



## DIVERSITY OF MANGROVE FLORA IN MUDFLATS OF KRUTHIVENNU MANDAL, KRISHNA DISTRICT

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### ABSTRACT

Mangroves are plant communities of the tropical and subtropical intertidal coastal zones which play an important and significant role in maintaining the coastal environment by reducing the impact of wave action and erosion in the coastal areas, preventing salinity and seawater ingress into the inland agricultural areas, and also providing protection to the coastline from the impact of cyclones. The present study was carried in mudflats mangrove patches, to find ecological status of the mangrove vegetation and to analyze significant changes). Results shows, *Avicennia marina* has highest Important Value Index (IVI) in Interu is 31.82, in Kruthivennu is 43.75 and in Nidamaru is 33.33. Maturity index values (MIV) of the field stations in the study area 67.00 of Interu, 61.00 of Kruthivennu and 71.00 of Nidamaru. Similarity indices (SI) is 100 and highest coefficient difference (CD) is 55.56. In the present study there is the densest mangrove vegetation at Nidamaru.

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### INTRODUCTION

Mangroves are opportunistic colonizers of intertidal along tropical and sub tropical coasts, these salt-tolerant trees that dominate the mudflats. Mudflats are described as very shallow, muddy areas along or near a shoreline that are exposed at low tide, at low tide the intertidal mud are exposed as a bare stretch of mud leaving water only in permanent channels while at high tide the mudflat is covered with water. Mudflats are recognized by Sutton, A, Sorenson, L & Keely, M. (2001) as one of the primary wetland ecosystems in the Caribbean. Mudflat ecosystems are very significantly influenced by biological, chemical and physical processes including predation and nutrient cycling and most of these processes are strictly influenced by the state of the tide (Hiscock, K. & Marshall, C. 2006).

Keshavarz, M, Kamrani, E, and Dabbagh (2013) undertook a study aimed at quantifying the higher macrobenthic infaunal taxa of mangrove mudflats at Khamir Por, Iran. Mangrove forests could play a crucial role in protecting coastal areas from sea level rise caused by climate change (Van Maanen *et al.*, 2015). Apart from these ecological functions, mangroves play a very significant economic role in the lives of the coastal village communities. The villagers are dependent on mangroves mainly for fodder, fuel-wood and fishing activities. Elliot *et al.* (1998) notes that mudflats typically have low

species diversity but support large numbers of particular kinds of animals especially invertebrates, many of which live buried in the [oxygen-poor] sediment and are specially adapted to life in these conditions. Other animals also exhibit special adaptations to living in mudflats and the ecosystem serves as an important food source for birds and fish. Curd (2009) noted that Intertidal areas such as mudflats dissipate wave energy, thus reducing the risk of eroding salt marshes, damaging coastal defenses and flooding low-lying land.

#### Study Area

Krishna district in Andhra Pradesh consists of 126 Sq.km mangrove vegetation protecting the coastal line by the uniqueness of vegetation present in between the riverine and coastal ecosystems. Krishna deltaic region covered by moderate dense mangrove forests is 39 Sq.km while that covered by open mangrove forests is 87 Sq.km.

Machilipatnam is from 16°10'N to 16°.17' N latitudes and from 81°09' E to 81.13°E longitudes on the southeast coast of India and in the eastern corner of Andhra Pradesh. Mangroves in this area are present between 16° 0'-16° 15'N latitude and 81° 10'-81° 15' E longitude. The northern tributary of Krishna river drains in this area near Hamsaladeevi.

Study areas are selected on the northward and eastward regions of agriculture drain systems to identify the mangrove diversity at which they join the sea. The study was carried out from June 2014 to May 2016. The study consists of the

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mudflat based villages in kruthivenu mandal viz., Interu, Kruthivenu, Nidamaru at which mangrove vegetation is present.

**Interu**

Interu is a medium size village located at a distance of 36.5 km from Machilipatnam. Interu is from 16° 20' 45"N latitudes and from 81° 19' 50"E longitudes. Its boundaries are Bay of Bengal on east and south side. It has 6 km coast line with Krishna river high tide and low tide zone the coastal side is full of mangrove forest.

**Kruthivenu**

kruthivenu is a large village located at a distance of 44.7 km from Machilipatnam. kruthivenu is from 16° 24' 21"N latitudes and from 81° 21' 28"E longitudes. Its boundaries are Bay of Bengal on east and south side. It has 6 km coast line with Krishna river high tide and low tide zone the coastal side is full of mangrove forest

**Nidamaru**

Nidamaru is a large village located at a distance of 41.9 km from Machilipatnam. Nidamaru is from 16° 21' 9"N latitudes and from 81° 23' 57"E Longitudes. Its boundaries are Bay of Bengal on east and south side. It has 5 km coast line with Krishna river high tide and low tide zone the coastal side is full of mangrove forest.

Volumes of the Department of Botany, Nagarjuna University, Guntur.

Various parameters like Frequency, Relative Frequency etc. are calculated by the using formulae (1) and (2),

$$\text{Frequency} = \frac{\text{No of occurrences of a species}}{\text{Total no of site samples taken}} \times 100 \quad (1)$$

$$\text{Relative Frequency} = \frac{\text{No of occurrences of particular species}}{\text{Total no of occurrences of all the species}} \times 100 \quad (2)$$

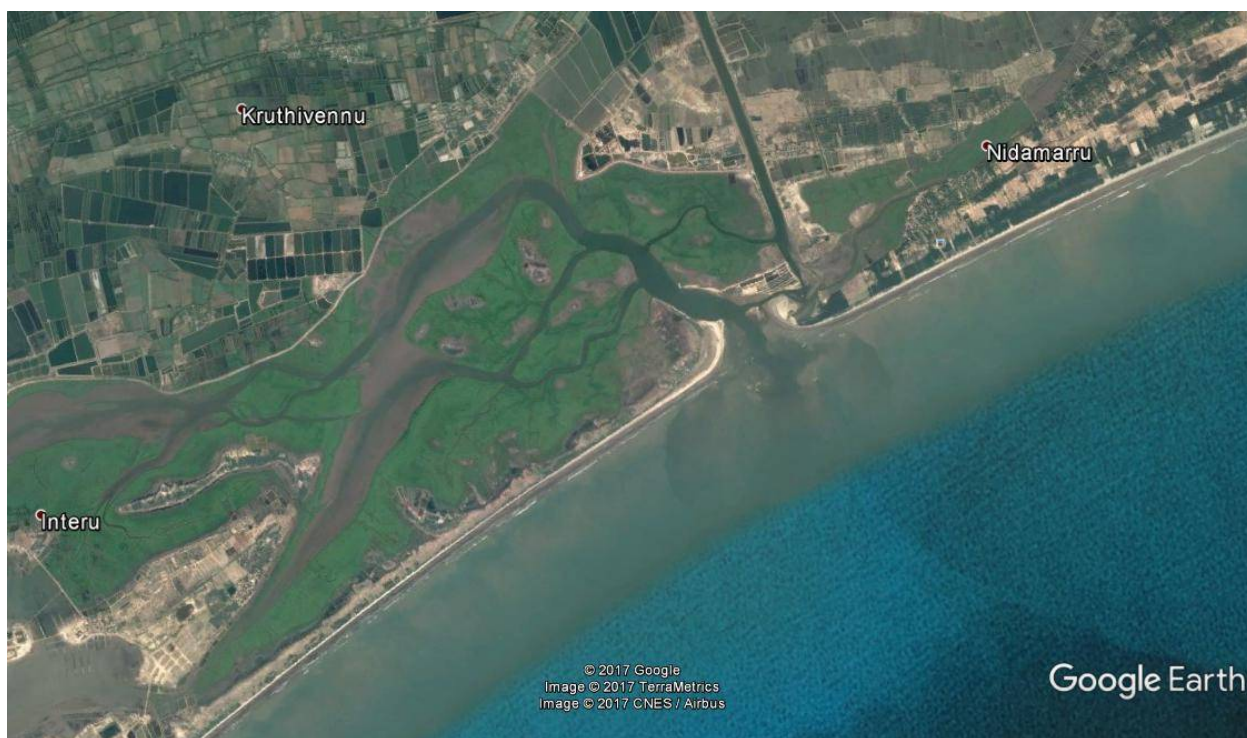
The values of relative frequency are calibrated on a 10-point scale to assign a status to the species in each region. Four distinct groups are derived from this 10-point scale and each group in each region is designated as follows:

7-10 Very Frequent; 5-7 Frequent; 3-5 Less Frequent; < 3 Rare

The abundance and density represent the numerical strength of species in the community (Mishra, 1968). Abundance is described as the number of individuals occurring per sampling unit and density as the number of individuals per sampling unit. Abundance and density were calculated using the formulae (3) (4) (5) and (6),

$$\text{Abundance (A)} = \frac{\text{Total number of individuals}}{\text{Number of Sampling units of occrance}} \times 100 \quad (3)$$

$$\text{Relative Abundance} = \frac{\text{Abundance of a particular species}}{\text{Sum of the abundances of all species}} \times 100 \quad (4)$$



**Figure 1** Satellite map showing the mangrove vegetation in mudflats of study area

**MATERIALS AND METHODS**

The mangrove vegetation ecological status was determined by making several field visits. Line transects of varying widths and quadrates from 4 m x 4 m to 10 m x 10 m are laid on either side of the creeks and data from each one are recorded from ten such transects / quadrats. Plant materials collected during sampling are identified with the help of the standard herbaria of the Botanical Survey of India and Gamble

$$\text{Density} = \frac{\text{Total no of individuals of a species in all quadrats}}{\text{Total no of quadrats sampled}} \times 100 \quad (5)$$

$$\text{Relative density} = \frac{\text{Density of a particular species}}{\text{Sum of the densities of all species}} \times 100 \quad (6)$$

**Importance Value Index (IVI)**

The concept of ‘Important Value Index (IVI)’ has been developed for expressing the dominance and ecological success of any species, with a single value, (Mishra, 1968). This index utilizes three characteristics, viz. relative

frequency, relative density and relative abundance. The three characteristics are computed using frequency, density and abundance for all the species falling in all the transects using formula (7),

$$IVI = \text{Relative frequency} + \text{Relative abundance} + \text{Relative density} \quad (7)$$

Maturity Index Value (MIV), Similarity Index (SI), Coefficient Difference (CD) are used to assess the maturity, similarity, diversity of mangrove vegetation among various field stations (Philips 1959).

**Maturity Index Value (MIV)**

The degree of maturity of a plant community is established based on the percent frequency of all species in the sites of study regions and divided by the number of species occurrence this is Maturity Index Value (MIV). Sampling is done by selecting 10 quadrats at each site and the frequency of each species is calculated, before calculating the percentage frequency. The Maturity Index Values are compared among different sites and it is inferred that the one nearer to 100 is highly matured in the community over others as suggested by Pichi-Sermolli (1948). The formulae for MIV is given in (8),

$$MIV = \frac{\text{Frequency of all species}}{\text{No of species studied}} \times 100$$

**Similarity Index (SI) and Coefficient Difference (CD)**

Expression of similarity of species and community coefficients indicate the degree of homogeneity of vegetation which reflects habitat status. The Similarity Index (SI) is calculated by using the formula (9) given by Oosting (1956).

$$S = \frac{2W}{(a+b)} \times 100 \quad (9)$$

where

- S = Similarity index between the sites being compared
- W = Sum of the species
- a = Total number of species in site number one
- b = Total number of species in site number two

The degree of similarity is determined among the sites as percentage of resemblance and categorised into highest, medium, lowest and no similarity. The corresponding Coefficient Difference (CD) values are obtained by subtracting the percentage similarity from 100. The formulae for CD is given in (10),

$$C.D = 100 - S$$

**RESULTS AND DISCUSSION**

**Mangrove vegetation**

The mangrove vegetation in the study area has been broadly classified into three main categories, based on the composition of species and distribution pattern. (Sasidhar.K and Brahmaji rao P. (2015).

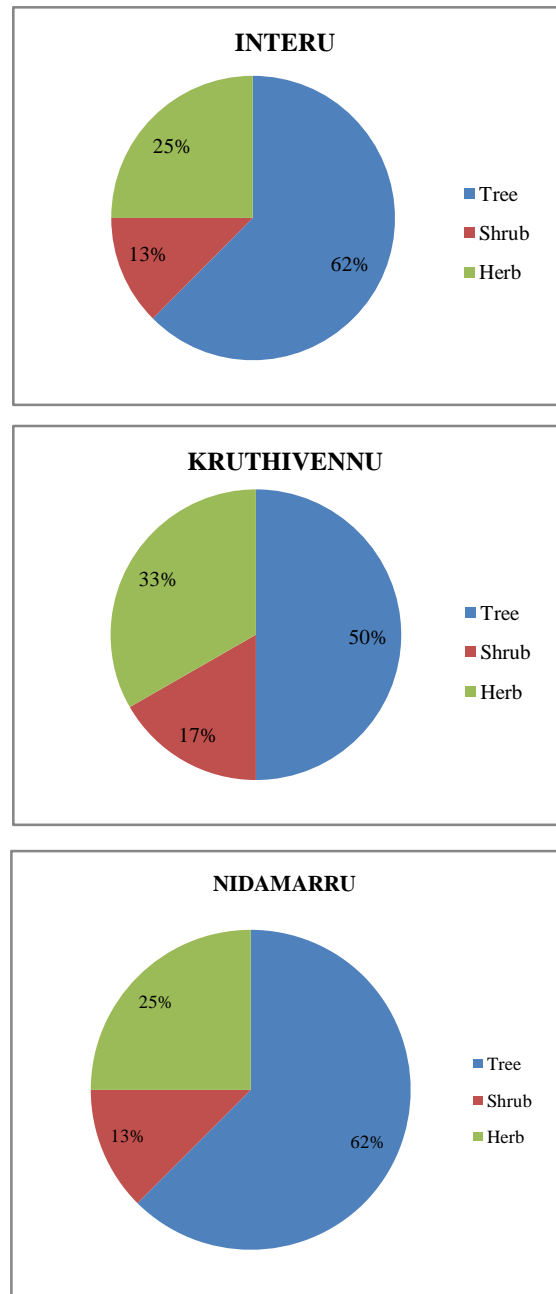
**Table 1** Systematic Position of the species present in the Mangrove Region of the Study area

S.No	Family	Name of the Species	Vernacular name	Habit
1	Avicenniaceae	<i>Avicennia marina</i>	Tellamada	Tree
2	Avicenniaceae	<i>Avicennia officinalis</i>	Nallamada	Tree
3	Rhizophoraceae	<i>Bruguiera gymnorhiza</i>	Thoddu ponna	Tree
4	Rhizophoraceae	<i>Ceriops decandra</i>	Calhasu / Thogara	Tree
5	Euphorbiaceae	<i>Excoecaria agallocha</i>	Tilla	Tree
6	Rhizophoraceae	<i>Rhizophora apiculata</i>	Ponna	Tree
7	Acanthaceae	<i>Acanthus ilicifolius</i>	Allchi	Shrub
8	Chenopodiaceae	<i>Suaeda maritima</i>	Elakura	Herb
9	Chenopodiaceae	<i>Suaeda monoica</i>	Elakura	Herb

The mangrove vegetation of the interior area consists of species of Avicenniaceae and Rhizophoraceae, central area consists of species of Euphorbiaceae and Acanthaceae, and peripheral area consists of species of Chenopodiaceae.

**Floral Composition**

Mangrove vegetation in the study area consisting of 9 genera and 9 species of 5 families has been recorded as 6 trees, 1 shrub and 2 herbs (Table-1). Habitat-wise distribution of mangroves in the three field stations of study area is shown in the (Figure-2(a) (b) and (c)).



**Figure 2(a, b and c)** Habitat-Wise Distribution of Mangroves In Study area

**Distribution Pattern in study areas**

The mangrove habitat-wise distribution is calculated in the three areas i.e. Interu, Kruthivenu and Nidamaru and species-wise distribution in those field stations (Figure-3) is discussed below, Nabi A. and Brahmaji Rao P. (2012).

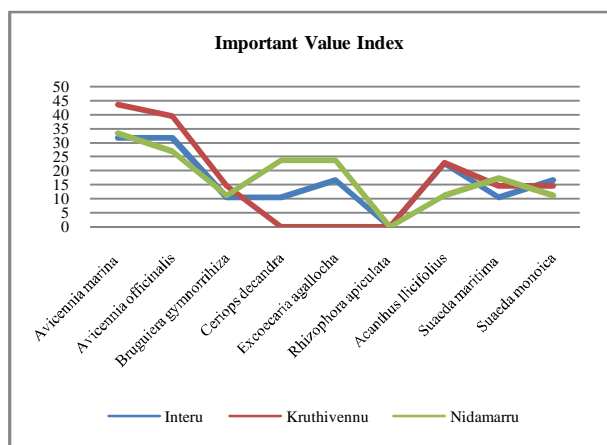


Figure 3 Distribution of Mangroves In Study area based on IVI values

**Interu**

Land areas towards sea influenced by river water, tidal inundation is moderate and hence the vegetation composition is moderate having 3 species like *Avicennia officinalis*, *Avicennia marina* and *Acanthus ilicifolius* are recorded in all the three areas. *Excoecaria agallocha* and *Suaeda monoica* Species are widely distributed only in two areas out of interior, central and peripheral areas. *Bruguiera gymnorrhiza*, *Ceriops decandra*, *Rhizophora apiculata* and *Suaeda maritima* have occasional occurrence in the interior and central zone. Habitat-wise distribution of mangrove vegetation in this region is observed as trees 62%, herbs 25 % and shrubs 13% (Figure-2 a).

Status of abundance of species is enumerated based on Relative Frequency values. 5 species with a Relative Frequency value ranging between 13.62 - 9.09 are “very frequent”. 3 species with a Relative Frequency value of 4.55 are “less frequent” followed by 1 specie with a Relative Frequency value 0 and fall in the category of “rare” status in this field station. It is worth noting that there are no species with “frequent” status and The Relative Frequency values and status of 9 existing species are shown in (Table-2).

**Kruthivennu**

Land areas towards sea influenced by river water, tidal inundation is moderate and hence the vegetation composition is moderate having 2 species like *Avicennia officinalis* and *Avicennia marina* are recorded in all the three areas. *Acanthus ilicifolius* Specie is widely distributed only in two areas out of interior, central and peripheral areas. *Excoecaria agallocha*, *Bruguiera gymnorrhiza*, *Ceriops decandra*, *Rhizophora apiculata*, *Suaeda maritima* and *Suaeda monoica* have occasional occurrence in the interior and central zone. Habitat-wise distribution of mangrove vegetation in this region is observed as trees 50%, herbs 33 % and shrubs 17% (Figure-2b).

Status of abundance of species is enumerated based on Relative Frequency values. 3 species with a Relative Frequency value ranging between 18.8- 12.5 are “very frequent”. 3 species with a Relative Frequency value of 6.25 are “frequent” followed by 3 specie with a Relative Frequency value 0 and fall in the category of “rare” status in this field station. It is worth noting that there are no species with “less frequent” status and The Relative Frequency values and status of 9 existing species are shown in (Table-2).

Species dominance is calculated based on the Important Value Index (IVI). In Kruthivennu the highest IVI value is 43.75 for *Avicennia marina* next for *Avicennia officinalis* by 39.58 followed by *Acanthus ilicifolius* with an IVI value of 22.92 (Table-3). The dominant species in this village is *Avicennia marina*.

**Nidamaru**

Land areas towards sea influenced by river water, tidal inundation is moderate and hence the vegetation composition is moderate having 5 species like *Avicennia officinalis*, *Avicennia marin*, *Ceriops decandra*, *Excoecaria agallocha* and *Suaeda maritima* are recorded in all the three areas. *Bruguiera gymnorrhiza*, *Acanthus ilicifolius* and *Suaeda monoica* Specie is widely distributed only in two areas out of interior, central and peripheral areas. *Rhizophora apiculata*

Table 2 Status of Mangrove Species based on Relative Frequency present at Interu, Kruthivennu and Nidamaru in study area

S.no	Name of the Plant Species	Interu			Kruthivennu			Nidamaru		
		Frequency %	Relative Frequency	Status	Frequency %	Relative Frequency	Status	Frequency %	Relative Frequency	Status
1	<i>Avicennia marina</i>	100	13.62	I	100	18.8	I	100	14.3	I
2	<i>Avicennia officinalis</i>	100	13.62	I	100	18.8	I	100	14.3	I
3	<i>Bruguiera gymnorrhiza</i>	33.33	4.55	III	33.33	6.25	II	33.33	4.76	III
4	<i>Ceriops decandra</i>	33.33	4.55	III	0	0	IV	100	14.3	I
5	<i>Excoecaria agallocha</i>	66.67	9.09	I	0	0	IV	100	14.3	I
6	<i>Rhizophora apiculata</i>	0	0	IV	0	0	IV	0	0	IV
7	<i>Acanthus ilicifolius</i>	100	13.62	I	66.67	12.5	I	33.33	4.76	III
8	<i>Suaeda maritima</i>	33.33	4.55	III	33.33	6.25	II	66.67	9.52	I
9	<i>Suaeda monoica</i>	66.67	9.09	I	33.33	6.25	II	33.33	4.76	III

> 7= Very Frequent-I, 5-7 = Frequent-II, 3-5 = Less Frequent - III, < 3 = rare - IV

Species dominance is calculated based on the Important Value Index (IVI). In Interu the highest IVI value is 31.82 for *Avicennia marina* and *Avicennia officinalis* next for *Acanthus ilicifolius* by 22.73 followed by *Excoecaria agallocha* and *Suaeda monoica* with an IVI value of 16.67 (Table-3). The dominant species in this village is *Avicennia marina* and *Avicennia officinalis*.

have occasional occurrence in the interior and central zone. Habitat-wise distribution of mangrove vegetation in this region is observed as trees 62%, herbs 25 % and shrubs 13% (Figure-2c).

Status of abundance of species is enumerated based on Relative Frequency values. 5 species with a Relative Frequency value ranging between 14.3 - 9.52 are “very frequent”. 3 species with a Relative Frequency value of 4.76 are “less frequent” followed by 1 specie with a Relative

Frequency value 0 and fall in the category of “rare” status in this field station. It is worth noting that there are no species with “frequent” status and The Relative Frequency values and status of 9 existing species are shown in (Table-2).

Species dominance is calculated based on the Important Value Index (IVI). In Nidamarru the highest IVI value is 33.33 for *Avicennia marina* next for *Avicennia officinalis* by 26.98 followed by *Excoecaria agallocha* with an IVI value of 23.81 (Table-3). The dominant species in this village is *Avicennia marina*.

**Table 3** Species dominance based on the Important Value Index (IVI) Values present in the study area

S.No	Name of the Plant Species	IVI Values in different field stations		
		Interu	Kruthivenu	Nidamarru
1	<i>Avicennia marina</i>	31.82	43.75	33.33
2	<i>Avicennia officinalis</i>	31.82	39.58	26.98
3	<i>Bruguiera gymnorrhiza</i>	10.61	14.58	11.11
4	<i>Ceriops decandra</i>	10.61	0.00	23.81
5	<i>Excoecaria agallocha</i>	16.67	0.00	23.81
6	<i>Rhizophora apiculata</i>	0.00	0.00	0.00
7	<i>Acanthus Ilicifolius</i>	22.73	22.92	11.11
8	<i>Suaeda maritima</i>	10.61	14.58	17.46
9	<i>Suaeda monoica</i>	16.67	14.58	11.11
	Total	151.52	150.00	158.73

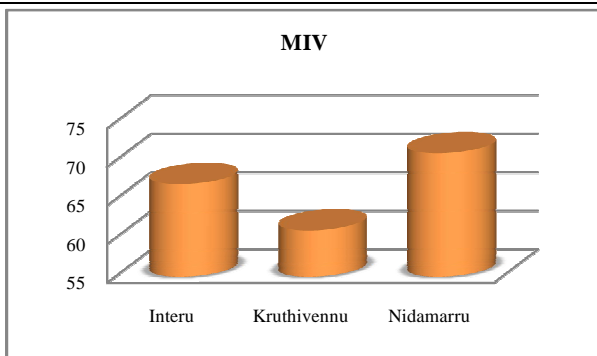
**Maturity Index**

Maturity index values of the field stations in the study area 67.00 of Interu, 61.00 of Kruthivenu and 71.00 of Nidamarru show that there is the densest mangrove vegetation at a place (Nidamarru in the present case), where there is a maximum frequency of inundation. Further, it can be inferred that places where there is less frequency of inundation, have less dense mangrove vegetation (Table -4). Prabhakar rao.V.V, Brahmaji rao.P (2017)

A comparison of MIV values of the study area is shown in the bar graph (Figure - 4)

**Table-4** Maturity Index Values (MIV) of Mangrove at different field stations of the Mangrove in the study area

S.No.	Name of the Plant Species	Frequency %		
		Interu	Kruthivenu	Nidamarru
1	<i>Avicennia marina</i>	100.0	100.0	100.0
2	<i>Avicennia officinalis</i>	100.0	100.0	100.0
3	<i>Bruguiera gymnorrhiza</i>	33.3	33.3	33.3
4	<i>Ceriops decandra</i>	33.3	0.0	100.0
5	<i>Excoecaria agallocha</i>	66.7	0.0	100.0
6	<i>Rhizophora apiculata</i>	0.0	0.0	0.0
7	<i>Acanthus Ilicifolius</i>	100.0	66.7	33.3
8	<i>Suaeda maritima</i>	33.3	33.3	66.7
9	<i>Suaeda monoica</i>	66.7	33.3	33.3
	Total	533.3	366.7	566.7
	MIV	67	61	71



**Figure 4** Station-Wise Maturity Index Values (MIV) of Mangrove Vegetation in study area

**Similarity Index**

Similarity Index for each station is calculated to know the extent of homogeneity of vegetation. Depending on the extent of homogeneity, the regions are categorized as given below:

80 to 100% --highest resemblance 60 to 80% -- medium resemblance

40 to 60% -- least resemblance 0 to 40% --no resemblance

**Table 5** Species-wise distribution pattern of different field stations of the Mangrove in study area

S.No.	Name of the Plant Species	Sites								
		1	2	3	4	5	6	7	8	9
1	<i>Avicennia marina</i>	+	+	+	+	+	+	+	+	+
2	<i>Avicennia officinalis</i>	+	+	+	+	+	+	+	+	+
3	<i>Bruguiera gymnorrhiza</i>	+	-	-	+	-	-	-	+	-
4	<i>Ceriops decandra</i>	-	+	-	-	-	-	+	+	+
5	<i>Excoecaria agallocha</i>	+	-	+	-	-	-	+	+	+
6	<i>Rhizophora apiculata</i>	-	-	-	-	-	-	-	-	-
7	<i>Acanthus Ilicifolius</i>	+	+	+	+	+	-	-	+	-
8	<i>Suaeda maritima</i>	-	+	-	-	-	+	+	-	+
9	<i>Suaeda monoica</i>	+	-	+	-	-	+	-	+	-
	Total no. of species in each station	6	5	5	4	3	4	5	7	5

The following table helps to understand the similarity in species diversity in study area

**Table 6** Similarity Index (SI) of Mangroves at different field stations of the study area

Site No	1	2	3	4	5	6	7	8	9
1	54.54	90.90	80.00	66.66	60.00	54.54	92.30	54.54	
2		60.00	66.66	75.00	66.66	80.00	66.66	80.00	
3			66.66	75.00	66.66	60.00	83.33	60.00	
4				85.71	50.00	44.44	72.72	44.44	
5					57.14	50.00	60.00	50.00	
6						66.66	54.54	66.66	
7							66.66	100	
8								66.66	

In the study area, majority of the sampling sites showed medium resemblances nearly in 18 sites with regard to species diversity with similarity indices ranging from 75.00 between sites 1&5, 1&6, 2&3, 2&4, 2&5, 2&6, 2&8, 3&4 and 3&5 to 60.00 between sites 3&6, 3&7, 3&9, 4&8, 5&8, 6&7, 6&9, 7&8 and 8&9. Similarly, the highest resemblance in 8 sites ranging from 100.00 between the sites 1&3, 1&8, 4&5 and 7&9 to 80.00 between the sites 1&4, 2&7, 2&9 and 3&4. The least resemblances nearly in 10 sites from 54.54 between the sites 1&2, 1&7, 1&9, 4&6 and 4&7 to 44.44 between the sites 5&6, 5&7, 5&9 and 6&8.(Table -6).

**Coefficient Difference**

In the study area highest coefficient difference of 55.56 is recorded between sub field stations 4&7 and 4&9 while the least coefficient difference value of 0.0 is obtained between the sub field stations 7&9. Other field stations show coefficient difference ranging from 50.50 to 7.70 (Table -7 ).

Coefficient Difference is made based on data present in the (Table-6)

**Table 7** Coefficient difference of Mangrove at different field stations of the Study area

Site No	1	2	3	4	5	6	7	8
1								
2	45.46							
3	9.10	40.00						
4	20.00	33.34	33.34					
5	33.34	25.00	25.00	14.29				
6	40.00	33.34	33.34	50.00	42.86			
7	45.46	20.00	40.00	55.56	50.00	33.34		
8	7.70	33.34	16.67	27.28	40.00	45.46	33.34	
9	45.46	20.00	40.00	55.56	50.00	33.34	00.00	33.34

## CONCLUSIONS

From the results of the present study the family Avicenniaceae is the single largest family in study. It is found that Nidamarru region has highly matured in the mangrove community.

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