on the foundation of appropriate.

Focus protection and promotion of natural regeneration of mangrove forests to increase the quality and quantity.

5.12.2 Use and management of plant biodiversity of mangrove forest in Bac Lieu

To use and manage mangrove biodiversity need to carry out community participation in the implementation of the plan steps, extensive propaganda and education about the benefits and value of mangrove trees also as mixed planting within the family through insitu conservation.

Economic development increase income for the community. Currently people living in difficult regions, low income, aquaculture low productivity and high risk. So we need to build economic development projects to attract investment in the economic development of mangroves.

Raise awareness for local people about biodiversity, forest protection laws in the stakeholders. Strengthen propaganda and education to communities in mangrove areas understand the value and importance of biodiversity to people's lives.

Capacity building for forest ranger force to implement law effectively. Organize training capacity to use the equipment, machinery, GIS (Google Earth) in the management of forest resources.

Solutions for science and technology: To enhance scientific research, monitoring biodiversity and genetic resources of rare genes toward building permanent plots for monitoring in the long term.

The levees, banks of the shrimp pond has restricted the tidal to regenerate seed to the area, consider the arrangement of the channel in the direction North - South or North - South for water overflows in areas where forests on high ground as *Lumnitzera racemosa*, *Ceriops tagal* to create good conditions for plant growth and development.

Based on sites and species composition in the PCA analysis for selection of species for mixed plantations in group by environmental conditions and the natural succession. Planting multi purpose trees by crowd, area mixed and the biological different characteristics of each species. Species mixed are not suitable for big areas.

Some plant species are not suitable planting, limitation of planting on raised bed, spending money but results is not expected.

Apply Co-management and adaptive management in the management of plant biodiversity in Bac Lieu.

Conducting thinning, pruning multi stems trees, leaving 2-3 stems in each tree to create space for other species to regenerate.

5.12.3. Access information on plant diversity in research areas

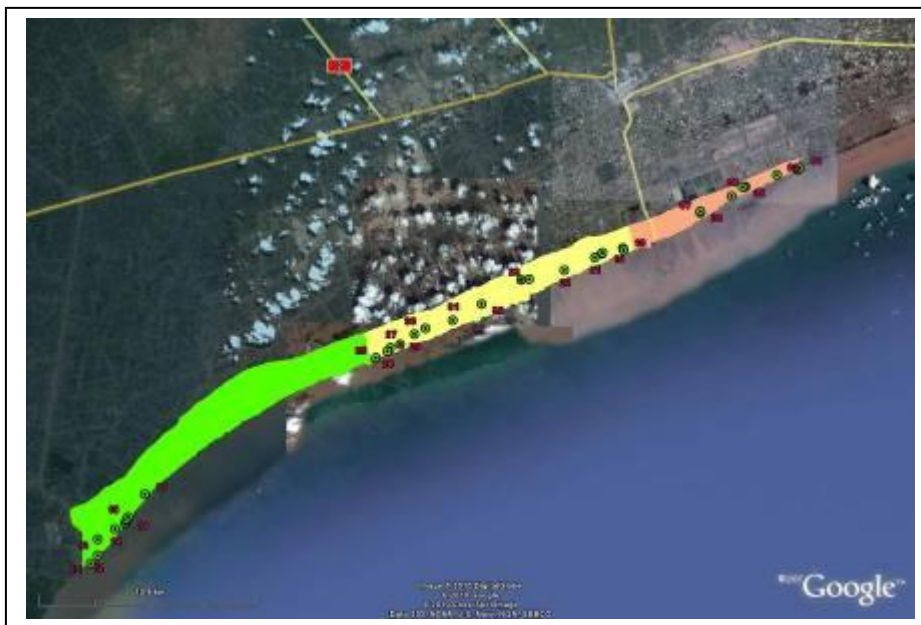


Figure 5.18: Map, location, pictures for biodiversity management

Initial construction of fast search tools on information of plant biodiversity of the 3 coastal districts of Bac Lieu for activities such as sightseeing, tourism, propagation and education activities in this region. Access data sources are including: location map of plots in three study areas, the information table on biodiversity (list of species, diversity index, ..) of 3 study areas, plants sample in pictures on Google Earth software.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The study identified 49 species of which 15 species (31%) are true mangrove and 34 species (69%) are associate mangrove under 27 families. Especially, Chùm lé (*Azima sarmentosa* (Blume) Benth. & Hook.f.) is the only species in the mangrove forests of Bac Lieu that is included in the list of Vietnam's Red Book.

Regarding life forms, there is 56% tree, herbaceous (24%), vines (14%), shrubs (4%), and 2% are ferns.

Seven species have important value index (IVI) > 5% as Mắm biển (*Avicennia marina*), Đà vôi (*Ceriops tagal*), Lức (*Pluchea indica*), Cóc kèn 3 lá (*Derris trifoliata*), Đước (*Rhizophora apiculata*), Rau muống biển (*Ipomoea pes-caprae*) and Đà quánh (*Ceriops zippeliana*).

Hoa Binh district has the highest beta index ($H_{\beta} = 6.33$) followed by Bac Lieu Town ($H_{\beta} = 4.23$) while Dong Hai district possesses the lowest ($H_{\beta} = 3.88$).

6.2. Recommendations

- Construction of permanent plots to periodically monitor plant diversity in the future through a variety of indicators in order to provide intervention when required to increase biodiversity of mangrove species.
- Establish a mangrove arboretum or botanical garden to collect mangrove species for the purposes of tourism and mangrove study.
- Conduct research on genetic diversity to form a foundation for preservation of precious species in the region.
- Use and wide dissemination of the results of study including pictures and information about species and communities' biodiversity to serve propagandic and conservational education activities and ecotourism services in the future.

REFERENCES

1. Ministry of Science, Technology and Environment, 2007. *Vietnam Red Book*, Part II of forest plants, pp 327 - 328.
2. Ministry of Forestry (now the Ministry of Agriculture and Rural Development), 1984. *Technical regulations for planting, maintenance and protection of mangrove forests (Rhizophora apiculata BL.)*, 24 pp.
3. Ministry of Agriculture and Rural Development, 2008. *Project rehabilitation and development of coastal mangrove forests - Period 2008 - 2015*, 39 pp.
4. Vien Ngoc Nam and Nguyen Son Thuy (1999). *Identify mangrove tree by pictures*. City Department of Agriculture and Rural Development. Ho Chi Minh City, 102 pp.
5. Vien Ngoc Nam, 2005. Biodiversity and genetic resources conservation in forestry. Master of Forestry, Nong Lam University Ho Chi Minh City, 88 pp.
6. Vien Ngoc Nam, Huynh Duc Hoan, Cao Huy Binh, Pham Van Quy, Bui Kiet, Phan Van Trung and Nguyen Thi Thu Hien (2008). *Research on biodiversity of Can Gio mangrove flora in strictly protected of natural reserve*, Ho Chi Minh City. Department of Science - Technology Ho Chi Minh City, 96 pp.
7. Do Dinh Sam, Nguyen Ngoc Binh, Ngo Dinh Que and Vu Tan Phuong, 2005. *Overview Vietnam mangroves*, The project tends to prevent environmental degradation of East Sea and Gulf of Thailand, Mangrove Component. Agriculture Publishing House, 136 pp.
8. Clarke K.R. and Gorley R. N., 2006 *PRIMER v6. User Manual/Tutorial PRIMER – E: Plymouth*. pp 190.
9. Guarino. C, Napolitano. F, 2006. Community habitats and biodiversity in the Taburno-Camposauo Regional Park. Woodland, rare species, endangered species and their conservation. *Italian Society of Silviculture and Forest Ecology*. pp 1-16.
10. Polidoro BA, Carpenter KE, Collins L, Duke NC, Ellison AM, Nam V. N, et al. (2010) The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern. *PLoS ONE* 5(4): e10095. doi:10.1371/journal.pone.0010095.

11. Sheue CR, Liu HY, Tsai CC, Rashid SMA, Yong JWH, et al. (2009) On the morphology and molecular basis of segregation of two species *Ceriops zippeliana* and *C. decandra* (Rhizophoraceae) from Southeastern Asia. *Blumea* 54, in press.
12. Shozo Kitamura, Chairil Anwar, Amayos Chaniago, Shigeyuki Baba, 1997. *Handbook of Mangroves in Indonesia*. JICA và ISME, 119 pp.

Appendix 1: Important Value Index (IVI) of coastal plants in Bac Lieu

STT	Local name	Scientific name	RD%	RF%	A%	IV%
1	Mắm biển	<i>Avicennia marina</i> (Forssk.) Vierh.	19.68	9.55	6.95	12.06
2	Dà vôi	<i>Ceriops tagal</i> (Perr.) C.B. Rob.	7.17	1.36	17.70	8.74
3	Lúc	<i>Pluchea indica</i> (L.) Lees	10.66	6.82	5.27	7.58
4	Cóc kèn 3 lá	<i>Derris trifoliata</i> Lour	9.07	6.36	4.80	6.74
5	Đước	<i>Rhizophora apiculata</i> Blume.	7.48	8.64	2.92	6.35
6	Rau muống biển	<i>Ipomoea pes-caprae</i> (L.)	1.81	0.45	13.44	5.24
7	Dà quánh	<i>Ceriops zippeliana</i>	6.03	4.55	4.47	5.02
8	Tra lâm vồ	<i>Thespesia populnea</i> (L.) Soland	4.63	6.36	2.45	4.48
9	Son cúc 2 hoa	<i>Wedelia biflora</i> (L.) DC	4.76	4.09	3.92	4.26
10	Cóc kèn 5 lá	<i>Deris indica</i> Blume	4.58	3.64	4.24	4.15
11	Giá	<i>Excoecaria agallocha</i> L.	3.27	4.55	2.42	3.41
12	Ngọc nữ biển	<i>Clerodendron inerme</i> (L.) Gaertn	2.72	5.91	1.55	3.39
13	Lìm kìm	<i>Psychotria serpens</i> L.	2.63	5.45	1.62	3.24
14	Cóc trắng	<i>Lumnitzera racemosa</i> Willd.	1.90	5.45	1.18	2.85
15	Vẹt trụ	<i>Bruguiera cylindrica</i> (L.) Blume.	2.27	1.82	4.20	2.76
16	Sam biển	<i>Sesuvium portulacastrum</i> L.	2.13	3.64	1.97	2.58
17	Ô rô tím	<i>Acanthus ilicifolius</i> L.	2.13	3.18	2.26	2.52
18	Mắm trắng	<i>Avicennia alba</i> Blume.	1.86	1.82	3.44	2.37
19	Dừa nước	<i>Nypa fruticans</i> Wurmb.	1.41	1.36	3.47	2.08
20	Lòà hùng	<i>Gymnanthera nitida</i> R. Br.	1.00	3.64	0.92	1.85
21	Cỏ nước mặn	<i>Paspalum vaginicum</i> Swort	1.00	3.18	1.06	1.75
22	Đưng	<i>Rhizophora mucronata</i> Lamk.	0.45	0.45	3.36	1.42
23	Tra búp	<i>Hibiscus tiliaceae</i> L.	0.27	1.36	0.67	0.77
24	Ráng đại	<i>Acrostichum aureum</i> L.	0.27	0.91	1.01	0.73
25	Bần ổi	<i>Sonneratia ovata</i> Backer. <i>Xylocarpus moluccensis</i> (Lam.) M. Roem.	0.18	0.45	1.34	0.66
26	Xu sung		0.14	0.91	0.50	0.52
27	Phi lao	<i>Casuarina equisetifolia</i> L.	0.14	0.91	0.50	0.52
28	Mắm đen	<i>Avicennia officinalis</i> L.	0.09	0.91	0.34	0.45
29	Điên điên	<i>Sesbania sesban</i> (L.) Merr.	0.09	0.45	0.67	0.41
30	Bần chua	<i>Sonneratia caseolaris</i> (L.) Engler.	0.05	0.45	0.34	0.28
31	Cỏ u du	<i>Cyperus elatus</i> L.	0.05	0.45	0.34	0.28
32	Muồng hoa vàng	<i>Cassia surattensis</i> Burm	0.05	0.45	0.34	0.28
33	Nhàu	<i>Morinda citrifolia</i> L.	0.05	0.45	0.34	0.28

Appendix 2: List of mangrove plants in Bac Lieu Province

No	Local name	Scientific name	Abbreviations	Life form	True mangrove	Associate mangrove	Family
1	Bần chua	<i>Sonneratia caseolaris</i> (L.) Engler.	Soncas	Tree	+		SONNERATIACEAE
2	Bần ổi	<i>Sonneratia ovata</i> Backer.	Sonova	Tree	+		SONNERATIACEAE
3	Dà quánh	<i>Ceriops zippeliana</i> Blume	Cerzip	Tree	+		RHIZOPHORACEAE
4	Dà vôi	<i>Ceriops tagal</i> (Perr.) C.B. Rob.	Certag	Tree	+		RHIZOPHORACEAE
5	Đưng	<i>Rhizophora mucronata</i> Lamk.	Rhimuc	Tree	+		RHIZOPHORACEAE
6	Đước	<i>Rhizophora apiculata</i> Blume.	Rhiapi	Tree	+		RHIZOPHORACEAE
7	Vẹt trụ	<i>Bruguiera cylindrica</i> (L.) Blume	Brucyl	Tree	+		RHIZOPHORACEAE
8	Dừa nước	<i>Nypa fruticans</i> Wurbm.	Nypfru	Herb	+		ARECACEAE
9	Cóc trắng	<i>Lumnitzera racemosa</i> Willd.	Lumrac	Tree	+		COMBRETACEAE
10	Mắm biển	<i>Avicennia marina</i> (Forssk.) Vierh.	Avimar	Tree	+		ACANTHACEAE
11	Mắm đen	<i>Avicennia officinalis</i> L.	Avioff	Tree	+		ACANTHACEAE
12	Mắm trắng	<i>Avicennia alba</i> Blume	Avialb	Tree	+		ACANTHACEAE
13	Ô rô tím	<i>Acanthus ilicifolius</i> L.	Acaili	Herb	+		ACANTHACEAE
14	Ráng đại	<i>Acrostichum aureum</i> L.	Acraur	Fern	+		PTERIDACEAE
15	Giá	<i>Excoecaria agallocha</i> L.	Excaga	Tree	+		EUPHORBIACEAE
16	Sam biển	<i>Sesuvium portulacastrum</i> L.	Sespor	Herb		+	AIZOACEAE
17	Xu sung	<i>Xylocarpus moluccensis</i> (Lam.)	Xylmol	Tree		+	MELIACEAE
18	Tra bụp	<i>Hibiscus tiliaceae</i> L.	Hibtil	Tree		+	MALVACEAE
19	Tra lâm vồ	<i>Thespesia populnea</i> (L.)	Thepop	Tree		+	MALVACEAE
20	Lìm kìm	<i>Psychotria serpens</i> L.	Psyser	Climber		+	RUBIACEAE

No	Local name	Scientific name	Abbreviations	Life form	True mangrove	Associate mangrove	Family
21	Cóc kèn 3 lá	<i>Derris trifoliata</i> Lour	Dertri	Climber		+	LEGUMINOSAE
22	Cóc kèn 5 lá	<i>Deris indica</i> Blume	Derind	Climber		+	LEGUMINOSAE
23	Me nước	<i>Dalbergia candenatensis</i> (Dennst) Prain	Dalcan	Climber		+	LEGUMINOSAE
24	Đậu cộ	<i>Canavalia lineata</i> (Thunb.) DC	Canlin	Climber		+	LEGUMINOSAE
25	Cỏ hôi	<i>Ageratum conyzoides</i> L.	Agecon	Herb		+	ASTERACEAE
26	Lúc	<i>Pluchea indica</i> (L.) Lees	Pluind	Herb		+	ASTERACEAE
27	Son cúc 2 hoa	<i>Wedelia biflora</i> (L.) DC	Wedbif	Herb		+	ASTERACEAE
28	Lỏa hùng	<i>Gymnanthera nitida</i> R. Br.	Gymnit	Climber		+	ASCLEPIADACEAE
29	Cỏ nước mặn	<i>Paspalum vaginicum</i> Swort	Pasvag	Herb		+	GRAMINEAE
30	Cỏ u du	<i>Cyperus elatus</i> L.	Cypela	Herb		+	CYPERACEAE
31	Muồng hoa vàng	<i>Cassia surattensis</i> Burm	Cassur	Tree		+	FABACEAE
32	Điên điên	<i>Sesbania sesban</i> (L.) Merr.	Sesses	Herb		+	FABACEAE
33	Nhàu	<i>Morinda citrifolia</i> L.	Morcit	Tree		+	FABACEAE
34	Rau muồng biển	<i>Ipomoea pes-caprae</i> (L.)	Ipopes	Herb		+	CONVOLVULACEAE
35	Vọng cách	<i>Premna integrifolia</i> L.	Preint	Herb		+	VERBENACEAE
36	Ngọc nữ biển	<i>Clerodendron inerme</i> (L.) Gaertn	Cleine	Herb		+	VERBENACEAE
37	Quao nước	<i>Dolichandrone spathacea</i> (L. F.)	Dolspa	Tree		+	BIGNONIACEAE
38	So đũa bông trắng	<i>Sesbania grandiflora</i> (L.) Poiret.	Sesgra	Tree		+	PAPILIONACEAE
39	So đũa bông đỏ	<i>Sesbania punicea</i> (Cav.) Benth	Sespun	Tree		+	PAPILIONACEAE
40	Me	<i>Tamarindus indica</i> L.	Tamind	Tree		+	CAESALPINIACEAE
41	Me ngọt (Thailand)	<i>Tamarindus</i> sp.	Tampsp.	Tree		+	CAESALPINIACEAE

No	Local name	Scientific name	Abbreviations	Life form	True mangrove	Associate mangrove	Family
42	Bàng	<i>Terminalia catappa</i> L.	Tercat	Thân gỗ		+	COMBRETACEAE
43	Trâm bầu	<i>Combretum quadrangulare</i> Kurz	Comqua	Thân gỗ		+	COMBRETACEAE
44	Phi lao	<i>Casuarina equisetifolia</i> L.	Casequ	Thân gỗ		+	CASUARINACEAE
45	Phi lao (Trung quốc)	<i>Casuarina</i> sp.	CasSp.	Thân gỗ		+	CASUARINACEAE
46	Dây vác	<i>Cayratia trifolia</i> (L.) Domino.	Caytri	Dây leo		+	XYRIDACEAE
47	Dừa	<i>Cocos nucifera</i> L.	Cocnuc	Thân thảo		+	ARECACEAE
48	Ngoại mộc	<i>Allophylus glaber</i> Radlk	Allgla	Thân gỗ		+	SAPINDACEAE
49	Chùm lé (Thứ mật)	<i>Azima sarmentosa</i> (Blume) Benth. & Hook.f.	Azisar	Cây bụi	EN	+	SALVADORACEAE

Appendix 3: The data measured in the plots

Scientific name	Abbreviations	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11
<i>Sonneratia caseolaris</i> (L.) Engler.	Soncas	0	0	0	0	0	0	0	0	0	0	0
<i>Sonneratia ovata</i> Backer.	Sonova	0	0	0	0	0	0	0	0	0	0	0
<i>Lumnitzera racemosa</i> Willd.	Lumrac	8	5	0	4	2	1	0	2	0	0	0
<i>Ceriops zippeliana</i> Bl.	Cerzip	0	1	3	0	36	0	0	0	0	0	1
<i>Ceriops tagal</i> (Perr.) C.B. Rob.	Certag	0	0	0	0	0	0	0	0	0	0	0
<i>Nypa fruticans</i> Wurmb.	Nypfru	0	0	0	0	0	0	0	0	10	8	0
<i>Rhizophora mucronata</i> Lamk.	Rhimuc	0	0	0	0	0	0	0	0	0	0	0
<i>Rhizophora apiculata</i> Blume.	Rhiapi	0	2	10	2	4	0	0	0	20	1	0
<i>Excoecaria agallocha</i> L.	Excaga	0	7	0	0	0	10	0	0	0	0	20
<i>Avicennia marina</i> (Forssk.) Vierh.	Avimar	3	0	0	0	0	2	62	75	0	54	0
<i>Avicennia officinalis</i> L.	Avioff	0	0	0	0	0	0	1	0	0	0	0
<i>Avicennia alba</i> Blume	Avialb	0	0	0	0	0	0	0	0	0	0	5
<i>Acanthus ilicifolius</i> L.	Acaili	8	0	0	12	0	0	0	0	0	0	2
<i>Acrostichum aureum</i> L.	Acraur	0	0	0	0	0	0	0	0	0	0	0
<i>Sesuvium portulacastrum</i> L.	Sespor	2	1	4	0	0	3	0	0	0	0	1
<i>Bruguiera cylindrica</i> (L.) Blume.	Brucyl	0	0	0	0	0	0	0	0	0	0	0
<i>Xylocarpus moluccensis</i> (Lam.)	Xylmol	0	0	0	0	0	0	0	0	0	0	0
<i>Hibiscus tiliaceae</i> L.	Hibtil	4	0	0	0	0	1	0	1	0	0	0
<i>Thespesia populnea</i> (L.)	Thepop	2	6	2	3	0	11	0	2	0	0	1
<i>Clerodendron inerme</i> (L.) Gaertn	Cleine	4	2	7	10	5	2	2	2	0	0	12
<i>Psychotria serpens</i> L.	Psyser	2	3	0	2	2	15	2	0	0	0	8
<i>Derris trifoliata</i> Lour	Dertri	8	1	11	0	0	0	4	4	0	0	32
<i>Deris indica</i> Blume	Derind	0	0	0	0	0	0	2	0	0	0	1
<i>Pluchea indica</i> (L.) Lees	Pluind	5	3	4	7	4	20	0	4	0	0	25

<i>Gymnanthera nitida</i> R. Br.	Gymnit	0	0	0	1	1	0	3	0	0	0	2
<i>Wedelia biflora</i> (L.) DC	Wedbif	9	2	0	0	0	0	0	0	0	0	8
<i>Casuarina equisetifolia</i> L.	Casequ	0	0	0	0	0	0	0	1	0	0	0
<i>Paspalum vaginicum</i> Swort	Pasvag	0	2	2	0	2	0	0	0	0	0	1
<i>Cyperus elatus</i> L.	Cypela	0	0	0	0	0	0	0	0	0	0	0
<i>Cassia surattensis</i> Burm	Cassur	0	0	0	0	1	0	0	0	0	0	0
<i>Sesbania sesban</i> (L.) Merr.	Sesacu	0	2	0	0	0	0	0	0	0	0	0
<i>Ipomoea pes-caprae</i> (L.)	Ipopes	0	0	0	0	0	0	0	0	0	0	0
<i>Morinda citrifolia</i> L.	Morcit	0	0	0	0	0	0	0	0	0	0	0

Scientific name	Abbreviations	Plot 12	Plot 13	Plot 14	Plot 15	Plot 16	Plot 17	Plot 18	Plot 19	Plot 20	Plot 21	Plot 22
<i>Sonneratia caseolaris</i> (L.) Engler.	Soncas	0	0	0	0	0	0	1	0	0	0	0
<i>Sonneratia ovata</i> Backer.	Sonova	0	0	0	0	0	0	0	0	0	0	0
<i>Lumnitzera racemosa</i> Willd.	Lumrac	4	1	0	0	3	0	0	0	0	0	0
<i>Ceriops zippeliana</i> Bl.	Cerzip	1	1	0	0	5	0	0	0	8	42	35
<i>Ceriops tagal</i> (Perr.) C.B. Rob.	Certag	0	0	0	149	2	0	0	0	0	0	0
<i>Nypa fruticans</i> Wurm.	Nypfru	0	0	0	0	0	13	0	0	0	0	0
<i>Rhizophora mucronata</i> Lamk.	Rhimuc	0	0	0	0	0	0	10	0	0	0	0
<i>Rhizophora apiculata</i> Blume.	Rhiapi	0	0	1	1	2	0	6	10	33	0	3
<i>Excoecaria agallocha</i> L.	Excaga	1	3	3	0	0	0	0	0	1	12	6
<i>Avicennia marina</i> (Forssk.) Vierh.	Avimar	10	0	2	2	0	0	52	18	6	12	2
<i>Avicennia officinalis</i> L.	Avioff	0	0	0	0	0	0	0	0	1	0	0
<i>Avicennia alba</i> Blume	Avialb	2	0	6	0	0	0	0	28	0	0	0
<i>Acanthus ilicifolius</i> L.	Acaili	0	8	4	0	0	0	12	0	0	0	0
<i>Acrostichum aureum</i> L.	Acraur	0	0	0	0	0	0	0	0	0	0	0
<i>Sesuvium portulacastrum</i> L.	Sespor	0	0	0	0	0	0	0	0	0	0	0

<i>Bruguiera cylindrica</i> (L.) Blume.	Brucyl	0	0	2	0	0	0	0	28	9	11	0
<i>Xylocarpus moluccensis</i> (Lam.)	Xylmol	0	1	2	0	0	0	0	0	0	0	0
<i>Hibiscus tiliaceae</i> L.	Hibtil	0	0	0	0	0	0	0	0	0	0	0
<i>Thespesia populnea</i> (L.)	Thepop	0	1	1	0	4	0	0	0	0	0	0
<i>Clerodendron inerme</i> (L.) Gaertn	Cleine	4	4	0	0	3	0	0	0	0	0	0
<i>Psychotria serpens</i> L.	Psyser	0	0	0	0	1	0	0	0	0	0	0
<i>Derris trifoliata</i> Lour	Dertri	24	1	12	0	41	26	21	0	0	0	0
<i>Deris indica</i> Blume	Derind	18	0	1	0	5	46	24	0	0	0	0
<i>Pluchea indica</i> (L.) Lees	Pluind	0	1	0	0	0	0	0	0	0	0	0
<i>Gymnanthera nitida</i> R. Br.	Gymnit	0	0	0	0	2	0	0	0	0	0	0
<i>Wedelia biflora</i> (L.) DC	Wedbif	0	1	0	0	4	0	6	0	0	0	0
<i>Casuarina equisetifolia</i> L.	Casequ	0	0	0	0	0	0	0	0	0	0	0
<i>Paspalum vaginicum</i> Swort	Pasvag	1	0	0	0	0	0	0	0	0	0	0
<i>Cyperus elatus</i> L.	Cypela	0	0	0	0	0	0	0	0	0	0	0
<i>Cassia surattensis</i> Burm	Cassur	0	0	0	0	0	0	0	0	0	0	0
<i>Sesbania sesban</i> (L.) Merr.	Sesacu	0	0	0	0	0	0	0	0	0	0	0
<i>Ipomoea pes-caprae</i> (L.)	Ipopes	0	0	0	0	0	0	0	0	0	0	0
<i>Morinda citrifolia</i> L.	Morcit	0	0	0	0	0	0	0	0	0	0	0

Scientific name	Abbreviations	Plot 23	Plot 24	Plot 25	Plot 26	Plot 27	Plot 28	Plot 29	Plot 30	Plot 31	Plot 32
<i>Sonneratia caseolaris</i> (L.) Engler.	Soncas	0	0	0	0	0	0	0	0	0	0
<i>Sonneratia ovata</i> Backer.	Sonova	0	4	0	0	0	0	0	0	0	0
<i>Lumnitzera racemosa</i> Willd.	Lumrac	0	1	1	0	0	0	0	0	10	0
<i>Ceriops zippeliana</i> Bl.	Cerzip	0	0	0	0	0	0	0	0	0	0
<i>Ceriops tagal</i> (Perr.) C.B. Rob.	Certag	7	0	0	0	0	0	0	0	0	0
<i>Nypa fruticans</i> Wurmb.	Nypfru	0	0	0	0	0	0	0	0	0	0

<i>Rhizophora mucronata</i> Lamk.	Rhimuc	0	0	0	0	0	0	0	0	0	0
<i>Rhizophora apiculata</i> Blume.	Rhiapi	11	9	1	0	20	0	17	12	0	0
<i>Excoecaria agallocha</i> L.	Excaga	0	0	9	0	0	0	0	0	0	0
<i>Avicennia marina</i> (Forssk.) Vierh.	Avimar	5	2	9	7	21	0	26	48	16	0
<i>Avicennia officinalis</i> L.	Avioff	0	0	0	0	0	0	0	0	0	0
<i>Avicennia alba</i> Blume	Avialb	0	0	0	0	0	0	0	0	0	0
<i>Acanthus ilicifolius</i> L.	Acaili	0	0	0	0	0	1	0	0	0	0
<i>Acrostichum aureum</i> L.	Acraur	0	0	0	5	0	1	0	0	0	0
<i>Sesuvium portulacastrum</i> L.	Sespor	0	0	4	0	0	30	0	0	0	2
<i>Bruguiera cylindrica</i> (L.) Blume.	Brucyl	0	0	0	0	0	0	0	0	0	0
<i>Xylocarpus moluccensis</i> (Lam.)	Xylmol	0	0	0	0	0	0	0	0	0	0
<i>Hibiscus tiliaceae</i> L.	Hibtil	0	0	0	0	0	0	0	0	0	0
<i>Thespesia populnea</i> (L.)	Thepop	0	7	18	23	0	0	0	0	0	21
<i>Clerodendron inerme</i> (L.) Gaertn	Cleine	0	0	0	0	0	0	0	0	0	3
<i>Psychotria serpens</i> L.	Psyser	0	0	5	4	0	12	0	0	0	2
<i>Derris trifoliata</i> Lour	Dertri	0	0	12	0	0	0	0	0	3	0
<i>Deris indica</i> Blume	Derind	0	0	4	0	0	0	0	0	0	0
<i>Pluchea indica</i> (L.) Lees	Pluind	0	6	3	42	0	46	0	0	31	34
<i>Gymnanthera nitida</i> R. Br.	Gymnit	0	0	1	8	0	0	0	0	0	4
<i>Wedelia biflora</i> (L.) DC	Wedbif	0	0	8	64	0	0	0	0	3	0
<i>Casuarina equisetifolia</i> L.	Casequ	0	0	2	0	0	0	0	0	0	0
<i>Paspalum vaginicum</i> Swort	Pasvag	11	3	0	0	0	0	0	0	0	0
<i>Cyperus elatus</i> L.	Cypela	0	1	0	0	0	0	0	0	0	0
<i>Cassia surattensis</i> Burm	Cassur	0	0	0	0	0	0	0	0	0	0
<i>Sesbania sesban</i> (L.) Merr.	Sesacu	0	0	0	0	0	0	0	0	0	0
<i>Ipomoea pes-caprae</i> (L.)	Ipopes	0	0	0	0	0	40	0	0	0	0
<i>Morinda citrifolia</i> L.	Morcit	0	0	1	0	0	0	0	0	0	0

Appendix 4: Location and environmental conditions of plots

Plot	X	Y	Site class	Soil	Flood	Elevation (m)	Flood day/month	Location
Plot 1	590853	1021995	1c	Tight mud	Average	1.5	4 – 9	TX Bac Lieu
Plot 2	590707	1021891	1c	Tight mud	Average	1.5	4 – 9	TX Bac Lieu
Plot 3	589413	1021574	1c	Tight mud	Average	1.5	4 – 9	TX Bac Lieu
Plot 4	587444	1020823	1c	Tight mud	Average	1.5	4 – 9	TX Bac Lieu
Plot 5	587279	1020802	1c	Tight mud	Average	1.5	4 – 9	TX Bac Lieu
Plot 6	586580	1020231	1c	Tight mud	Average	1.5	4 – 9	TX Bac Lieu
Plot 7	584666	1019012	1c	Tight mud	Average	1.5	4 – 9	TX Bac Lieu
Plot 8	584629	1019270	1e	Hard soil	High	3	3 - 4	TX Bac Lieu
Plot 9	579774	1016963	1e	Hard soil	High	3	3 - 4	TX Bac Lieu
Plot 10	579821	1016841	1e	Hard soil	High	3	3 - 4	TX Bac Lieu
Plot 11	546449	997201	1e	Hard soil	High	3	3 - 4	H. Đông Hải
Plot 12	546907	997699	1d	Soft soil	Average	2	4 – 9	H. Đông Hải
Plot 13	546905	998707	1d	Soft soil	Average	2	4 – 9	H. Đông Hải
Plot 14	547985	999356	1c	Tight mud	Average	1.5	4 – 9	H. Đông Hải
Plot 15	548309	999734	1c	Tight mud	Average	1.5	4 – 9	H. Đông Hải
Plot 16	548721	999943	1c	Tight mud	Average	1.5	4 – 9	H. Đông Hải
Plot 17	548603	999711	1c	Tight mud	Average	1.5	4 – 9	H. Đông Hải
Plot 18	549861	1001530	1c	Tight mud	Average	1.5	4 – 9	H. Đông Hải
Plot 19	578497	1016681	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 20	578440	1016606	1c	Tight mud	Average	1.5	4 - 9	H. Hoà Bình
Plot 21	578011	1016382	1d	Soft clay	Average	2	4 – 9	H. Hoà Bình
Plot 22	576107	1015585	1d	Soft clay	Average	2	4 – 9	H. Hoà Bình

Appendix 4: Location and environmental conditions of plots

Plot	X	Y	Site class	Soil	Flood	Elevation (m)	Flood day/month	Location
Plot 23	573905	1015021	1d	Soft clay	Average	2	4 – 9	H. Hoà Bình
Plot 24	573404	1014973	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 25	564322	1010089	1c	Soft mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 26	565044	1010491	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 27	565233	1010716	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 28	565844	1010932	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 29	566730	1011572	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 30	567417	1011933	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 31	569129	1012443	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình
Plot 32	570935	1013455	1c	Tight mud	Average	1.5	4 – 9	H. Hoà Bình

Appendix 5: Distribution patterns of mangrove trees

TT	Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
1	<i>Sonneratia caseolaris</i> (L.) Engler.	0.03	0.03	31.00	31	0.47	Ngẫu nhiên
2	<i>Sonneratia ovata</i> Backer.	0.50	0.13	124.00	31		Đám
3	<i>Lumnitzera racemosa</i> Willd.	6.03	1.31	142.38	31		Đám
4	<i>Ceriops zippeliana</i>	123.68	4.16	922.52	31		Đám
5	<i>Ceriops tagal</i> (Perr.) C.B. Rob.	692.71	4.94	4349.14	31		Đám
6	<i>Nypa fruticans</i> Wurm.	9.77	0.97	312.74	31		Đám
7	<i>Rhizophora mucronata</i> Lamk.	3.13	0.31	310.00	31		Đám
8	<i>Rhizophora apiculata</i> Blume.	62.91	5.16	378.22	31		Đám
9	<i>Excoecaria agallocha</i> L.	21.55	2.25	296.89	31		Đám
10	<i>Avicennia marina</i> (Forssk.) Vierh.	440.90	13.56	1007.77	31		Đám
11	<i>Avicennia officinalis</i> L.	0.06	0.06	30.00	31	0.52	Ngẫu nhiên
12	<i>Avicennia alba</i> Blume.	25.69	1.28	621.63	31		Đám
13	<i>Acanthus ilicifolius</i> L.	11.87	1.47	250.53	31		Đám
14	<i>Acrostichum aureum</i> L.	0.80	0.19	132.67	31		Đám
15	<i>Sesuvium portulacastrum</i> L.	28.45	1.47	600.49	31		Đám
16	<i>Bruguiera cylindrica</i> (L.) Blume.	29.42	1.56	583.60	31		Đám
17	<i>Xylocarpus moluccensis</i> (Lam.)	0.15	0.09	50.33	31	0.02	Đám
18	<i>Hibiscus tiliaceae</i> L.	0.54	0.19	90.00	31		Đám
19	<i>Thespesia populnea</i> (L.) Gaertn	39.19	3.19	381.14	31		Đám
20	<i>Clerodendron inerme</i> (L.) Gaertn	9.27	1.88	153.33	31		Đám
21	<i>Psychotria serpens</i> L.	12.87	1.81	220.07	31		Đám
22	<i>Derris trifoliata</i> Lour	118.19	6.25	586.24	31		Đám
23	<i>Deris indica</i>	88.52	3.16	869.46	31		Đám
24	<i>Pluchea indica</i> (L.) Lees	176.56	7.34	745.29	31		Đám
25	<i>Gymnanthera nitida</i> R. Br.	2.74	0.69	123.45	31		Đám
26	<i>Wedelia biflora</i> (L.) DC	129.89	3.28	1227.11	31		Đám
27	<i>Casuarina equisetifolia</i> L.	0.15	0.09	50.33	31	0.02	Đám
28	<i>Paspalum vaginicum</i> Swort	4.16	0.69	187.45	31		Đám
29	<i>Cyperus elatus</i> L.	0.03	0.03	31.00	31	0.47	Ngẫu nhiên
30	<i>Cassia surattensis</i> Burm	0.03	0.03	31.00	31	0.47	Ngẫu nhiên
31	<i>Sesbania sesban</i> BL.	0.13	0.06	62.00	31		Đám
32	<i>Ipomoea pes-caprae</i> (L.)	50.00	1.25	1240.00	31		Đám
33	<i>Morinda citrifolia</i> L.	21.13	0.81	806.00	31		Đám

Appendix 6: Caswell index of plots

Plot	N	S	H'	E[H']	SD[H']	V(N.D.)	F-ratio	DF1	DF2
Plot 1	55	11	2.26	1.91	0.18	1.96	4.07	45.94	11.68
Plot 2	37	13	2.37	2.23	0.12	1.19	1.84	89.74	13.65
Plot 3	43	8	1.90	1.61	0.19	1.51	3.05	30.31	8.91
Plot 4	41	8	1.81	1.62	0.19	1.01	1.91	31.33	8.92
Plot 5	57	9	1.37	1.67	0.20	-1.49	0.52	31.22	9.81
Plot 6	65	9	1.77	1.64	0.21	0.63	1.42	28.88	9.78
Plot 7	76	7	0.79	1.34	0.24	-2.24	0.31	17.30	7.82
Plot 8	91	8	0.78	1.44	0.24	-2.68	0.27	19.86	8.78
Plot 10	63	3	0.46	0.61	0.25	-0.61	0.57	4.14	3.28
Plot 11	119	14	2.05	2.00	0.21	0.24	1.11	44.53	14.31
Plot 12	65	9	1.65	1.64	0.21	0.06	1.03	28.88	9.78
Plot 13	22	10	1.93	2.05	0.10	-1.24	0.63	93.12	11.24
Plot 14	34	10	1.95	1.93	0.14	0.16	1.08	56.11	10.89
Plot 15	152	3	0.11	0.53	0.27	-1.54	0.12	2.94	3.16
Plot 16	72	11	1.64	1.84	0.20	-1.05	0.65	38.67	11.64
Plot 17	85	3	0.98	0.58	0.26	1.54	7.46	3.64	3.23
Plot 18	132	8	1.70	1.37	0.27	1.24	2.32	16.88	8.73
Plot 19	84	4	1.32	0.81	0.27	1.89	13.46	6.33	4.56
Plot 20	58	6	1.26	1.24	0.24	0.09	1.06	15.24	6.85
Plot 21	77	4	1.19	0.82	0.27	1.39	4.17	6.57	4.58
Plot 22	46	4	0.79	0.89	0.24	-0.42	0.73	8.37	4.67
Plot 23	34	4	1.34	0.94	0.22	1.78	13.11	9.91	4.74
Plot 24	33	8	1.85	1.67	0.17	1.05	1.95	36.94	8.99
Plot 25	78	14	2.28	2.10	0.18	1.01	1.62	56.59	14.37
Plot 26	153	7	1.51	1.22	0.28	1.04	2.06	12.85	7.73
Plot 28	130	6	1.36	1.10	0.28	0.95	2.02	10.64	6.73
Plot 31	63	5	1.28	1.04	0.25	0.93	2.09	10.66	5.77
Plot 32	66	6	1.23	1.21	0.25	0.07	1.04	14.27	6.83

Appendix 7: Biodiversity index of plots

Plot No	S	N	d	J'	Fisher	H'(loge)	D
Plot 1	11	55	2.50	0.94	4.13	2.26	0.10
Plot 2	13	37	3.32	0.92	7.13	2.37	0.09
Plot 3	8	43	1.86	0.91	2.90	1.90	0.15
Plot 4	8	41	1.88	0.87	2.97	1.81	0.17
Plot 5	9	57	1.98	0.62	3.01	1.37	0.41
Plot 6	9	65	1.92	0.81	2.83	1.77	0.19
Plot 7	7	76	1.39	0.41	1.88	0.79	0.67
Plot 8	8	91	1.55	0.38	2.11	0.78	0.68
Plot 9	2	30	0.29	0.92	0.48	0.64	0.54
Plot 10	3	63	0.48	0.42	0.66	0.46	0.75
Plot 11	14	119	2.72	0.78	4.12	2.05	0.16
Plot 12	9	65	1.92	0.75	2.83	1.65	0.23
Plot 13	10	22	2.91	0.84	7.08	1.93	0.16
Plot 14	10	34	2.55	0.85	4.77	1.95	0.17
Plot 15	3	152	0.40	0.10	0.53	0.11	0.96
Plot 16	11	72	2.34	0.68	3.62	1.64	0.34
Plot 17	3	85	0.45	0.89	0.61	0.98	0.40
Plot 18	8	132	1.43	0.82	1.87	1.70	0.23
Plot 19	4	84	0.68	0.95	0.87	1.32	0.27
Plot 20	6	58	1.23	0.70	1.68	1.26	0.37
Plot 21	4	77	0.69	0.86	0.90	1.19	0.36
Plot 22	4	46	0.78	0.57	1.05	0.79	0.59
Plot 23	4	34	0.85	0.96	1.18	1.34	0.25
Plot 24	8	33	2.00	0.89	3.36	1.85	0.16
Plot 25	14	78	2.98	0.86	4.97	2.28	0.11
Plot 26	7	153	1.19	0.77	1.51	1.51	0.27
Plot 27	2	41	0.27	1.00	0.44	0.69	0.49
Plot 28	6	130	1.03	0.76	1.30	1.36	0.28
Plot 29	2	43	0.27	0.97	0.43	0.67	0.51
Plot 30	2	60	0.24	0.72	0.40	0.50	0.67
Plot 31	5	63	0.97	0.79	1.28	1.28	0.33
Plot 32	6	66	1.19	0.69	1.60	1.23	0.36
Trung binh	6.88 ±1.28	68.91 ± 12.61	1.45 ± 0.33	0.76 ± 0.07	2.33 ± 0.66	1.36 ± 0.21	0.36 ± 0.08

Appendix 8: Biodiversity index of plots in Bac Lieu Town

TT	S	N	d	J'	H'(loge)	Ưu thế D
Plot 1	11	55	2.50	0.94	2.26	0.90
Plot 2	13	37	3.32	0.92	2.37	0.91
Plot 3	8	43	1.86	0.91	1.90	0.85
Plot 4	8	41	1.88	0.87	1.81	0.83
Plot 5	9	57	1.98	0.62	1.37	0.59
Plot 6	9	65	1.92	0.81	1.77	0.81
Plot 7	7	76	1.39	0.41	0.79	0.33
Plot 8	8	91	1.55	0.38	0.78	0.32
Plot 9	2	30	0.29	0.92	0.64	0.46
Plot 10	3	63	0.48	0.42	0.46	0.25

Appendix 9: Biodiversity index of plots in Hoa Binh District

TT	S	N	d	J'	H'(loge)	Ưu thế D
Plot 19	4	84	0.68	0.95	1.32	0.27
Plot 20	6	58	1.23	0.70	1.26	0.37
Plot 21	4	77	0.69	0.86	1.19	0.36
Plot 22	4	46	0.78	0.57	0.79	0.59
Plot 23	4	34	0.85	0.96	1.34	0.25
Plot 24	8	33	2.00	0.89	1.85	0.16
Plot 25	14	78	2.98	0.86	2.28	0.11
Plot 26	7	153	1.19	0.77	1.51	0.27
Plot 27	2	41	0.27	1.00	0.69	0.49
Plot 28	6	130	1.03	0.76	1.36	0.28
Plot 29	2	43	0.27	0.97	0.67	0.51
Plot 30	2	60	0.24	0.72	0.50	0.67
Plot 31	5	63	0.97	0.79	1.28	0.33
Plot 32	6	66	1.19	0.69	1.23	0.36

Appendix 10: Biodiversity index of plots Dong Hai District

TT	S	N	d	J'	H'(loge)	Ưu thế D
Plot 11	14	119	2.72	0.78	2.05	0.84
Plot 12	9	65	1.92	0.75	1.65	0.77
Plot 13	10	22	2.91	0.84	1.93	0.84
Plot 14	10	34	2.55	0.85	1.95	0.83
Plot 15	3	152	0.40	0.10	0.11	0.04
Plot 16	11	72	2.34	0.68	1.64	0.66
Plot 17	3	85	0.45	0.89	0.98	0.60
Plot 18	8	132	1.43	0.82	1.70	0.77

Appendix 11: The result of PCA**PCA****Principal Component Analysis***Data worksheet*

Name: So lieu chu tat

Data type: Other

Sample selection: All

Variable selection: All

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	710	34.0	34.0
2	470	22.5	56.5
3	260	12.4	68.9
4	181	8.7	77.6
5	119	5.7	83.3

Eigenvectors

(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4	PC5
Soncas	-0.001	-0.003	0.000	-0.004	0.001
Sonova	0.000	0.003	0.002	0.004	-0.003
Lumrac	-0.007	0.016	-0.005	-0.018	-0.009
Cerzip	-0.017	0.075	0.275	0.358	0.450
Certag	0.978	-0.150	-0.094	-0.037	0.022
Nypfru	-0.007	-0.008	0.038	-0.074	-0.024
Rhimuc	-0.006	-0.026	-0.004	-0.043	0.007
Rhiapi	-0.023	-0.039	0.163	0.198	-0.074
Excaga	-0.011	0.061	0.024	-0.013	0.071
Avimar	-0.189	-0.908	-0.310	0.004	0.031
Avioff	-0.001	-0.003	0.001	0.003	0.000
Avialb	-0.009	-0.004	0.033	0.017	-0.024
Acaili	-0.011	-0.002	0.009	-0.054	-0.015
Acraur	-0.002	0.011	-0.039	-0.002	0.039
Sespor	-0.008	0.076	-0.129	0.042	-0.313
Brucyl	-0.010	-0.011	0.070	0.108	0.030
Xylmol	0.000	0.002	0.004	-0.001	-0.001
Hibtil	-0.001	0.000	-0.003	-0.001	0.001
Thepop	-0.019	0.108	-0.211	-0.027	0.198
Cleine	-0.010	0.039	0.013	-0.047	-0.006
Psyser	-0.010	0.068	-0.101	-0.002	-0.097
Dertri	-0.042	0.046	0.137	-0.705	0.030
Derind	-0.028	-0.031	0.130	-0.534	-0.013
Pluind	-0.048	0.301	-0.662	0.031	-0.184
Gymnit	-0.006	0.018	-0.065	-0.016	0.079
Wedbif	-0.029	0.131	-0.454	-0.128	0.651
Casequ	-0.001	-0.003	-0.003	-0.003	0.003
Pasvag	0.001	0.011	0.022	0.015	-0.008
Cypela	0.000	0.001	0.001	0.001	-0.001
Cassur	0.000	0.001	0.002	0.003	0.003
Sesacu	0.000	0.002	0.001	0.001	0.000
Ipopes	-0.007	0.081	-0.166	0.065	-0.412
Morcit	0.000	0.000	0.000	-0.001	0.001

Principal Component Scores

Sample	SCORE1	SCORE2	SCORE3	SCORE4	SCORE5
Plot 1	-2.74	10.3	0.741	-3.41	2.03
Plot 2	-1.66	12	5.14	3.48	-0.511
Plot 3	-2.14	11.6	9.3	-0.797	-3.31
Plot 4	-1.79	12.2	3.79	3.28	-3.84
Plot 5	-2.06	13.4	16.5	17.5	12.4
Plot 6	-2.94	16.6	-9.04	4.14	-5.75
Plot 7	-13.1	-46.7	-10	0.205	-0.529
Plot 8	-15.7	-57.2	-17	1.41	-0.491
Plot 9	-1.59	8.36	12.4	7.19	-4.31
Plot 10	-11.3	-39.9	-7.49	3.81	-1.17
Plot 11	-4.44	21.7	-7.04	-19.9	-0.143
Plot 12	-4.59	1.05	11.7	-22.4	-1.4
Plot 13	-1.39	10.2	8.06	2.81	-1.4
Plot 14	-2.17	8.12	10.3	-4.8	-2
Plot 15	144	-15	-5.67	-1.32	0.636
Plot 16	-1.38	12.2	13.7	-26.3	4.12
Plot 17	-3.54	8.89	18.8	-39.9	-2.72
Plot 18	-12.9	-37.5	-3.01	-24.1	2.72
Plot 19	-5.22	-7.93	7.73	9.51	-2.59
Plot 20	-3.19	3.05	15.2	14.4	-0.901
Plot 21	-4.32	2.09	17.7	20.1	17.8
Plot 22	-2.19	10.3	18.4	17	13.4
Plot 23	4.6	3.32	8.6	6.07	-3.19
Plot 24	-2.08	9.68	4.25	5.79	-2.96
Plot 25	-4.33	6.56	-1.98	-7.81	5.12
Plot 26	-6.8	26.9	-56.2	-3.69	36.6
Plot 27	-5.49	-10.6	5.54	8.02	-3.41
Plot 28	-3.95	29.4	-33.4	9.18	-38.1
Plot 29	-6.36	-15	3.5	7.45	-3.03
Plot 30	-10.4	-34.8	-4.14	6.55	-1.97
Plot 31	-5.88	4.72	-17.7	2.31	-5.86
Plot 32	-3.2	22.2	-18.8	4.32	-5.23

Outputs

Plot: Graph14

Mangrove tree sample in coastal of Bac Lieu Province



1. Cóc trắng
Lumnitzera racemosa Willd



2. Đà vôi
Ceriops tagal ((Perr.)
C.B. Rob.



3. Đà quánh
Ceriops zippeliana Blume



4. Lức
Pluchea indica (L.) Lees



5. Lìm kìm
Psychotria serpens L.



6. Quao nước
Dolichandrone spathacea
(L.) K.Sch.



7. Ô rô tím
Acanthus ilicifolius L.



8. Ráng đại
Acrostichum aureum L.



9. Vẹt tru
Bruguiera cylindrica (L.)
Blume



10. Mắm trắng
Avicennia alba Blume



11. Mắm đen
Avicennia officinalis L.



12. Mắm biển
Avicennia marina
(Forssk.) Vierh



13. Tra lâm vô
Thespesia populnea (L.)
Soland ex Correa



14. Tra búp
Hibiscus tiliaceae L.



15. Giá
Excoecaria agallocha L.



16. Cóc kèn 5 lá
Deris indica Blume



17. Cóc kèn 3 lá
Derris trifoliata Lour



18. Nhàu
Morinda citrifolia L.



19. Cỏ nước mặn
Paspalum vaginicum Swort



20. Rau muống biển
Ipomoea pes-caprae (L.)



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



22. Phi lao
Casuarina equisetifolia L.



23. Phi lao
Casuarina sp.



24. Loã hùng
Gymnanthera nitida R.
Br.



25. Đước đôi
Rhizophora apiculata
Blume



26. Đưng
Rhizophora mucronata
Lamk



27. Dừa nước
Nypa fruticans Wurm



28. So đũa bông trắng
Sesbania grandiflora (L.)
Poiret.



29. So đũa bông đỏ
Sesbania punicea (Cav.)
Benth



30. Xu ổi
Xylocarpus granatum
Koenig



31. Me
Tamarindus indica L.



32. Me ngọt
Tamarindus sp.



33. Ngọc nữ biển
Clerodendron inerme (L.)
Gaertn



34. Bần ổi
Sonneratia ovata Backer



35. Bần chua
Sonneratia caseolaris (L.)
Engler



36. Ngoại mộc
Allophylus glaber Radlk

37. Cỏ U du
Cyperus elatus L.



38. Trâm bầu
Combretum



39. Đậu cộ
Canavalia lineata



40. Sam biển
Sesuvium portulacastrum
L.



41. Chùm lè (Thứ mật)
Azima sarmentosa
(Blume) Benth. & Hook.f.



42. Dây vác
Cayratia trifolia (L.)
Domino.



43. Me nước
Dalbergia candenatensis
(Dennst) Prain

44. Bàng
Terminalia catappa L.

45. Dừa
Cocos nucifera L.

46. Vọng cách
Premna integrifolia L.



47. Cỏ hôi
Ageratum conyzoides L.



48. Muồng hoa vàng
Cassia surattensis Burm



49. Điền điền
Sesbania sesban (L.) Merr.



Sạt lở ven biển



Quần xã Đước, Mắm
biển, Đà



Ngăn bờ nuôi tôm cản trở
tái sinh tự nhiên

Quần xã Dừa nước, Cóc
kèn 3 lá

Quần xã Đước - Mắm
biển trong vùng tôm

Pictures of mangrove biodiversity activities in Bac Lieu



Training on survey of mangrove diversity



Practice in the field



Land drilling in the field



The group surveyed in the field



Through the canal to investigate



Analysis samples in the field