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DIVERSITY OF EXOTIC PLANT SPECIES AND PHYTOSOCIOLOGICAL STUDIES OF DIGHA COAST, WEST BENGAL, INDIA

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Abstrct: The present study was conducted to investigate the exotic species diversity, population structure and distribution in Digha coast of West Bengal, India. A total of 39 taxa of exotic plant species belonging to 36 genera and 24 families were recorded from the Digha coast, Purba Medinipur, West Bengal**.** The number of dicotyledonous exotic coastal plant species was found to be 36 under 33 genera and 21 families, while 3 species of monocotyledons were found under 3 genera and 3 families.Highest important index value was reported for the species *Croton bonplandianum* (16.80), followed by *Cassia alata* (15.42), *Lanta camara* (12.88), *Calotropis gigantea* (10.95), *Acacia auriculiformis* (10.82), *Casuarina equisetifolia* (8.50), *Eupatorium odorata* (8.29). The Shannon-Weiner index value of 1.5, suggests a good and diverse species ecosystem in this coastal area.

***IndexTerms*- Plant diversity, phytosociological study, exotic plant, Digha coast.**

I. INTRODUCTION

An exotic species is non-indigenous andliving outside its native distributional range and arrives at a new place either by human activity or by other agents, deliberately or accidentally.Some of them may not have any negative effect on the new place of growing and may prove to be beneficial, instead. Coastal regions of India are home to many invasive species and different types of halophytes/mangrove are the major plant species of coastal area (Chapman, 1997). Apart from mangrove, beach plant communities form an important part of coastal vegetation and the plants belonging to beach plant communities tolerate salinity, sea-wind, sea waves, salty air, sand dunes formation and movement (Rao and Shastri, 1972). Most of the coastal regions of India are tourist spots and as a result, the plant communities of the coastal area are affected by commercial and tourism related activities. Digha is very popular and attractive coastal tourist spot in West Bengal, India.

Coastal dune vegetation has high ecological values and rich in genetic diversity and can be called as ecological storehouse (Untawale, 1994; Banerjee, 1994). The plant establishment, nature of growth and structure of plant community of any coastal area are subject to the influence of salinity, soil pH, organic matter changes and soil erosion (Arun et al., 1999). The present vegetation of Digha is not very old because Digha coast itself was formed only 500 years ago. One of the chief characteristics of the vegetation of the coastal area of Digha is its dynamic nature due to intense effect of biotic factors and fragile geological nature (Desai 2000; Chakraborty, 2010). The vegetation, in turn, also leaves much impact on sand dunes, geomorphology, sand erosion, sand accretion and sand stability.

The coastal region of Purba Medinipur is home to a rich variety of vegetation including many economic and medical plants. Samanta and Panda (2016) mentioned about a total of 80 families, 226 genera and 27 species in extended coastal belt of Digha. Sand dunes constitute a very important part of any coastal region (Bhakat, 2011) and coastal plant community plays significant roles to determine the structure and stability of the sand dunes. Because of the interaction as well as mutual dependence between the sand dunes and the vegetation upon them, the coastal inland gets separated from the active shoreline and that results in separated vegetation zones (Paul, 2002). Some of the important plants of Digha coast which play vital roles in this process are *Spinifex littorals*, *Ipomoea pres-carpea* etc.

The nature and variety of the plant community of any area depends on the naturally grown plants of the area as well as the plants which are planted by local people and by the forest department. The scope of ecotourism in Digha has been created by two factors: firstly, the deep connection between Digha's geographical condition and its cultural aspects; secondly, mutual influence of sand mass and vegetation upon one another (Mandal et al., 2013). According to a report (Chakraborty et al., 2012), local people of Digha have planted 60 plant species under 33 families for their various needs. Some of the important families among these are Poaceae, Papilionaceae, Convolvualaceae, Cyperacae etc. The nature, variety and survival of coastal plants are not only dependent on physical aspects of the area, but also upon the ecological and cultural aspects of the area (Carter, 1988).

Rao and Mehar Homje (1985) have classified Indian coastal areas into seven plains. Digha coastal belt belongs to Utkal and Bengal plain and this plain is constituted by Mahanadi delta, Bhadrak, Balashore and Kanthi, Midnapore coastal zone is an extension of this plain. There are a lot of similarities between Digha and the Odisha coastal zone adjacent to it. Many research works have been done on the vegetation of the coast of Odisha, but not much study have been done on the vegetation of Digha. In Odisha coast, *Hydrophylax maritime*, *Ipomoea pres-caprae*, *Launaeasermentosa* and *Spinifex littoreus* etc. are sand dunes pioneer species, and act as sand binder and protector of sand dunes from wind and waves. Coastal areas of Purba Medinipur district are characterized by continuously changing vegetation, both due to regular intense frequenting by visitors of astronomical figures, the dynamism of the area under the influence of strong wind current from the open sea on the eastern part and sea waves and also greatly because of the decisions and drives made by the government.
The present plant community of Digha belongs to two categories: a) naturally grown plants and b) the plants introduced by forest department, DSDA, Block, Panchayet and also by local people for various purpose. Bhakat (2001) mentioned that the function of some important plant of Digha a) *Spinifex littoreus*creates beachfront of shorelines, b) *Ipomoea pres-caprae* thwart the movement of dunes, and c) *Casuarina-Ipomoea-Pandanus* stabilize sand dunes, though it was a transient cultural effort only and out of them only *Casuarina equisetifolia* remained till date even being severely diminished in number. These species, however, help stabilize the shore and ultimately protect the shore from erosion and expedite the development of new coast. The active role of plants in coastal development is very much evident in Digha. The vegetation of the Digha coastal belt is rapidly changing, and many exotic plants have been planted in the area to prevent soil erosion, deforestation and pollution as well as to maintain the town's natural landscape in the face of fast urbanization. Das (2014) provided information on the plant communities in the Mohana and old Digha and mentioned about the exotic elements of ecological significance.
In Digha, the increases of invasive species like *Calotropis gigantea* and *Lantana camara* have caused the decrease of native species like *Ipomea pres-caprae.* Chakraborty et al. (2012) claimed that though plantation of tree species decreased soil erosion and absorbed the energy of wind, the plantation of *Casuarinaequisetifolia* tree could not show any significant result in the protection of coast in Digha. Das (2012) documented 90 plant species under 66 genera and 45 families in Digha coastal belt. But, it has been observed that the entire biodiversity including the flora and fauna of the area are constantly changing because of urbanization, firm establishment, industrialization and other development activities like constructing building and sewages system (Paul, 2002). The most notable plant of Digha is *Casuarinaequisetifolia*, but beneath this species, there are many other plants which are endangered by tourism related activities like picnic, car parking, horse riding and other recreational activities (Chakraborty, 2010).
Digha being a coastal belt, it is susceptible to tidal flood and cyclone, which alter the vegetation components and microbes, landscape, and animal community. Digha has already endured the Calcutta cyclone in 1737, Midnapore cyclone in1942, Sunderban cyclone in 1989 (Sing, 2007), Alia in 2009, BulBul in 2018, and Amphan in 2020. These devastating cyclones along with many other small cyclones and tidal floods have reconfigured the distribution of vegetation in Digha coastal belt. So, the change of diversity, distribution and establishment etc. of exotic plants as well as vegetation is a continuous process at Digha coastal belt. Topographically the study area of Digha exhibits a remarkable diversity as the coastal sand dune of the Bay of Bengal.
The eastern coastal part of India, the place is ecologically very dynamic and is subject to constant changes due to natural forces as well as human intervention. Digha being a busy, dynamic (Chetterjee, 1995) and flourishing tourist spot, many hotels, resorts etc. are illegally constructed very close to the sea. These construction works violate CRZ acts of India. As a result of rapid urbanization, the flora and fauna of the area are getting destroyed day by day. Many plants which this study has incorporated may not exist anymore. Besides, because of human activities likedumping of waste materials, heaping of construction materials etc. and new vegetation has appeared in places where there was none. All the changes in the vegetation in the last three years have been taken into account in this study.

II. MATERIALS AND METHODS

2.1 Study Area

The study area of Digha coast under Purba Medinipur district is having an area of (5.5 x 1) sq. km lies between 21^0 37' N to 22^0 39' N latitude and 87^0 29' E to 87^0 32' E longitude and it is located in the extreme South part of West Bengal.

2.2 Plant Species

Plant species exotic to India were taken into consideration. Enumerating all exotic species occurring in the study area, seven major ones were selected for detail study. These plants were *Acacia auriculiformis*A.Cunn.exBenth., *Calotropis gigantea* (L.) Dryand., *Eucalyptus robusta* Sm., *Eupatorium odoratum* L., *Lantana camara* L., *Melaleuca leucadendra* (L.) L., *Parthenium hysterophorus* L. etc.

2.3 Vegetation Sampling

Quadrate method (Sykes and Hornil, 1977) in its latest version was used for the present study. The size and number of quadrate was fixed at 10 meter × 10 meter unit for tree or herb plants and 5 meter × 5 meter unit for shrub or climber. The sampling was laid from sea shore line towards northern metal road (South to North). The transects were laid at the interval of 80 meters and the space between two rows of quadrate was fixed at 200 meters. Total one hundred quadrates comprising fifty 10m × 10m and fifty 5m × 5m plots were laid across 4.7 square kilometer area.

2.4 Phytosociological analyses

A couple of aspects, for example, density, frequency, abundance, relative density, relative frequency and relative abundance etc. were taken into consideration for these analyses.

Density

$$Density = \frac{Total\ no\ of Individuals}{Total\ no\ of quadrates\ used}$$

Frequency

$$Frequency = \frac{No\ of quadrate\ in\ which\ species\ occurred}{Total\ no\ of quadrates\ used}\ X\ 100$$

Abundance

$$Abundance = \frac{Total\ no\ of individuals\ of\ the\ species}{Total\ no\ of\ quadrates\ of\ occurrence}$$

Relative density

$$Relative\ Density(RD) = \frac{No\ of\ Individual\ of\ the\ species}{Number\ of Indivisual\ of all\ species}\ X\ 100$$

Relative frequency

$$Relative\ Frequence(RF) = \frac{No\ of\ occurrence\ of the\ species}{Number\ of\ occurrence\ of all\ species}\ X\ 100$$

Relative abundance

Relative abundance (%).= n/N X 100

n = total number of individuals of plant species under study

N = total number of individuals of all plant species

Relative abundance was determined according to a standard scale (Skubala, 1999). According to the scale all plant species were categorized as Eudominant (>10%), Dominant (5.1-10%), Subdominant(2.1-5%), Recedent (1.1-2%) and Subrecedent (<1%).

Important Value Index (IVI) = *Relative* **density + Relative frequency + Basal area**

Diversity Index (Shannon Index)

Margalef's (1968) formula

$H = - \frac{ni}{N} \log \frac{ni}{N}$

H = Shannon index of general diversity

ni= Number of individuals of the species

N = Number of individuals of all species

Simpson's (1949) Index of Dominance: Simpson Index (D) $=\sum\frac{n(n-1)}{N(N-1)}$

Where, n= the total number of organism of a particular species
N = the total number of organism of all species

III. RESULTS AND DISCUSION

Altogether 39 taxa of invasive alien plant species belonging to 36 genera and 24 families were recorded from the Digha coast, Purba Medinipur, West Bengal (Table 1). The number of dicotyledonous exotic plant species in Digha coast was found to be 36 under 33 genera and 21 families, while 3 species of monocotyledons were found under 3 genera and 3 families. The study revealed 24 species (61.5%) as herbs, followed by trees with 6 species (15.3%), shrub 8 species (20.5%), and climbers 1 species (2.5%) (Figure 1).

The life form pattern distribution showed that herbaceous species (24 spp.) were dominant over other life forms (Table 2). The habit distribution analysis showed that 56.4% (22 spp.) were perennials and 44.6% (17 spp.) were annuals. From the taxonomic distribution of alien flora, Asteraceae showed maximum representation (of 7 spp.) among the invasive alien species in the studied area, followed by Caesalpiniaceae (3 spp.), Mimosaceae (3 spp.), Papilionaceae (3 spp), Convolvulaceae (2 spp.), Myrtaceae (2 spp.), Solanaceae (2 spp.), and other Families represented by only 1 sp. of each (Table 4). These 7 dominant families contributed 22 species (56.4%) of the total invasive plant species studied (Figure 3). The genus *Cassia* showed the highest number of member species (3 spp.) and *Crotalaria* had 2 species.

The dicotyledonous exotic plant species in that coast were found to be 36 under 33 genera and 21 families, while 03 species of monocotyledons under 03 genera and 03 families were found. From the study, it was noted that 24 species (61.5%) were herbs, followed by trees with 06 species (15.3%), shrub 08 species (20.5%), and climbers 01 species (2.5%) (Figure 1).

Table 2: Total list of exotic plant of Digha coast

Sl No	Name	Family	Habit	Life Form	Local Name	Nativity
1	*Acacia auriculiformis*A.Cunn.exBenth.	Mimosaceae	P	T	Aakasia	Australia
2	*Argemone mexicana* L.	Papavaraceae	A	H	Shiyalkanta	Cent. & South America
3	*Blumealacera* (Burm.f.)DC.	Asteraceae	A	H	Kukurshunka	Trop. America
4	*Borassus flabellifer* L	Arecaceae	P	T	Taal	Trop. Africa
5	*Calotropis gigantea* (L.) Dryand.	Asclepiadaceae	P	S	Arak	Trop. Africa
6	*Cassia alata* L.	Caesalpiniaceae	P	S	Dadmari	West Indies
7	*Cassia occidentalis* L.	Caesalpiniaceae	P	H	Kalkasunda	Trop. & South America
8	*Cassia tora* L.	Caesalpiniaceae	P	H	Dadmari	Trop. & South America
9	*Casuarina equisetifolia* L	Casuarinaceae	P	T	Jhau	Australia
10	*Celosia argentea* L.	Amaranthaceae	A	H	Morogjhunti	Trop. Africa
11	*Corchorus aestuans* L.	Tiliaceae	A	H	Bon jhot	Trop. America
12	*Crotalaria pallida*Aiton.	Papilionaceae	A	H	Churchuri	Trop. America
13	*Crotalaria retusa* L.	Papilionaceae	A	H	Atasi	Trop. America
14	*Croton bonplandianum* Baill.	Euphorbiaceae	P	H	Churchuri	South America
15	*Cuscutareflexa* Roxb.	Cuscutaceae	A	H	Bon shon	Mediterranean
16	*Cyperus difformis* L.	Cyperaceae	P	H	Mutha	Trop. America
17	*Datura metel* L.	Solanaceae	P	S	Dhutra	Trop. America
18	*Ecliptaprostrata* (L.)Mant.	Asteraceae	A	H	Kalakista	Trop. America
19	*Eichhornia crassipes* (Mart.) Solms.	Pontedariaceae	P	H	Jhanjhi	Trop. America
20	*Eucalyptus robusta* Sm.	Myrtaceae	P	T	Potas	Australia
21	*Eupatorium odoratum* L.	Asteraceae	A	H	Matmatia	Trop. America
22	*Evolvulusnummularius* (L.) L.	Convolvulaceae	P	H	Vuinsusni	Trop. America
23	*Grangeamadera spatana* (L.) Poir	Asteraceae	A	H	Namuti	Trop. & South America
24	*Ipomoea quamoclit* L.	Convolvulaceae	P	H	Tarulata	Trop. America
25	*Lantana camara* L.	Verbenaceae	P	S	Chotra	Trop. America
26	*Mecardonia procumbens* (Mill.) Small	Plantaginaceae	A	S	Mikardana	Trop. & North America

27	*Melaleuca leucadendra* (L.) L	Myrtaceae	P	T	Rupsi	Australia
28	*Mikania micrantha* L.	Asteraceae	A	C	Rabanlata	Trop. America
29	*Mimosa pudica* L.	Mimosaceae	P	H	Lojjaboti	Brazil
30	*Opuntia stricta* (Haw.)Haw.	Cactaceae	P	S	Monsha	Trop. America
31	*Oxalis coruiculata* L.	Oxalidaceae	A	H	Amruli	Europe
32	*Parthenium hysterophorous* L.	Asteraceae	A	H	Parthenium	Trop. & North America
33	*Pithecellobium dulce* (Roxb.) Benth.	Mimosaceae	P	T	Kichimichi	Mexico
34	*Portulaca oleracea* L.	Portulaceae	A	H	Nunia	Trop. & South America
35	*Saccharum spontaneum* L.	Poaceae	A	H	Kash	Trop. & West Asia
36	*Sesbania grandiflora* Pers.	Papilionaceae	P	S	Bok ful	Trop. America
37	*Sida acuta*Burm.f.	Malvaceae	A	H	Berela	Trop. America
38	*Solanum torvum* Sw.	Solanaceae	P	S	Bonbegun	West Indies
39	*Tridex procumbens* L.	Asteraceae	P	H	Tridokhho	Mexico

The study revealed that 24 species as herbs followed by shrub with 8 species, tree 6 species and climber 1 species. In the Present Study area the highest important value index is observed for the species *Croton bonplandianum*(16.80) followed by *Cassia alata*(15.42), *Lanta camara* (12.88), *Calotropis gigantea* (10.95), *Acacia auriculiformis*(10.82), *Casuarina equisetifolia* (8.50), *Eupatorium odoratum* (8.29). **(Fig-1).** According to Raunkiaer (1934) classify to 5 frequency classes based on percentage of frequency. Class A, B, C, D and E has been marked with the species frequency ranging from i.e. class A (1-20), class B (21-40), Class C (41-60), Class D (61-80) and Class E (81-100). In this results A Class belongs to (11), B Class (6), C Class (16), D Class (4) and E Class belongs to 2 species respectively.

Table 3 Phytosociological attributes of Digha coast

Sl. no.	Name	Density	Frequency	Abundance	Relative Density	Relative Frequency	Shannon Diversity index	Simpson's index	Importance Value Index	Frequency class
1	**Acacia auriculiformisA.Cunn.ex Benth.**	**1.8**	**75.0**	**2.3**	**0.40**	**1.42**	**0.02**	**0.00**	**10.82**	**D**
2	**Argemone mexicana L.**	**0.5**	**33.3**	**1.5**	**0.11**	**0.63**	**0.01**	**0.00**	**4.74**	**B**
3	**Blumealacera (Burm.f.)DC.**	**2.3**	**25.0**	**9.3**	**0.53**	**0.47**	**0.03**	**0.00**	**4.00**	**B**

4	**Borassus flabellifer L**	**0.4**	**16.7**	**2.5**	**0.09**	**0.32**	**0.01**	**0.00**	**2.41**	**A**
5	**Calotropis gigantea (L.) Dryand.**	**2.3**	**75.0**	**3.1**	**0.53**	**1.42**	**0.03**	**0.00**	**10.95**	**D**
6	**Cassia alata L.**	**11.8**	**91.7**	**12.9**	**2.69**	**1.74**	**0.10**	**0.00**	**15.42**	**E**
7	**Cassia occidentalis L.**	**4.4**	**58.3**	**7.6**	**1.00**	**1.10**	**0.05**	**0.00**	**9.11**	**C**
8	**Cassia tora (L.) Roxb.**	**2.3**	**41.7**	**5.6**	**0.53**	**0.79**	**0.03**	**0.00**	**6.32**	**C**
9	**Casuarina equisetifolia L.**	**1.8**	**58.3**	**3.0**	**0.40**	**1.10**	**0.02**	**0.00**	**8.50**	**C**
10	**Celosia argentea L.**	**0.3**	**8.3**	**3.0**	**0.06**	**0.16**	**0.00**	**0.00**	**1.21**	**A**
11	**Corchorus aestuans L.**	**1.8**	**50.0**	**3.7**	**0.42**	**0.95**	**0.02**	**0.00**	**7.36**	**C**
12	**Crotalara pallida Aiton.**	**2.2**	**50.0**	**4.3**	**0.49**	**0.95**	**0.03**	**0.00**	**7.44**	**C**
13	**Crotalaria retusa L.**	**2.2**	**58.3**	**3.7**	**0.49**	**1.10**	**0.03**	**0.00**	**8.60**	**C**
14	**Croton bonplandianum L.**	**23.0**	**83.3**	**27.6**	**5.23**	**1.58**	**0.15**	**0.00**	**16.80**	**E**
15	**CuscutareflexaRoxb.**	**3.5**	**16.7**	**21.0**	**0.80**	**0.32**	**0.04**	**0.00**	**3.11**	**A**
16	**Cyperus difformis L.**	**6.5**	**41.7**	**15.6**	**1.48**	**0.79**	**0.06**	**0.00**	**7.27**	**C**
17	**Datura metel L.**	**0.7**	**33.3**	**2.0**	**0.15**	**0.63**	**0.01**	**0.00**	**4.78**	**B**
18	**Ecliptaprostrata (L.)L.**	**2.6**	**66.7**	**3.9**	**0.59**	**1.26**	**0.03**	**0.00**	**9.85**	**D**
19	**Eichhornia crassipes (Mart.) Solms.**	**11.5**	**16.7**	**69.0**	**2.61**	**0.32**	**0.10**	**0.00**	**4.93**	**A**
20	**Eucalyptus robusta Sm.**	**1.8**	**50.0**	**3.7**	**0.42**	**0.95**	**0.02**	**0.00**	**7.36**	**C**
21	**Eupatorium odoratum L.**	**11.0**	**41.7**	**26.4**	**2.50**	**0.79**	**0.09**	**0.00**	**8.29**	**C**

22	**Evolvulusnummularius (L.) L.**	**7.3**	**41.7**	**17.6**	**1.67**	**0.79**	**0.07**	**0.00**	**7.45**	**C**
23	**Grangeamaderaspatana (L.) Poir.**	**1.1**	**16.7**	**6.5**	**0.25**	**0.32**	**0.01**	**0.00**	**2.56**	**A**
24	**Ipomoea quamoclit L.**	**0.5**	**16.7**	**3.0**	**0.11**	**0.32**	**0.01**	**0.00**	**2.43**	**A**
25	**Lantana camara L**	**10.8**	**75.0**	**14.4**	**2.46**	**1.42**	**0.09**	**0.00**	**12.88**	**D**
26	**Mecardonia procumbens (Mill.) Small**	**0.3**	**16.7**	**1.5**	**0.06**	**0.32**	**0.00**	**0.00**	**2.37**	**A**
27	**Melaleuca leucadendron (L.) L**	**1.5**	**41.7**	**3.6**	**0.34**	**0.79**	**0.02**	**0.00**	**6.13**	**C**
28	**Mikania scandens B.L.Rob.**	**6.0**	**25.0**	**24.0**	**1.36**	**0.47**	**0.06**	**0.00**	**4.84**	**B**
29	**Mimosa pudica L.**	**4.3**	**41.7**	**10.2**	**0.97**	**0.79**	**0.04**	**0.00**	**6.75**	**C**
30	**Opuntia stricta**	**0.4**	**16.7**	**2.5**	**0.09**	**0.32**	**0.01**	**0.00**	**2.41**	**A**
31	**Oxalis coruiculata**	**0.8**	**33.3**	**2.3**	**0.17**	**0.63**	**0.01**	**0.00**	**4.80**	**B**
32	**Parthenium hysterophorous L.**	**8.0**	**41.7**	**19.2**	**1.82**	**0.79**	**0.07**	**0.00**	**7.61**	**C**
33	**Pithecellobium dulce (Roxb.) Benth.**	**0.3**	**16.7**	**1.5**	**0.06**	**0.32**	**0.00**	**0.00**	**2.37**	**A**
34	**Portulaca oleracea**	**0.6**	**16.7**	**3.5**	**0.13**	**0.32**	**0.01**	**0.00**	**2.45**	**A**
35	**Saccharum spontaneum L.**	**11.4**	**8.3**	**137.0**	**2.59**	**0.16**	**0.09**	**0.00**	**3.75**	**A**
36	**Sesbania grandiflora**	**0.3**	**25.0**	**1.0**	**0.06**	**0.47**	**0.00**	**0.00**	**3.53**	**B**
37	**Sida acuta Burm.f.**	**3.6**	**41.7**	**8.6**	**0.81**	**0.79**	**0.04**	**0.00**	**6.60**	**C**
38	**Solanum torvum Sw.**	**1.7**	**50.0**	**3.3**	**0.38**	**0.95**	**0.02**	**0.00**	**7.33**	**C**

39	**Tridex procumbens L.**	**5.4**	**41.7**	**13.0**	**1.23**	**0.79**	**0.05**	**0.00**	**7.02**	**C**

Table 4: Phytosociological attributes of tree exotic species of Digha coast

Sl. no.	Name	Density	Frequency	Abundance	Relative Density	Relative Frequensy	Shannon Diversity index	Simpson's index	Importance Value Index	Frequency class
1	Acacia auriculiformisA.Cunn.exBenth.	1.8	75.0	2.3	0.40	1.42	0.02	0.00	10.82	D
2	Borassus flabellifer L	0.4	16.7	2.5	0.09	0.32	0.01	0.00	2.41	A
3	Casuarina equisetifolia L.	1.8	58.3	3.0	0.40	1.10	0.02	0.00	8.50	C
4	Eucalyptus robusta Sm.	1.8	50.0	3.7	0.42	0.95	0.02	0.00	7.36	C
5	Melaleuca leucadendron (L.) L	1.5	41.7	3.6	0.34	0.79	0.02	0.00	6.13	C
6	Pithecellobium dulce (Roxb.) Benth.	0.3	16.7	1.5	0.06	0.32	0.00	0.00	2.37	A

Table 5:Phytosociological attributes of shrub exotic specis of Digha coast

Sl. no.	Name	Density	Frequency	Abundance	Relative Density	Relative Frequensy	Shannon Diversity index	Simpson's index	Importance Value Index	Frequency class
1	Calotropis gigantea (L.) Dryand.	2.3	75.0	3.1	0.53	1.42	0.03	0.00	10.95	D
2	Cassia alata L.	11.8	91.7	12.9	2.69	1.74	0.10	0.00	15.42	E
3	Datura metel L.	0.7	33.3	2.0	0.15	0.63	0.01	0.00	4.78	B
4	Lantana camara L	10.8	75.0	14.4	2.46	1.42	0.09	0.00	12.88	D
5	Mecardonia procumbens (Mill.) Small	0.3	16.7	1.5	0.06	0.32	0.00	0.00	2.37	A
6	Opuntia stricta	0.4	16.7	2.5	0.09	0.32	0.01	0.00	2.41	A
7	Sesbania grandiflora	0.3	25.0	1.0	0.06	0.47	0.00	0.00	3.53	B
8	Solanum torvum Sw.	1.7	50.0	3.3	0.38	0.95	0.02	0.00	7.33	C

Table 6: Phytosociological attributes of herb & climber exotic specis of Digha coast

Sl. no.	Name	Density	Frequency	Abundance	Relative Density	Relative Frequency	Shannon Diversity index	Simpson's index	Importance Value Index	Frequency class
1	Argemone mexicana L.	0.5	33.3	1.5	0.11	0.63	0.01	0.00	4.74	B
2	Blumealacera (Burm.f.)DC.	2.3	25.0	9.3	0.53	0.47	0.03	0.00	4.00	B
3	Cassia occidentalis L.	4.4	58.3	7.6	1.00	1.10	0.05	0.00	9.11	C
4	Cassia tora (L.) Roxb.	2.3	41.7	5.6	0.53	0.79	0.03	0.00	6.32	C
5	Celosia argentea L.	0.3	8.3	3.0	0.06	0.16	0.00	0.00	1.21	A
6	Corchorus aestuans L.	1.8	50.0	3.7	0.42	0.95	0.02	0.00	7.36	C
7	Crotalara pallida Aiton.	2.2	50.0	4.3	0.49	0.95	0.03	0.00	7.44	C
8	Crotalaria retusa L.	2.2	58.3	3.7	0.49	1.10	0.03	0.00	8.60	C
9	Croton bonplandianum L.	23.0	83.3	27.6	5.23	1.58	0.15	0.00	16.80	E
10	Cuscutareflexa Roxb.	3.5	16.7	21.0	0.80	0.32	0.04	0.00	3.11	A
11	Cyperus difformis L.	6.5	41.7	15.6	1.48	0.79	0.06	0.00	7.27	C
12	Ecliptaprostrata (L.)L.	2.6	66.7	3.9	0.59	1.26	0.03	0.00	9.85	D
13	Eichhornia crassipes (Mart.) Solms.	11.5	16.7	69.0	2.61	0.32	0.10	0.00	4.93	A
14	Eupatorium odoratum L.	11.0	41.7	26.4	2.50	0.79	0.09	0.00	8.29	C
15	Evolvulusnummularius (L.) L.	7.3	41.7	17.6	1.67	0.79	0.07	0.00	7.45	C
16	Grangeamaderaspatana (L.) Poir.	1.1	16.7	6.5	0.25	0.32	0.01	0.00	2.56	A
17	Ipomoea quamoclit L.	0.5	16.7	3.0	0.11	0.32	0.01	0.00	2.43	A
18	Mikania scandens B.L.Rob.	6.0	25.0	24.0	1.36	0.47	0.06	0.00	4.84	B
19	Mimosa pudica L.	4.3	41.7	10.2	0.97	0.79	0.04	0.00	6.75	C
20	Oxalis coruiculata	0.8	33.3	2.3	0.17	0.63	0.01	0.00	4.80	B
21	Parthenium hysterophorous L.	8.0	41.7	19.2	1.82	0.79	0.07	0.00	7.61	C
22	Portulaca oleracea	0.6	16.7	3.5	0.13	0.32	0.01	0.00	2.45	A
23	Saccharum spontaneum L.	11.4	8.3	137.0	2.59	0.16	0.09	0.00	3.75	A
24	Sida acuta Burm.f.	3.6	41.7	8.6	0.81	0.79	0.04	0.00	6.60	C
25	Tridex procumbens L.	5.4	41.7	13.0	1.23	0.79	0.05	0.00	7.02	C

The study revealed 24 species as herbs, followed by shrub with 8 species (15.3%), tree 6 species (20.5%), and climbers 1 species (2.5%). Among the tree species highest IVI found in *Acacia auriculiformis*(10.82), followed by *Casuarina equisetifolia* (8.50) and *Eucalyptus robusta* (7.36) which are shown in fig–A, whereas, in shrubby species the highest IVI found in *Cassia alata* (15.42), *Lanta camara* (12.88), *Calotropis gigantea* (10.95), show in fig–B. Among the herbaceous species highest IVI found in *Croton bonplandianum*(16.80), then *Eupatorium odorata* (8.29) and *Parthenium hysterophorous* (7.61) shown in fig – C. Diversity Index is proportionally related with the IVI of a plant community.
Highest Shanon-Diversity Index has been recorded for *Croton bonplandianum* (0.15) and lowest for *Pithecellobium dulci*. This index helps to estimate species diversity of a community. The highest species diversity index found in herbaceous and climber species (1.14), lowest species diversity index found in tree species (0.10) and moderate species diversity found in shrub species (0.25). In this study it is seen that the area covered by tree and shrubs are quite less and gradually decreasing, because of the area being a popular tourist spot and a highly economic zone, construction of building, beautification artificially with abiotic elements, extension of road etc. for the purpose of economic development. In recent time, while this study was going on, little sporadic efforts of plantation with *Casuarina equisitefolia*, *Calotropis gigantea*, *Pandanas*spp and *Opunctia stricta* etc. on the part of government were witnessed. For the reason of artificial plantation natural regenerations from exotic plants of earlier plantations like *Acacia auriculiformis, Casuarina equisitefolia, Eucalyptus robusta and Melaleuca leucodendra* were witnessed to get replaced at Digha coastal belt.
The results revealed that out of 34 families the top 5 families have an abundance of 54.45% of the total exotic abundance in the Digha coastal area (Table-2). Seventeen families were represented by single exotic species with an abundance of 154.5 individuals which account for 45.72% of total abundance.

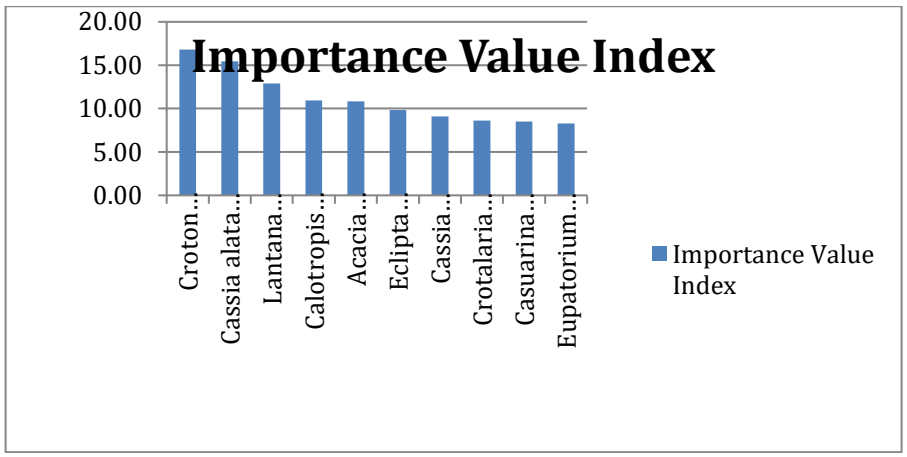

Figure 1: Top 10 Important Value Index Species

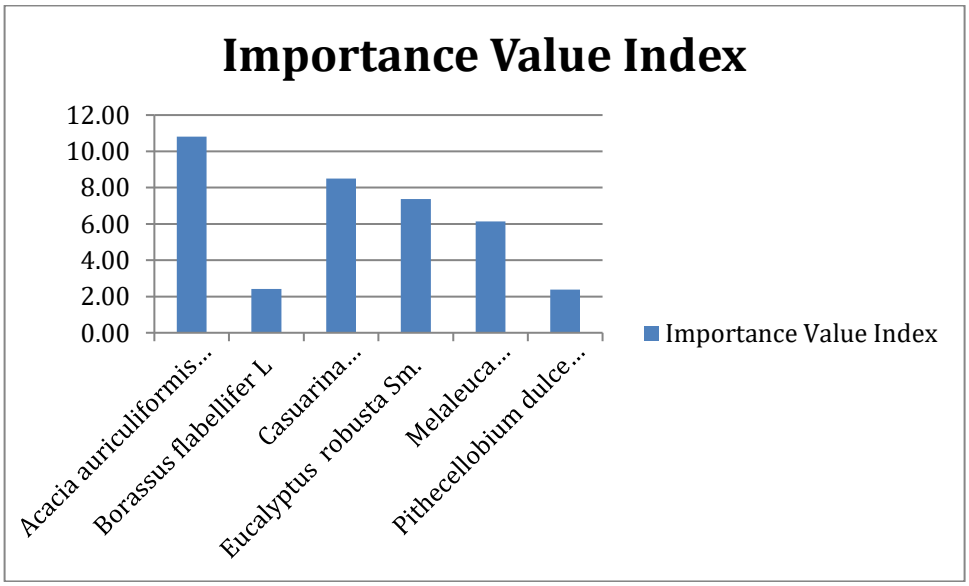

Figure 2: Important Value Index of tree exotic Species of Digha coast

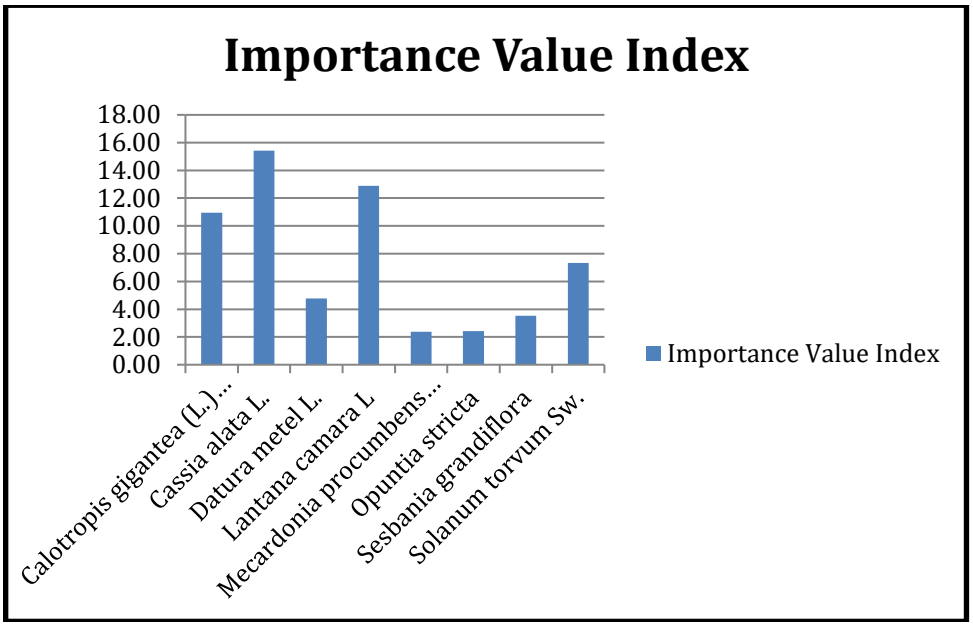

Figure 3. Important Value Index of shrub exotic species of Digha Coast

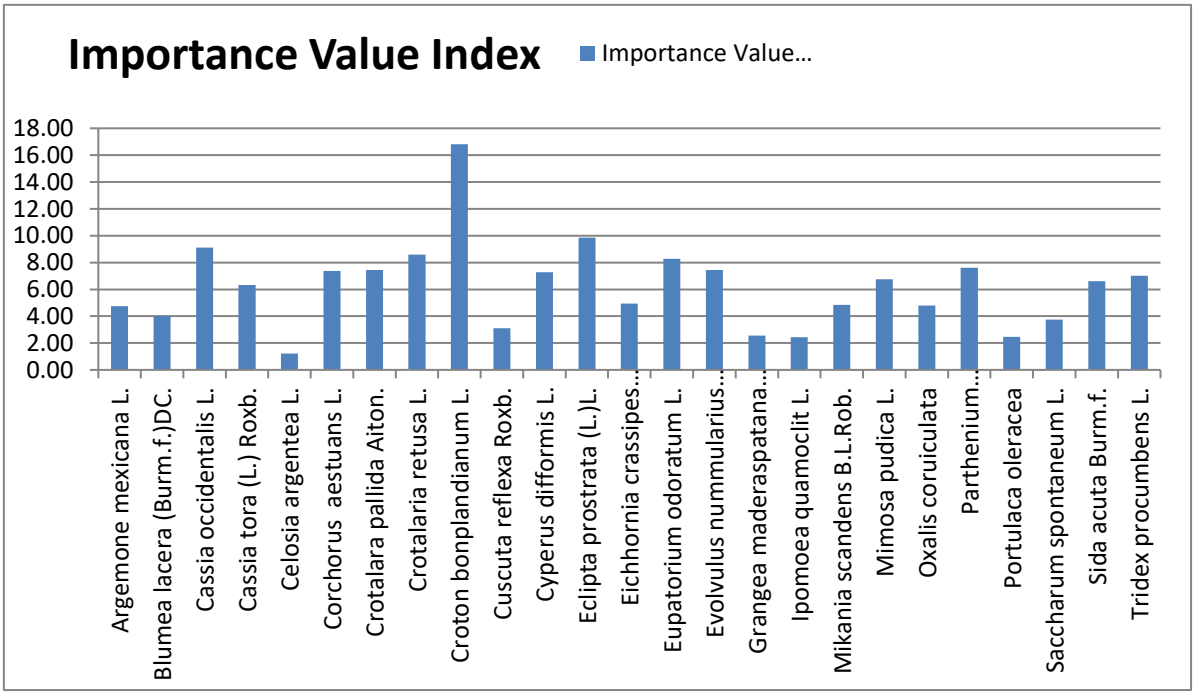

Figure 4. Important Value Index of herb exotic Species of Digha coast

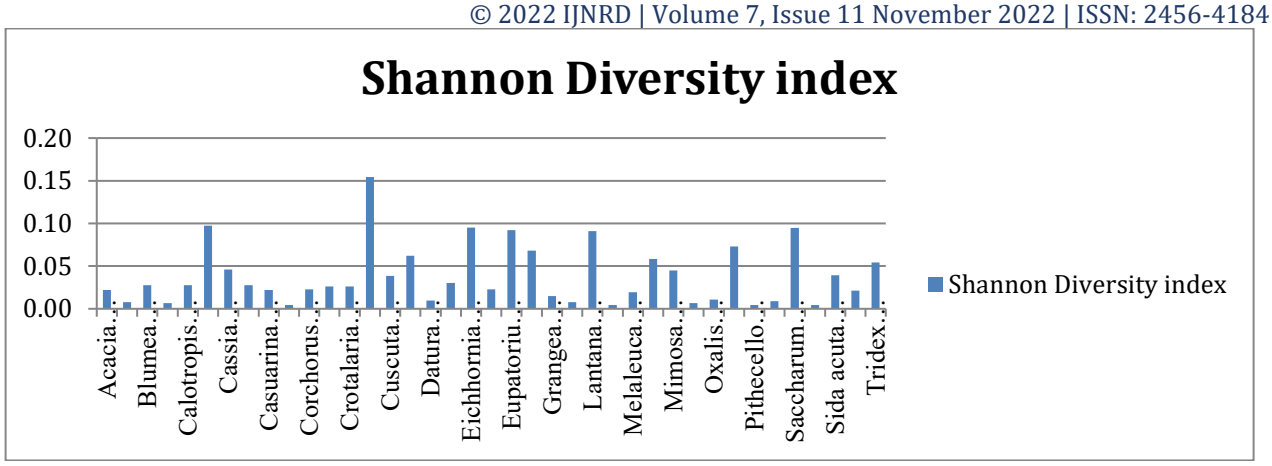

Figure 5. Shannon Diversity Index of exotic species of Digha coast

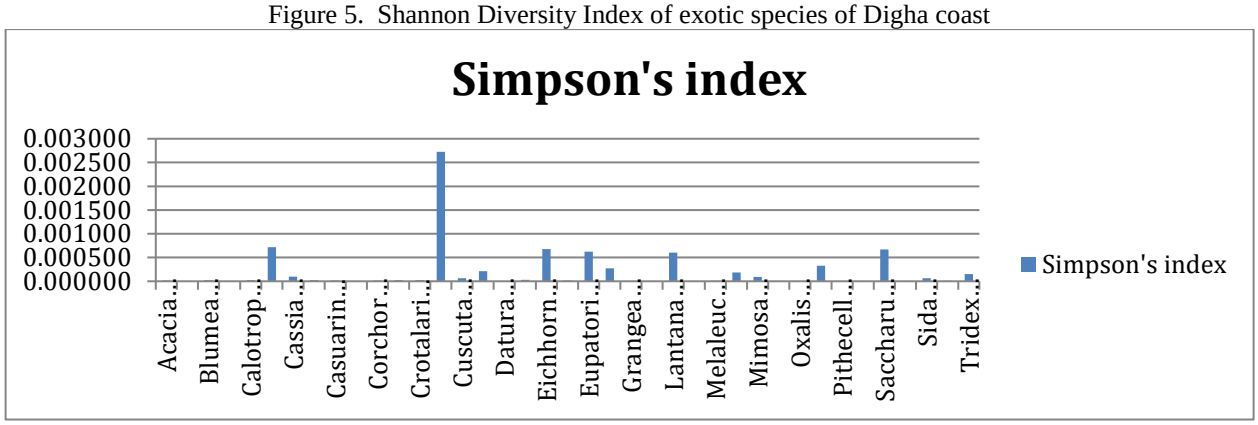

Figure 6. Simpson's Diversity Index of exotic species of Digha coast

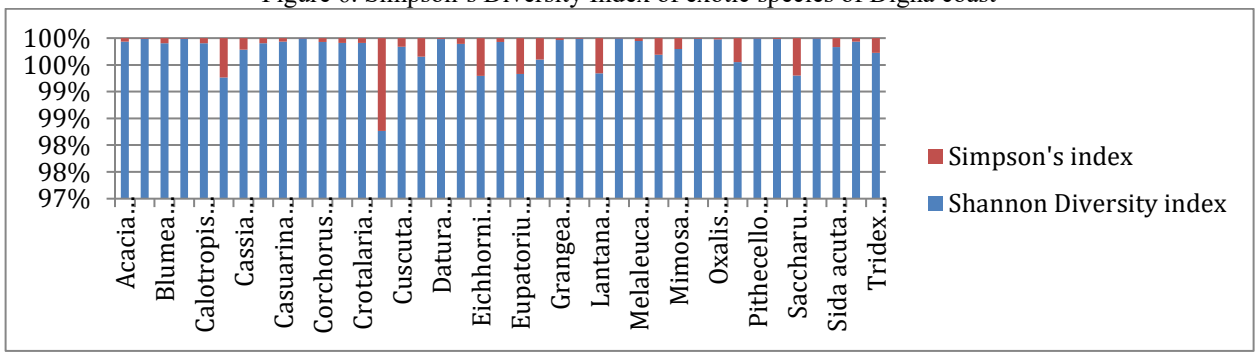

Figure 7. Comparison of Shannon Diversity Index and Simpson's Index of exotic species of Digha coast

Enumeration of exotic plant species diversity and distribution are very important for sustainable vegetation management, conservation of desire plant species and also complete ecosystems management (Kacholi, 2014). The present study has described the exotic plant species diversity, distribution and dynamics of Digha coastal belt of most southern part of West Bengal, India. In any ecosystem the plant diversity is measured by the density, frequency, abundance, composition and distribution of the individual plant species (Wattenberg and Breckle, 1995). The abundance of any plant species is the strong numerical data for bio-statistical analysis (Misra, 1968). The present study has noted that *Acacia auriculiformis*, *Casuarina equisitefolia* and *Eucalyptus robusta* as tree exotic plants, *Cassia alata*, *Eupatorium odorata* and *Lantana camara* as shrub plants and *Parthenium hysterophorus* as herbs plants recorded the highest density values among the exotic plant species of Digha coast. However, the establishment of exotic plant species in Digha coastal belt is dominated by only few species (Bhakat, 2012; Samanta and Panda, 2016) and some distribution similarities noticed by these researchers. In Digha, the increases of invasive species like *Calotropis gigantea* and *Lantana camara* have caused the decrease of native species like *Ipomeapres-caprae* (Chakraborty et al., 2012). The most notable plant of Digha is *Casuarina equisetifolia*, but many other plants growing as understory were found to be severely damaged and destroyed by tourism-related activities like picnic, car parking, horse riding and other recreational activities (Chakraborty, 2010). Different researches (Barman et al., 2015) have shown that the heavy human interference, huge urbanization, beautification and road construction led to the higher density of only few species at Digha coastal area. The Shannon-Weiner index for Digha coast was measured as 2.15, which suggests a good and diverse exotic plant species ecosystem in this tourist spot. The converse index is obtained between the Shannon's maximum diversity index and Simpson's diversity index which indicates the dominance and

diversity of the trees species and they formed the mirror image (Tiwari, 1993). The Importance Value Index (IVI) is used for species conservation measures whereby the plant species with lower IVI value need high conservation (if necessary) than those tree species with higher IVI values (Kacholi, 2014). The presence of many tree species such as *Pithecellobium dulce* (Roxb.) Benth. (2.37), *Borassus flabellifer* L. (2.41) and *Melaleuca leucadendron* (L.) L. (6.13) etc. with lower IVI in the present study indicates that those species should be given more conservation priorities, also the families with lower FIV needs serious attention for the proper maintenance of greenery of Digha coastal area for future. The rarity of IVI could be attributed to various, such as poor distribution of species, anthropogenic disturbances, competition between species, etc. (Hubbell et al., 2001; Schwarz et al., 2003 Comita et al., 2007).

With the other local vegetation exotic plants grow simultaneously, but the colony of exotic plants larger than native vegetation. This distribution of diverse kind of exotic plants may be due to increased competition for water, light and available nutrients. The probable allelopathic interaction by exotic plants might inhibit the growth of other native plants (Hierro and Callaway, 2003), which may be the most plausible explanation for the less occurrence of native plants in contrast with the remarkable growth of exotic species. The finding of Haderlie et al (1989) like many other workers supported such impact due to inter specific competition and allelopathy on crop plants in Canada.

CONCLUSION

This study showed quite a remarkable diversity of exotic species in Digha coastal area providing a considerable coverage, even amidst an increasing threat of urbanization for the sake of tourism. Anthropogenic activities has remained the main threat for the vegetation, be it a case of natural or artificial plantation. The present study portrayed the present status of the diversity as well as distribution of exotic plants in that area. It leaves an account and would enable to understand the nature and extent of change, if any takes place, in future.

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