International Journal of Sciences & Applied Research

www.ijsar.in

A Floristic Study of stressed rivers of The Western Ghats

Ayantika Das[1]*, Jigna Desai[2]

[1,2]Department of Biosciences, Veer Narmad South Gujarat University, Surat 395007, Gujarat, India.

Corresponding author: *Ayantika Das, Department of Biosciences, Veer Narmad South Gujarat University, Surat 395007, Gujarat, India.

Abstract

The principal objective of the present research work is to determine the floristic composition of riverine ecotones and determine the factors responsible for the floristic pattern of two stressed rivers of Valsad district in the northern part of the Western Ghats. We have studied the floristic diversity of the thirteen study area for two years and analyzed the same using ecological models. Floristic diversity of the area is qualitatively determined using the Jaccardian index of various riverine sites, and quantitatively determined by the Important Value Index of trees, and frequency, abundance, and density of herbaceous cover. A total of 221 species were recorded represented by 183 genera of 64 families. We analyzed the difference in vegetation composition between two rivers is mainly due to geological and climatic reason and little anthropogenic influence was also observed. Finding the most prototypical stress factor affecting the floristic diversity of the riverine ecotone of hilly tracks of northern the Western Ghats and creating a database of the same will help in better preservation of biodiversity. This will guide future ecologists and governmental bodies in environmental management.

Keywords: Floristic diversity; Western Ghats; Jaccardian similarity Index; Important Value Index

Introduction

The river is a complex ecosystem. In India, rivers play an important role in human civilization as the water used in all spheres of life. The riverine ecosystem includes aquatic macrophytes, microphytes, and plants of the ecotone. The riverine ecotones are shelter zone for the surrounding terrestrial and aquatic patches (Chapman et al, 1996), are most biodiverse region as compared to surrounding terrestrial and aquatic ecosystems. Any change in the physicochemical characteristic of this zone will affect the flora of this zone as well as the adjacent lake ecosystem (Schmieder et al, 2004). Ecology of any ecosystem depends on the interaction among abiotic and biotic factors. Now a day, due to increased demand for land, forested areas converted into agricultural land, industrial belts, and the urban area leading to loss of habitat as well as habitat fragmentation for both flora and fauna (Thuiler, 2016). We need to ascertain whatever biodiversity left in these already stressed habitats for their much-needed preservation. Preservation of biodiversity needed to maintain the stability of the ecosystem. For sustainable management of the resources of the riverine ecotones, we need to create a floristic database at the taluk level.

Floral biodiversity of riverine ecotones affects the ecological status of the rivers. As ecotones protect the surrounding ecosystem and control their nutrient cycling, we should recover and restore the degraded ecotones to preserve the river and its surroundings. These days due to the pressure of urbanization dimension of these areas reduced. A survey conducted of rivers of Valsad district to interpret the floristic structure and composition of lacustrine ecotone vegetation. Taxonomic Similarity index used to elucidate the beta diversity of the floristic composition of the riverine ecotone plants, island vegetation (Izsak et al, 2001) has a similar function with the Jaccardian similarity index. Jaccardian similarity index used in ecology, genetics, biochemistry, and molecular biology researches (Real et al, 1996). Many a time Jaccardian indexes modified based on specific research requirements such as the Tanimoto similarity index for pharmaceutical and chemical research. There are other similarity indexes such as the Sorensen index based on the same principle (Soosairaj et al, 2005; Goodall, 1978). These similarity indexes hold good so far the sample sizes are not too small. Jaccardian index used to find the presence or absence of species diversity of sites. As each riverine site has a different microhabitat, so it is likely to have slightly different species diversity. The presence of homogeneity in the specie composition will indicate similar disturbance at various sites.

In our study, we have characterized riverine sites based on stress factors. Effect of various stress factors that were present in the study sites listed and how they affect the floral diversity analyzed. Stress can be due to environmental as well as anthropogenic causes. Floristic diversity of a site is a mirror of the level of stress the particular ecosystem is enduring. The presence of ruderals specie indicates a disturbance of the site. Cyano and the algal bloom is an indicator of eutrophication (Jaanus et al, 2009), low pH, rise in temperature of the water, and vertical mixing of water of a lake. Although they can also be due to changes in the precipitation, pattern, or intensifying storm that causes enrichment of water due to lakes. Eventually, they die and decompose to produce toxic gases such as ammonia, characterized by offensive odor (Vasconcelps, 2006).

Since riverbanks are in the middle of human settlement, so naturally it is used for bathing of animals as well as human. Besides, some riverine regions used for agriculture, so agricultural runoff from the surrounding ecotone can cause eutrophication leading to cyano and algal blooms and fish kills (Jia Y Li et al, 2018). Cyan bloom was observed in every country for example lake Tai (3rd largest lake in China). They occur mostly during summer or early fall. No such bloom found in our study area during our course of study. Factors that effects the growth of aquatic plants are salinity, siltation, and the flow of fertilizer or pesticide and water availability.

Materials and methods

Description of the study area

Flora of two stressed rivers Auranga and Par and its immediate surroundings in Valsad district studied for two years. Research carried out in Valsad district lies at a latitude of 20.6100 N and longitude of 72.9260E, located in the northern tip of Western Ghats. The total riverine stretch understudy was 47.80 km for the Auranga River and 51.25 km in the case of Par River. Average temperature 26.9 ^{0}C and average rainfall 2000mm in the area. Valsad belongs to the zone III seismic zones. Geologically the rivers originate in Maharashtra and travel through Gujarat to meet the Arabian Sea. Both rivers are facing pollution mostly due to agriculture. The width of the riparian zone not much extended.

Method of data collection

We laid 5 composite quadrants in each of the 13 sampling sites. A total of 65 composite quadrants were laid in the study sites. A large quadrant was laid on the study site, within which 10 smaller quadrants were laid on each of the four corners and in the center. Line transect on the border of the large quadrant used for enumeration of trees and smaller quadrants was used for non-woody vegetation. The dimension of the large quadrant taken was 30 m ^{2}, line transect was 30 m^2, quadrant for shrubs was taken $5m^2$, herb transect was taken as $1m^2$. The composition and distribution of vegetation and factors that are responsible for the distribution of vegetation are determined. We describe the position of the thirteen study sites in figure 1.

Figure 1: Various sampling sites along Auranga river - 1 (Khatana), 2 (Vadpada), 3 (Bhairavi), 4 (Thakkarwada), 5 (Abrama), (6) Lilapur. Along Par River - 7 (Parvasa), 8 (Binwada, 9 (Atul), 10 (Haria), 11 (Bagodh), 12 (Magodh), 13 (Umarsadi)

Statistics used

Among presence or absence data of enormous proportion, Jaccardian similarity data is most robust, while other similarity indices such as Bray Curtis, BD_{Total} are robust over narrow sense (P Jason Schroeder, David G Jenkins, 2018).

Important Value Index is used in phytosociology to determine the dominance pattern of tree species in the area under study. It is calculated as the sum of relative frequency, relative density, and relative dominance.

Frequency is the number of times plant species occur in a given number of quadrants. It is expressed as a percentage. It describes the distribution of species but does not compare abundance between different species. Ecologists to compare plant communities and detect temporal vegetation composition changes have used frequency. Frequency of a plant species related to sampling size. Frequency is highly sensitive for annuals and less sensitive for perennials.

Density is the number of individuals of species in all quadrants studied. Plant density will vary according to geographical location and climatic factors (Rahman and Hussain, 2011). Plant density affects its microenvironment and the growth of plants. An increase in plant population density will cause a decrease in growth rate (Caliskan et al, 2009). There a threshold beyond which any increase in plant density will cause a reduction in yield of plants, which is different for different species (Rahman et al 2004), genotype, and geographical location (Rani and Kodandaramiah, 1997; Grichar, 2007).

Abundance is the ratio of the number of individuals of specie to the total number of all individuals of all species. Relative abundance determines the evenness of a plant species among other plant species in the community. The distributional pattern of species depends upon environmental factors and anthropogenic interferences.

Results and discussion

In the present results based on two years of intensive study of the riverine ecotones of two much dammed perennial rivers, we observe a total of 221 species represented by 183 genera of 64 families. Two species of algae were enumerated, belonging to two genera of one family. One species of pteridophytes of one genus of one family. Bryophyte found one specie belonging to one genus one family. Monocot belonging to 46 species of 42 genera and 10 families. 171 species of dicots represented by 137 genera and 50 families found. The predominance of dicots observed followed by monocots. A negligible number of algae, pteridophytes, and bryophyte was noted.

Horizontal stratification of vegetation observed from the immediate riverine bank to dry wooded area. Agricultural was the mainland use pattern change for the upper and middle course of both the rivers. The great array of crops observed in immediate riverbank indicating soil fertility and water quality conducive for plant growth. Crops grown in the area are *Cajanus cajan, Coccinia grandis, Momordica charanthia, Musa paradisiac, Oryzae sativa, Pennisitum glaucum, Saccharum officinarun,* and *Zea mays.* Analysis of the intermediate herbaceous cover, it was observed that the riverine ecotone contained many weedy of medicinal importance. We can tap this resource for rural development. A critical analysis reveals the presence of invasive exotic trees, which endangers the less competitive indigenous trees. A great variety of exotic weeds also found but of low frequency indicating that these species have not yet been naturalized. Wooded area occurring farthest from rivers is not dense and hence there is no continuous canopy. Irregularity of water availability in these hilly terrains is the main deterrent for low specie richness. Other factors affecting specie composition and richness are the alteration of humans used land-use patterns.

The plants were categorized based on the relative percentage of a dicot, monocot, pteridophytes, algae, and pteridophytes given in figure 2.

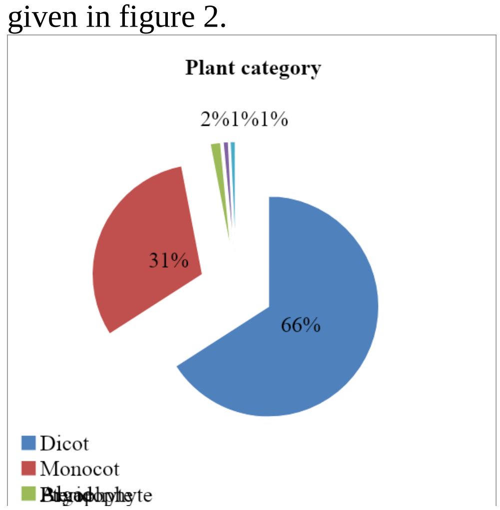

Figure 2: Plant category

The predominance of herbaceous cover observed is due to the human-induced landscape. Most of the dense forested riverine areas are converted to the agricultural field and plantation area. This altered land use pattern is due to water availability year-round in riverine areas. Though the upper and middle of these rivers lie in the Western Ghat area thus get abundant rain by southwest monsoon still drought prevails during the non-monsoon period. This is since the catchment area is undulating areas with steep slopes allowing very little water retention during rains. Mostly grasses dominate the non-cultivated and non-plantation areas. Grasses growing in these areas are mostly fodder grass and are harvested multiple times during wet seasons. So shrubby vegetation is chopped down until it has some medicinal value. The categorization of plants in our study area

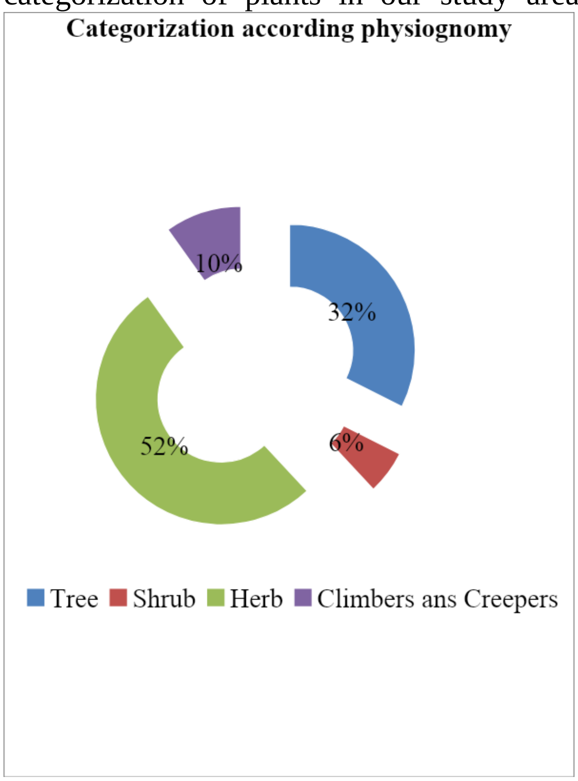

Figure 3: Physiognomy bases categorization of plant

Most abundant plant families in our study area being Poaceae followed by Fabaceae, Asteraceae, and Malvaceae. Poaceae dominates the terrain as in the flat riverine area rice is cultivated, whereas in steep slopes fodder grasses grow during the rainy season and after rain period. Steep slopes also dominated by bamboo. Large track of land used to grow legumes, also there is an abundance of Fabaceae tree, shrub, and herbaceous weeds. Asteraceae and Malvaceae weeds become abundant during rains. The relative abundance of various families in our study area is indicated in Figure 4. Those plant families having extremely low scores are excluded from the following pie chart.

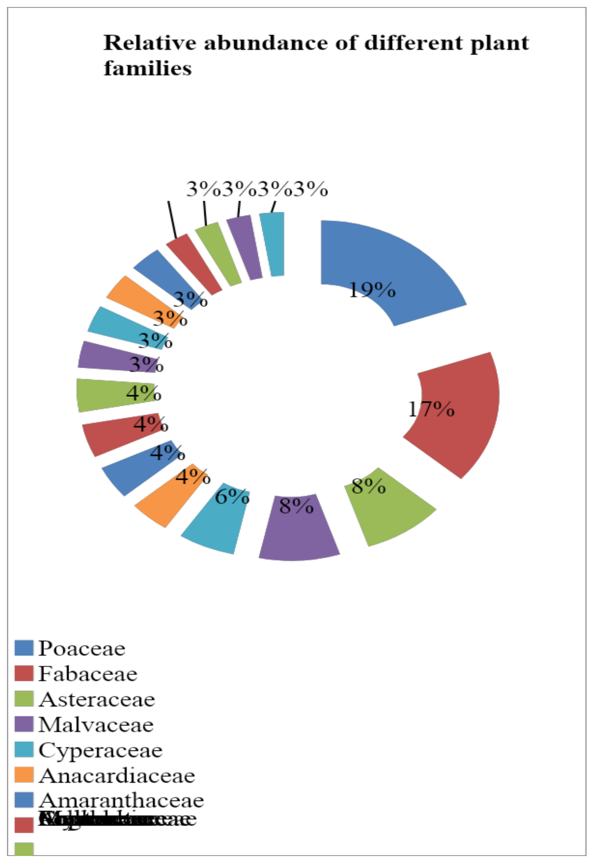

Figure 4: The relative abundance of various plant family in our study area

The highest IVI of tree species belonged to Carissa carandas followed by *Tectona* and *Woodfordia*. High IVI was due to high frequency in every quadrant. Lowest IVI belonged to *Syzygium cumini*, *Boswellia serrata*, and *Callistemon* and *Crateva religiosa*. Low IVI of these trees is due to low relative frequency, low relative density, and low relative dominance. Highest Relative dominance was found in *Adansonia* followed by *Sterculia* and *Thespasia*. The Important Value Index which is quantitative parameters of plant diversity is indicated in Table 1.

Table 1: Important Value Index of Tree species

Trees	Relative Frequency	Relative Density	Relative Dominance	Important Value Index (IVI)
Acacia auriculiformis	4.42	4.10	1.13	9.65
Acacia mearnsii	2.60	2.05	1.27	5.92
Acacia nilotica	4.42	2.87	0.16	7.45
Adansonia digitate	1.56	0.96	4.23	6.75
Aegle marmelos	0.52	0.27	0.85	1.64
Albizzia lebbeck	0.26	0.27	2.68	3.21
Albizzia saman	1.30	0.82	1.56	3.69
Anogeissu latifolius	0.52	0.27	0.56	1.36
Annona reticulata	0.26	0.55	0.69	1.50
Annona squamosa	0.26	0.41	0.68	1.35
Avecennia marina	1.56	5.88	1.30	8.73
Azadirachta indica	2.08	1.64	1.44	5.16
Bambusa bamboos	2.60	5.60	0.08	8.29
Bauhinea purpurea	1.82	2.05	0.32	4.19
Bombax ceiba	2.08	2.19	0.28	4.55
Borassus flabellifer	0.52	0.82	1.34	2.68
Boswellia serrata	0.52	0.55	0.75	1.81
Butea monosperma	1.56	1.23	0.85	3.64
Callistemon	0.52	0.68	0.01	1.22
Callotropis gigantea	1.30	1.09	0.06	2.45
Crateva religiosa	0.26	0.27	0.70	1.24
Carica papaya	2.08	1.91	1.27	5.26
Carrisa carandas	5.98	7.79	0.13	13.90
Casuarina	4.94	4.24	0.70	9.88
Ceiba pentendra	1.30	0.68	0.99	2.97
Cocos nucifera	2.34	1.91	1.38	5.64
Derris indica	3.33	1.75	2.79	7.87
Delonix regia	2.86	2.05	1.55	6.46
Eucalyptus	1.30	1.37	1.41	4.08
Ficus arnoltiana	1.82	1.50	0.56	3.89
Ficus bengalensis	1.56	1.09	1.41	4.06
Ficus elastic	0.52	0.41	0.56	1.49

Ficus hispida	0.51	1.88	1.97	4.37
Ficus religiosa	1.30	0.82	1.27	3.39
Gliricidium	1.56	0.96	1.13	3.65
Hibiscus tilaceous	1.04	0.55	2.54	4.12
Lagerstroemia speciosa	0.26	0.27	1.27	1.80
Leucaena leucocephala	4.94	3.14	0.18	8.27
Mangifera indica	1.82	2.60	2.20	6.62
Manilkara zapota	1.56	1.91	1.38	4.86
Melia azadiracht	0.78	0.41	2.75	3.94
Morinda citrifolia	1.30	1.37	1.11	3.78
Moringa olifera	0.78	0.41	1.20	2.39
Musa paradisiac	0.26	1.37	2.40	4.02
Neolamarkia	0.26	0.14	2.37	2.77
Phoneix dactylifera	0.52	0.27	1.27	2.06
Pithecelobium dulce	0.26	0.27	1.69	2.23
Polyalthia longifolia	0.26	0.27	1.83	2.37
Prosopis chilensis	3.33	2.56	3.24	9.13
Prosophis julifora	1.56	1.23	1.97	4.76
Psidium guajava	0.26	0.14	2.11	2.51
Peltophorum pterocarpum	0.52	0.55	1.83	2.90
Salvadora persicaria	1.04	4.65	3.24	8.93
Saraca ashoka	0.26	0.14	2.83	3.23
Sterculia urens	0.26	0.68	5.64	6.58
Syzigium cumini	0.52	0.41	1.18	2.11
Tabermontana divaricate	0.52	0.27	0.31	1.10
Tabermontana citrifolia	0.26	0.14	1.72	2.12
Tamarix dioica	1.79	4.71	3.13	9.63
Tectona grandis	5.98	4.24	1.73	11.95
Terminalia catappa	1.82	0.96	2.66	5.44
Thespasia populnea	2.86	2.05	5.02	9.93
Thevetia peruviana	1.82	0.96	0.28	3.06
Toona ciliate	0.78	0.41	2.82	4.01
Woodfordia fructicosa	2.82	3.10	4.23	10.14
Ziziphus jujube	4.16	2.32	0.16	6.64

The highest frequency of *Capparis sepiaria, Sphaeranthus indicus, Cissampelos pareira, Echinocystis lobata,* and *Xanthium strumarium* found. A low frequency of *Bougainvillea, Chenopodium, Ipomoea alba, Ipomoea pres capre, Jasminum sambac, Malvastrum coromandalicum, Martynia annua, Nerium oleander, Opuntia* and *Rosa* were found. A low frequency of many plants indicates these species were not widely spread.

A high abundance of non-woody vegetation includes *Spigelia anthelmia, Polygonum plebeium, Adiantum, Phyllanthus reticulatus*, and *Ocimum canum.* A large number of herbaceous plants had very low abundance namely all species of *Alternanthera and Ipomoea, Boerhavia repens, Datura stramonium, Dioscorea bulbifera, Gloriosa superba, Cissampelos pareira, Clitoria ternea, Citrulus colocynthis, Cocculus hirsutus, Hibiscus chinensis, Jasminum sambac, Passiflora foetida, Pergularia daemia, Portulaca oleraceae, Tridex procumbens* and *Wedelia chinensis*. This indicates a skewed distribution with few species forming the bulk in the ecosystem.

A high density of Sphaeranthus indicus, *Urena lobata, Rungia repens, Impatiens balsamina, Peristrophe paniculata, and Vernonia cineraria observed. Bougainvillea, Jasminum sambac, Nerium oleander, Passiflora foetida,* and *Ipomoea pres capre* found in very low density. Except for Ipomoea escape, all other plants are ornamental and not natural vegetation of the valleys.

Table 2: Frequency, Abundance, and Density of shrubby and herbaceous vegetation

Plant	Frequency	Abundance	Density
Acanthus illicifolius	0.05	8.00	0.37
Abelmoschus moschatus	0.12	3.25	0.40
Abrus precatorius	0.08	2.40	0.18
Abutilon indicum	0.03	3.50	0.11
Acalypha indica	0.06	2.75	0.17
Achyranthus aspera	0.08	3.40	0.26
Adiantum	0.05	13.33	0.62
Ageratum conyzoides	0.06	4.50	0.28
Alternanthera pungens	0.03	1.00	0.03
Alternanthera bettzikiana	0.14	1.00	0.14
Alternanthera ficoidea	0.05	1.00	0.05
Alternanthera sessilis	0.12	1.00	0.12
Alysicarpus vaginalis	0.08	4.20	0.32
Ammania baccifera	0.06	2.00	0.12
Amaranthus spinosus	0.03	5.00	0.15
Ampelocissus latifolius	0.05	1.33	0.06
Ampelocissus tomentosa	0.05	1.00	0.05
Argemone mexicana	0.15	3.30	0.51
Blumea lacera	0.05	7.00	0.32
Boerhavia repens	0.09	1.00	0.09
Bougainvillea	0.02	1.00	0.02
Calotropis procera	0.17	1.09	0.18
Canscora	0.03	3.00	0.09
Capparis sepiaria	0.29	1.05	0.30
Cassia tora	0.22	2.43	0.52
Cassia augustifolia	0.05	1.67	0.08
Celosia argentia	0.11	1.29	0.14
Celosia cristata	0.03	2.00	0.06
Catharanthus rosesus	0.05	1.67	0.08
Cissampelos pareira	0.23	1.00	0.23

Circium arvense	0.06	2.25	0.14
Croton	0.02	4.00	0.06
Cleome viscosa	0.05	2.67	0.12
Clitoria ternea	0.14	1.00	0.14
Citrulus colocynthis	0.18	1.00	0.18
Chenopodium	0.02	5.00	0.08
Coccinia grandis	0.15	2.60	0.40
Cocculus hirsutus	0.08	1.00	0.08
Colocasia	0.06	9.75	0.60
Commelina forkslai	0.05	1.33	0.06
Conyza bipinatifida	0.05	2.67	0.12
Conyza sumatrensis	0.03	5.50	0.17
Corchorus aestuans	0.06	3.00	0.18
Corchorus tridens	0.11	2.86	0.31
Corchorus olitorius	0.05	2.33	0.11
Datura metel	0.08	1.80	0.14
Datura stramonium	0.08	1.00	0.08
Dioscorea	0.21	1.00	0.21
Echinocystis lobate	0.23	1.67	0.38
Emilia sonchifolia	0.05	2.33	0.11
Euphorbia hirta	0.05	4.00	0.18
Euphorbia roylena	0.15	3.20	0.49
Funaria hygrometrica	0.05	4.33	0.20
Gloriosa superba	0.15	1.00	0.15
Helitropium indicum	0.08	3.00	0.23
Hibiscus chinensis	0.09	1.00	0.09
Hibiscus furcellatus	0.09	1.17	0.11
Hybanthus enna spermus	0.05	2.67	0.12
Hygrophila auriculata	0.05	2.00	0.09
Impatiens balsamina	0.18	4.58	0.85
Ionidium suffruticosum	0.03	5.00	0.15
Ipomoea alba	0.02	2.00	0.03
Ipomoea carnea	0.15	4.40	0.68
Ipomoea hederifolia	0.06	1.00	0.06
Ipomoea pres capre	0.02	1.00	0.02
Ipomoea quamoclit	0.03	1.00	0.03
Ipomoea trilobata	0.15	1.00	0.15
Ischaenum indicum	0.06	1.75	0.11
Jasminum sambac	0.02	1.00	0.02
Jatropa gossipifolia	0.11	2.43	0.26
Lantana camera	0.09	2.17	0.20
Launea procumbens	0.18	2.75	0.50
Luffa cyllindrica	0.06	1.00	0.06
Luffa operculata	0.06	1.25	0.08
Malachra capitate	0.12	3.88	0.48

Malvastrum coromondalicum	0.02	6.00	0.09
Martynia annua	0.02	4.00	0.06
Nerium oleander	0.02	2.00	0.03
Ocimum canum	0.05	10.33	0.47
Operculina turpenthum	0.12	1.13	0.14
Opuntia	0.02	6.00	0.09
Passiflora foetida	0.03	1.00	0.03
Parthenium hysterophorus	0.06	3.50	0.22
Pergularia daemia	0.03	1.00	0.03
Persicaria glabra	0.03	2.50	0.08
Peristrophe paniculata	0.20	4.00	0.79
Phaseolus trilobatus	0.03	7.50	0.23
Phyllanthus niruri	0.03	11.00	0.34
Phyllanthus reticulatus	0.18	4.08	0.74
Polygonum plebeium	0.03	16.50	0.51
Portulaca oleraceae	0.05	1.00	0.05
Rosa	0.02	2.00	0.03
Ricinus communis	0.08	5.40	0.42
Rungia repens	0.14	6.33	0.88
Sida cordifolia	0.06	6.75	0.42
Solanum surattense	0.09	6.50	0.60
Solanum xanthocarpum	0.09	5.17	0.48
Sonchus asper	0.03	7.00	0.22
Sphaeranthus indicus	0.20	5.15	1.03
Spigelia anthelmia	0.03	20.00	0.62
Tephrosia purpurea	0.14	5.11	0.71
Triamphetta rhomboidea	0.06	7.00	0.43
Tridex procumbens	0.32	1.00	0.32
Typha augustata	0.06	3.50	0.22
Urena lobate	0.18	5.42	1.00
Vernonia cineraria	0.21	3.64	0.77
Vigna trilobata	0.19	1.00	0.19
Vicia sativa	0.03	4.00	0.12
Wedelia chinensis	0.03	1.00	0.03
Xanthium strumarium	0.23	2.00	0.46
Zornia gibbosa	0.03	1.00	0.03

The Jaccardian Similarity Index for tree species at various sites along the two rivers in the Valsad district is indicated in Table 3. We observe that sites 1, 2, 5, and 6 are having some similarities amongst themselves. So are the sites 8, 10, 11, 12, and 13. Here we observe that some trees are unique for a river ecotone and vegetation along a river retains some similarity at a different course of that river. Thus there will be a difference in floristic composition between different rivers but similarity amongst different sites along the same river. This may be due to the geophysical characteristic of the riverine areas. Sites 3, 4, and 7 are having similar trees as these are plantation sites. Site 9 is different from all other sites as it is an industrial zone that has some habitation of the people working in these industries. Afforestation work is carried at Site 9 so this site has a dense canopy of the artificial secondary forest that supports a large variety of flora both natural and introduced. Thus we can group the sites based on specie similarity that in thus depend upon geological factors, anthropogenic influences. Anthropogenic influences were mainly alteration of land use patterns such as the conversion of fertile riverine wooded land to agricultural land, recent construction of the road in remote areas, construction of resorts in these hilly regions.

We describe the Jaccardian Similarity Index for shrubby and herbaceous weeds in Table 4. We can find a similarity between sites 1, 2, and 3, and the similarity between 10, 11, 12, and 13. Sites 1, 2, and 3 belong to hilly terrain and of the same river Auranga and faces drought during the non-monsoon period. Also, sites 1, 2, and 3 have low population density, mostly tribal population. Sites 10, 11, 12, and 13 belonged to a downstream area of the same river Par that faces tidal bore so has a salinity in the soil.

Table 3: Jaccardian Similarity Index for tree

Site	1	2	3	4	5	6	7	8	9	10	11	12	13
1		0.83	0.32	0.19	0.38	0.30	0.19	0.28	0.29	0.27	0.23	0.27	0.23
2	0.83		0.34	0.17	0.40	0.36	0.22	0.26	0.26	0.30	0.31	0.31	0.24
3	0.32	0.34		0.38	0.22	0.26	0.44	0.19	0.21	0.22	0.25	0.17	0.29
4	0.19	0.17	0.38		0.17	0.20	0.38	0.17	0.29	0.11	0.15	0.10	0.18
5	0.38	0.40	0.22	0.17		0.39	0.26	0.30	0.31	0.32	0.35	0.34	0.24
6	0.30	0.36	0.26	0.20	0.39		0.20	0.22	0.30	0.28	0.40	0.31	0.23
7	0.19	0.22	0.44	0.38	0.26	0.20		0.31	0.25	0.29	0.32	0.22	0.33
8	0.28	0.26	0.19	0.17	0.30	0.22	0.31		0.31	0.38	0.31	0.37	0.32
9	0.29	0.26	0.21	0.29	0.31	0.30	0.25	0.31		0.22	0.28	0.22	0.23
10	0.27	0.30	0.22	0.11	0.32	0.28	0.29	0.38	0.22		0.40	0.43	0.37
11	0.23	0.31	0.25	0.15	0.35	0.40	0.32	0.31	0.28	0.40		0.48	0.42
12	0.27	0.31	0.17	0.10	0.34	0.31	0.22	0.37	0.22	0.43	0.48		0.40
13	0.23	0.24	0.29	0.18	0.24	0.23	0.33	0.32	0.23	0.37	0.42	0.40	

These areas are inhabited by fisher folks. So the similarity between sites 10, 11, 12, and 13 is due to geomorphology, high anthropogenic stress, and saline edaphic condition. Similarities 6 and 7 belonging to different rivers may be due to low anthropogenic stress due to low population density as these are plantation areas. Sites 4 and 5 have similarity as these areas has land use in both agricultural and plantation. Sites 8 and 9 are having similarities in weed composition due to the closeness of these sites. If two sites are close enough there will be easy dispersal of seeds leading to homogeneity in the vegetative composition. In all the clustering for weeds, we observe that similarity or dissimilarity in weed flora of different sites is due to distance between sites, presence of barriers for dispersal of seed, topography, land use pattern, and similarity between edaphic characters between sites.

Table 4: Jaccardian Similarity Index for weeds

Site	1	2	3	4	5	6	7	8	9	10	11	12	13
1		0.58	0.34	0.24	0.22	0.19	0.24	0.20	0.23	0.26	0.21	0.21	0.18
2	0.58		0.33	0.20	0.28	0.20	0.30	0.26	0.26	0.27	0.24	0.20	0.13
3	0.34	0.33		0.42	0.18	0.26	0.20	0.17	0.26	0.46	0.20	0.17	0.19
4	0.24	0.20	0.42		0.26	0.23	0.15	0.14	0.22	0.50	0.23	0.24	0.27
5	0.22	0.28	0.18	0.26		0.19	0.20	0.16	0.12	0.15	0.21	0.17	0.16
6	0.19	0.20	0.26	0.23	0.19		0.23	0.13	0.15	0.20	0.20	0.28	0.19
7	0.24	0.30	0.20	0.15	0.20	0.23		0.23	0.24	0.18	0.14	0.19	0.13
8	0.20	0.26	0.17	0.14	0.16	0.13	0.23		0.37	0.20	0.25	0.19	0.16
9	0.23	0.26	0.26	0.22	0.12	0.15	0.24	0.37		0.44	0.28	0.37	0.16
10	0.26	0.27	0.46	0.50	0.15	0.20	0.18	0.20	0.44		0.22	0.22	0.21
11	0.21	0.24	0.20	0.23	0.21	0.20	0.14	0.25	0.28	0.22		0.38	0.28
12	0.21	0.20	0.17	0.24	0.17	0.28	0.19	0.19	0.37	0.22	0.38		0.39
13	0.18	0.13	0.19	0.27	0.16	0.19	0.13	0.16	0.16	0.21	0.28	0.39	

The Jaccardian Similarity Index for aquatic macrophytes between various riverine sites of the two rivers understudy is indicated in Figure 5. We observe that there is a low level of similarity when we consider aquatic vegetation. Site 8 has a maximum number of aquatic macrophytes. Site 1 and 2 have homogeneity in vegetation, both being in low populated inaccessible terrain. Site 11 and 12 are homogenous. Both being close to the estuarine mangrove belt. The similarity between sites 5 and 10 of two different rivers is due to year-round water availability at these sites. Most pollution comes from site 9 in the form of effluent. But the effluent is discharged into sea by pipelines in the riverbed. So aquatic vegetation at site 9 and its downstream sites are not adversely affected. Site 4 has no macrophytic vegetation and site 13 turns into mudflat during summer months harboring only salinity tolerant *Aeluropus lagopoides*. Heterogeneity in the composition of aquatic macrophytic mainly due to water availability that is in turn dependent on whether water is pumped out of the river to support agricultural activities around the year.

Table 5: Jaccardian Similarity Index of Aquatic plants

	1	2	3	4	5	6	7	8	9	10	11	12	13
1		0.50	0.20	0.00	0.00	0.25	0.40	0.00	0.00	0.00	0.13	0.50	0.00
2	0.50		0.50	0.00	0.00	0.25	0.40	0.00	0.00	0.00	0.00	0.20	0.00
3	0.20	0.50		0.00	0.00	0.25	0.75	0.00	0.00	0.00	0.00	0.20	0.00
4	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00		0.17	0.00	0.14	0.00	0.20	0.10	0.00	0.00
6	0.25	0.25	0.25	0.00	0.17		0.20	0.00	0.00	0.00	0.14	0.25	0.00
7	0.40	0.40	0.75	0.00	0.00	0.20		0.00	0.00	0.00	0.11	0.40	0.00
8	0.00	0.00	0.00	0.00	0.14	0.00	0.00		0.00	0.00	0.13	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00		0.00	0.35	0.27
11	0.13	0.00	0.00	0.00	0.10	0.14	0.11	0.13	0.00	0.00		0.29	0.00
12	0.50	0.20	0.20	0.00	0.00	0.25	0.40	0.00	0.00	0.35	0.29		0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	

The position of the stream in the drainage basin is quite low and steep slopes in the upper and middle reaches ensure maximum runoff during monsoons. Streambed vegetation were few and was limited to deeper sections of the river. This is due to massive-scale water withdrawal from the river during the dry seasons. Damming reduces the seasonal flooding and thus the decline of the recruitment of new strands. Reduction of the amount of water flow causes drought-induced death of plants. So we observed poor species diversity of aquatic macrophytes in the river bed. During our study period, it was observed that certain sites had *Eichhornia crassipes* throughout the year except for the monsoon when water gets diluted. This is an indicator of eutrophication sites. Riverine pollution sources are agricultural runoff during excess monsoon rainfall. Water turbidity increases as a result and no macrophytes found during this period. Quite a large number of cultivated species were observed as these riverine sites were used for agricultural purposes in the upper and middle sections of the rivers.

Riverine invasions are dominated by *Acacia auriculiformis* followed by *Leucaena leucocephala* and *Acacia nilotica*. Among weed maximum invasion seen by *Sphaeranthus sp* followed by *Urena sp*. Invadable areas are invaded over time there will be further increased in the density of exotics. This will further increase the cost of management.

Conclusion

In the present study using the Jaccardian Similarity Index, we observed that both rivers showed a characteristic difference in specie composition in its riverine ecotone, indicating heterogeneity, low anthropogenic stress and environmental stress due to geological factors. Using IVI we find that maximum IVI belonged to native plants which are an indicator of low anthropogenic stress. High frequency of drought-tolerant plants is an indicator of extreme water shortage that these areas suffer during summer months due to the dual cause of small volume of water in the stream and increasing rate of water withdrawal from the rivers. A high density of annuals seen mainly during the wet season. We thus used a combination of qualitative and quantitative measures such as the Jaccardian Similarity Index and Important Value index to create a database of the plant community in riverine ecosystems and predict stress factors responsible for such a plant distribution pattern. Knowledge of the database will help in the preservation of biodiversity of the plant community and environmental management.

References

Caliskan, M.E., Kusman, N., Caliskan, S., 2009. Effects of plant density on the yield and yield components of true potato seed (TPS) hybrids in early and maincrop potato production systems. Field crops research 11:223-232.

Chapman, D.V., 1996. Water quality assessments: a guide to the use of biota, sediments, and water in environmental monitoring. E & FN Spon, London.

Goodall, D.W., 1978. Sample similarity and species correlation. In: Ordination of plant communities, Springer, Dordrecht, pp 99-149.

Grichar, W.J., 2007. Row spacing, plant populations, and cultivar effects on soybean production along the Texas Gulf Coast. Crop Management 6:0-0.

Izsak, C., Price, A.R.G., 2001. Measuring b-diversity using a taxonomic similarity index, and its relation to spatial scale. Marine Ecology Progress Series 215:69-77.

Jaanus, A., Toming, K., Hällfors, S., Kaljurand, K., Lips, I., 2009. Potential phytoplankton indicator species for monitoring Baltic coastal waters in the summer period. In: Eutrophication in Coastal Ecosystems, Springer, Dordrecht, pp 157-168.

Jia, Y., Li, H., Qu, Y., Chen, W., Song, L., 2018. Phytotoxicity, bioaccumulation and potential risks of plant irrigations using cyano bloom-loading freshwater. Science of the total environment 624:704-712.

Rahman, M., Hossain, M., Bell, R.W., 2011. Plant density effects on growth, yield and yield components of two soybean varieties under equidistant planting arrangement. Asian Journal of Plant Sciences 10:278-286.

Rahman, M.M., Mwakangwale, M.G., Hampton, J.G., Hill, M.J., 2004. The effect of plant density on seed yield of two cool tolerant soybean cultivars in Canterbury. Agronomy New Zealand 34:149-159.

Rani, B.P., Kodandaramaiah, D., 1997. Response of soybean varieties to inoculation with different strains of Rhizobium japonicum in the black soils of Andhra Pradesh. Journal of Research-Acharya NG Ranga Agricultural University India 25:56-57.

Real, R., Vargas, J.M., 1996. The probabilistic basis of Jaccard's index of similarity. Systematic Biology 45:380-385.

Schmieder, K., 2004. European lakeshores in danger - concepts for a sustainable development. Limnologica 34:3-14.

Schroeder, P.J., Jenkins, D.G., 2018. How robust are popular beta diversity indices to sampling error?. Ecosphere 9: e02100.

Soosairaj, S., Britto, S.J., Balaguru, B., Natarajan, D., & Nagamurugan, N., 2005. Habitat similarity and species distribution analysis in tropical forests of eastern ghats, Tamil Nadu. Tropical Ecology 46:183-192.

Van Doorn-Hoekveld, W. J., Goytia, S.B., Suykens, C., Homewood, S., Thuillier, T., Manson, C., Van Rijswick, H.F., 2016. Distributional effects of flood risk management - a cross-country comparison of pre-flood compensation. Ecology and Society 21:26.

Vasconcelos, V., 2006. Eutrophication, toxic cyanobacteria, and cyanotoxins: when ecosystems cry for help. Limnetica 25:425-432.