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## REPORT ON QUADRAT ANALYSIS OF MICRO-CATCHMENTS





# INTEGRATED RURAL URBAN WATER MANAGEMENT FOR CLIMATE BASED ADAPTATIONS IN INDIAN CITIES (IAdapt)

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## Report on Quadrat Analysis of Micro-catchments September 2017

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<b>Project Consortium:</b>	ICLEI South Asia (Lead Member) Athena Infonomics LLC International Water Management Institute (IWMI) Indian Institute of Technology, Madras (IIT M)



## Introduction

Under the Integrated Rural Urban Water Management for Climate Based Adaptations in Indian Cities (IAadapt) Project, it has been proposed to select one micro-catchment in each city region and conduct the primary project activities in the selected micro-catchment.

In order to select a micro-catchment from the different catchment areas of the two cities, a framework has been developed as depicted in the diagram below. The framework consists of a three pronged approach, with group discussions with local communities to collect socio-environmental information of the micro-catchments, quadrat sampling in the villages of micro-catchments to assess the biodiversity, as well as interviews with relevant officials of the rural and urban administration to assess the catchment areas that should be focused on for socio-ecological importance based on the interest and awareness of the officials.

This report provides the details of the quadrat analysis of the micro-catchments of the two cities of Vijayawada and Solapur.

## Methodology

The floral diversity assessment was conducted through a quadrat sampling. Quadrats of 10 X 10m were studied for trees, 5m X 5m for shrubs and 1m X 1m for herbs. In Vijayawada, in each micro-catchment, 5 such quadrats were laid. In Solapur, 40 quadrats were laid in 2 micro-catchments, 30 quadrats in the third and 10 quadrats in the fourth micro-catchment. The data thus collected was used to assess the species diversity index and richness in each micro-catchment.

The Shannon Diversity Index and the Simpsons Diversity Index was calculated to get an overall picture of the species diversity. Simpson gave the probability of any two individuals drawn at random from an infinitely large community belonging to different species. The Simpson index is therefore expressed as  $1-D$  or  $1/D$ . Simpson's index is heavily weighed towards the most abundant species in the sample while being less sensitive to species richness. It has been shown that once the number of species exceeds 10 the underlying species abundance distribution is important in determining whether the index has a high or low value.

Shannon and Wiener independently derived the function which has become known as Shannon index of diversity. This assumes that individuals are randomly sampled from an independently large population. The index also assumes that all the species are represented in the sample. Log<sub>2</sub> is often used for calculating this diversity index but any log base maybe used, though consistently. The value of Shannon diversity is usually found to fall between 1.5 and 3.5

The following formulae were used for this calculation:

Shannon Diversity Index ( $H'$ )

$$H' = - \sum_{i=1}^{S^*} (p_i \ln p_i)$$

where  $H'$  is the average uncertainty per species in an infinite community made up of  $S^*$  species with known proportional abundances  $p_1, p_2, p_3, \dots, p_{S^*}$ .  $S^*$  and the  $p_i$ 's are population parameters and, in practice,  $H'$  is estimated from a sample as

$$H' = - \sum_{i=1}^S ( (n_i/N) \ln (n_i/N) )$$

where  $n_i$  is the number of individuals belonging to the  $i$ th species of  $S$  species in the sample and  $N$  is the total number of individuals in the sample.

Simpson's diversity index ( $\lambda$ ) was calculated as

$$\lambda = \sum_{i=1}^S P_i^2$$

where  $P_i$  is the proportional abundance of the  $i^{\text{th}}$  species, given by  $P_i = n_i/N$

where  $n_i$  is the number of individuals of the  $i^{\text{th}}$  species and  $N$  is the known total number of individuals for all the  $S$  species in the population.

These indicators will then be assigned a weightage to finally select the micro-catchment in each city region where the project will be conducted.

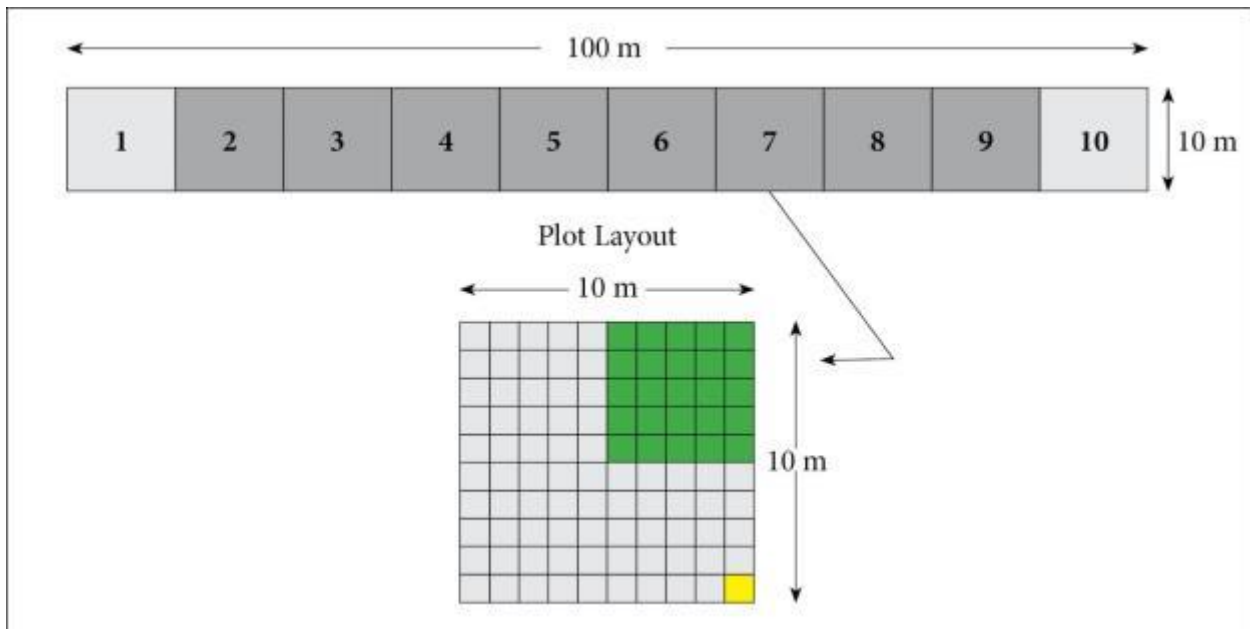


Figure 1: The sampling unit layout for different life-forms

## Preliminary Findings from Quadrat Study in Solapur Micro-catchments

There were four micro-catchments delineated in Solapur and quadrats were laid out in all of them, covering different villages in the micro-catchments. The following sections provide the details of the quadrat study of each micro-catchment. Table 1 provides the complete list of species in the micro-catchments.

**Table 1: List of species recorded in each micro-catchment in Solapur**

<b>Name of the species</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>
<i>Azadirachta indica</i>				
<i>Acacia nilotica</i>				
<i>Zizyphus mauritiana</i>				
<i>Tamarindus indica</i>				
<i>Thespesia populnea</i>				
<i>Prosopis cineraria</i>				
<i>Sesbania sesban</i>				
<i>Pithecellobium dulce</i>				
<i>Curcuma caesia</i>				
<i>Annona squamosa</i>				
<i>Ficus bengalensis</i>				
<i>Ficus racemosa</i>				
<i>Cassia auriculata</i>				
<i>Calotropis gigantea</i>				
<i>Caesalpinia decapetala</i>				
<i>Barleria prionitis</i>				
<i>Ocimum sanctum</i>				
<i>Tephrosia purpurea</i>				
<i>Amaranthus paniculatus</i>				
<i>Cassia auriculata</i>				
<i>Tridax procumbens</i>				
<i>Parthenium hysterophorus</i>				
<i>Cynodon dactylon</i>				
<i>Achyranthes aspera</i>				
<i>Solanum stramonifolium</i>				
<i>Tribulus terrestris</i>				
<i>Alteranthera triandra</i>				
<i>Amaranthus sp.</i>				
<i>Euphorbia hypericifolia</i>				
<i>Commelina benghalensis</i>				
<i>Argemona mexicana</i>				
<i>Securinega virosa</i>				
<i>Cuscuta reflexa</i>				
<i>Spiraea lindleyana</i>				

<b>Name of the species</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>
<i>Vetiveria zizanoides</i>				
<i>Girardinia diversifolia</i>				
<i>Cyperus rotundus</i>				
<i>Securinega virosa</i>				
<i>Cuscuta reflexa</i>				
<i>Lawsonia inermis</i>				
<i>Lantana camera</i>				
<i>Coccinea grandis</i>				
<i>Dischrostachys cinerea</i>				
<i>Ricinus communis</i>				
<i>Sansiviera sp.</i>				
<i>Phoenix sylvestris</i>				
<i>Aegel marmelos</i>				
<i>Euphorbia sp.</i>				
<i>Cardia dichotoma</i>				
<i>Bauhinia racemosa</i>				
<i>Pongamia pinnata</i>				
<i>Adhatoda vasica</i>				
<i>Ceropegia bulbosa</i>				
<i>Santalum album</i>				
<i>Sporobolus sp.</i>				
<i>Capparis decidua</i>				
<i>Capparis sepiaria</i>				
<i>Balanites aegyptica</i>				

### Microcatchment S1

21 tree species, 7 shrub and 24 herb species were recorded from this micro-catchment (Figure 2), belonging to 30 families (Figure 3). Fabaceae is the most dominant family.

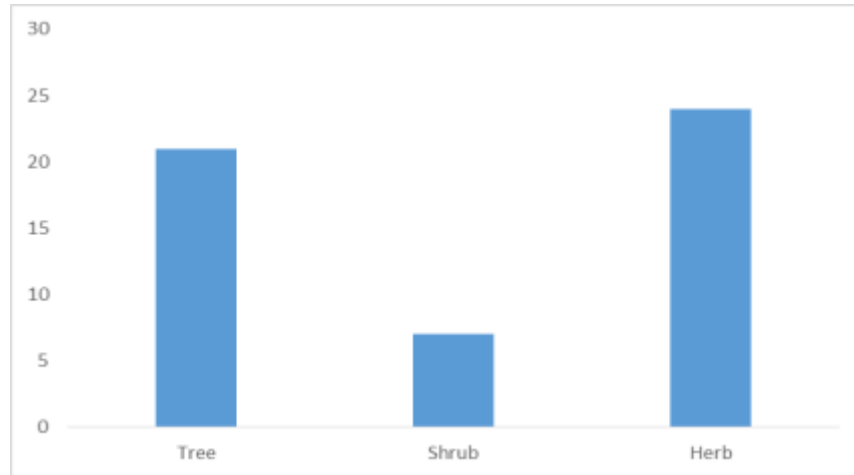


Figure 2: Vegetational lifeforms recorded

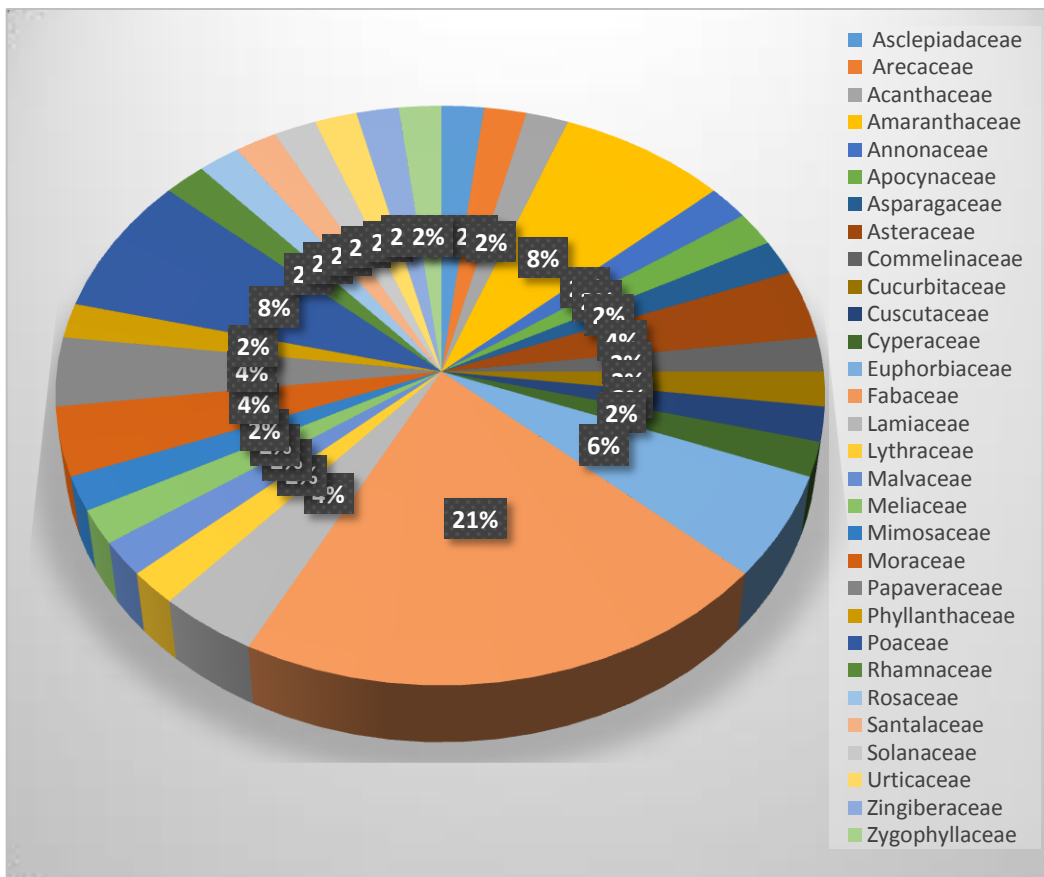


Figure 3: Family wise distribution of the plant species recorded

## Microcatchment S2

24 tree species, 7 shrub and 25 herb species were recorded from this micro-catchment (Figure 4), belonging to 33 families (Figure 5). Fabaceae is the most dominant family.

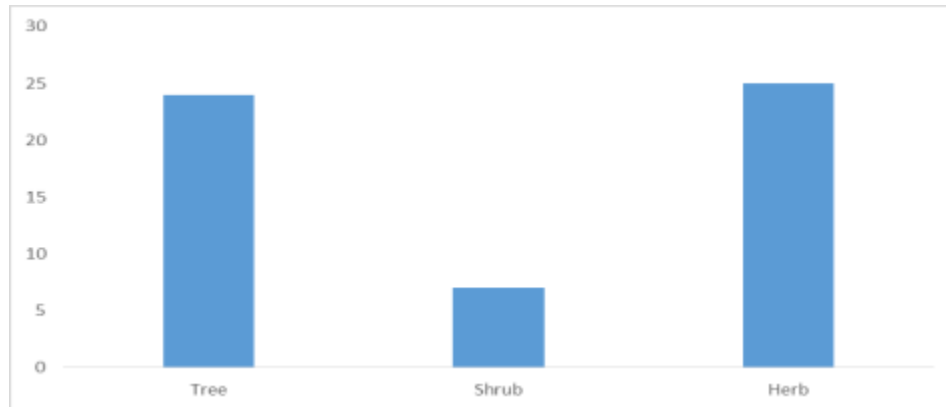


Figure 4: Vegetational lifeforms recorded

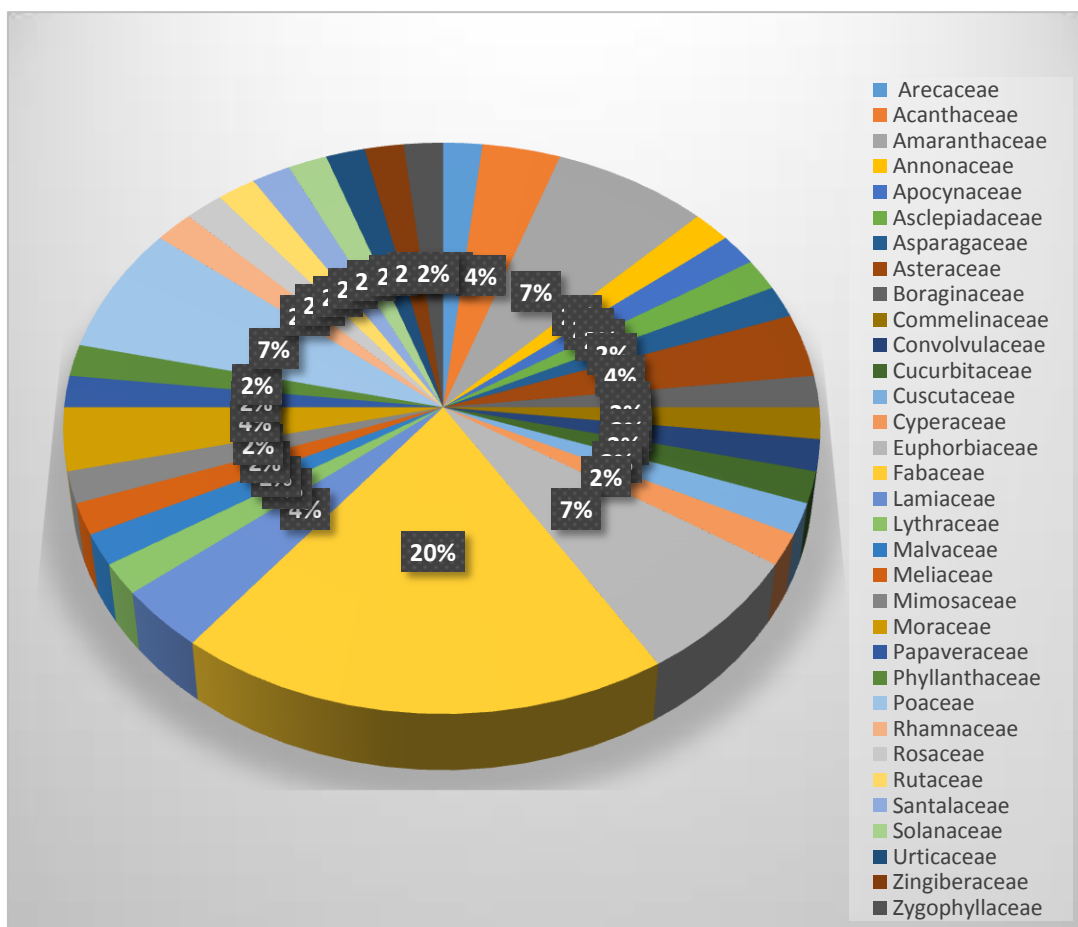


Figure 5: Family wise distribution of the plant species recorded



### Microcatchment S3

22 tree species, 6 shrub and 24 herb species were recorded from this micro-catchment (Figure 6), belonging to 30 families (Figure7). Fabaceae is the most dominant family.

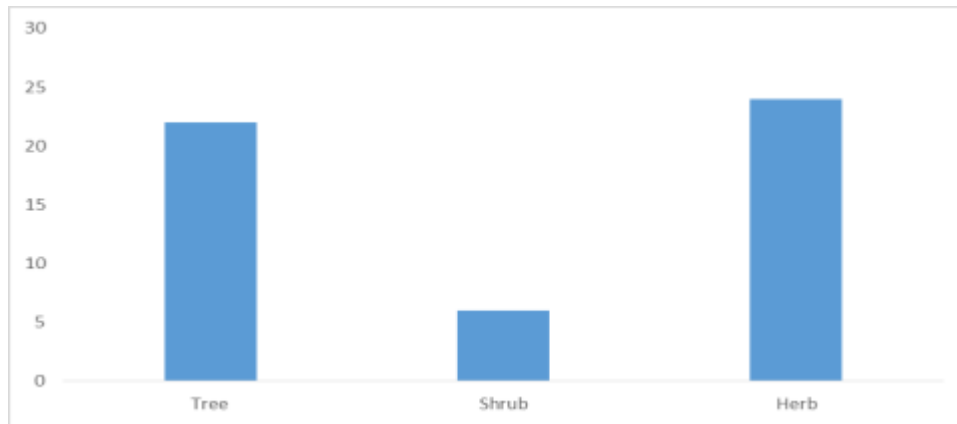


Figure 6: Vegetational lifeforms recorded

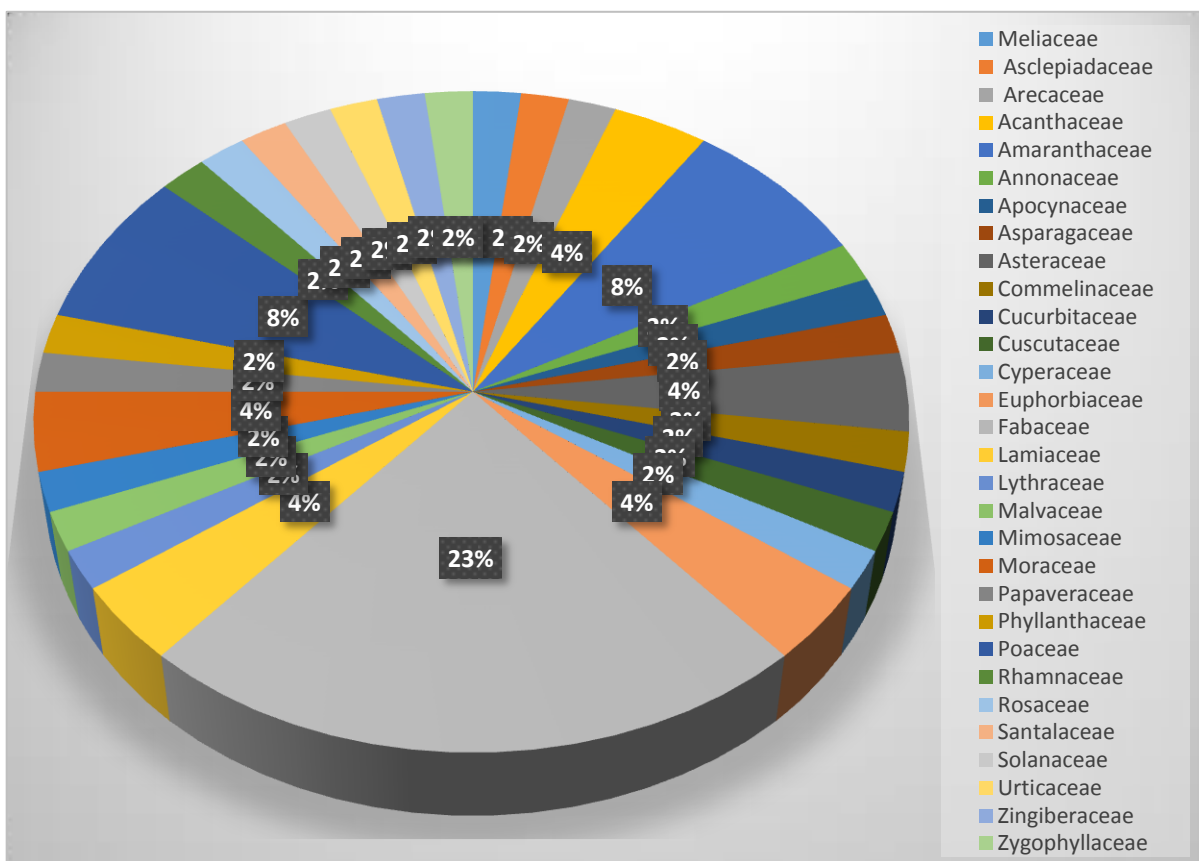


Figure 7: Family wise distribution of the plant species recorded

### Microcatchment S4

21 tree species, 6 shrub and 21 herb species were recorded from this micro-catchment (Figure 8), belonging to 30 families (Figure 9). Fabaceae is the most dominant family.

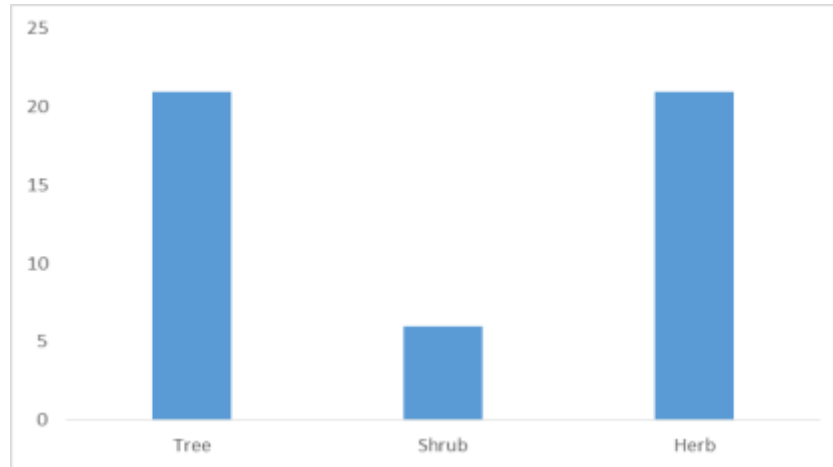


Figure 8: Vegetational lifeforms recorded

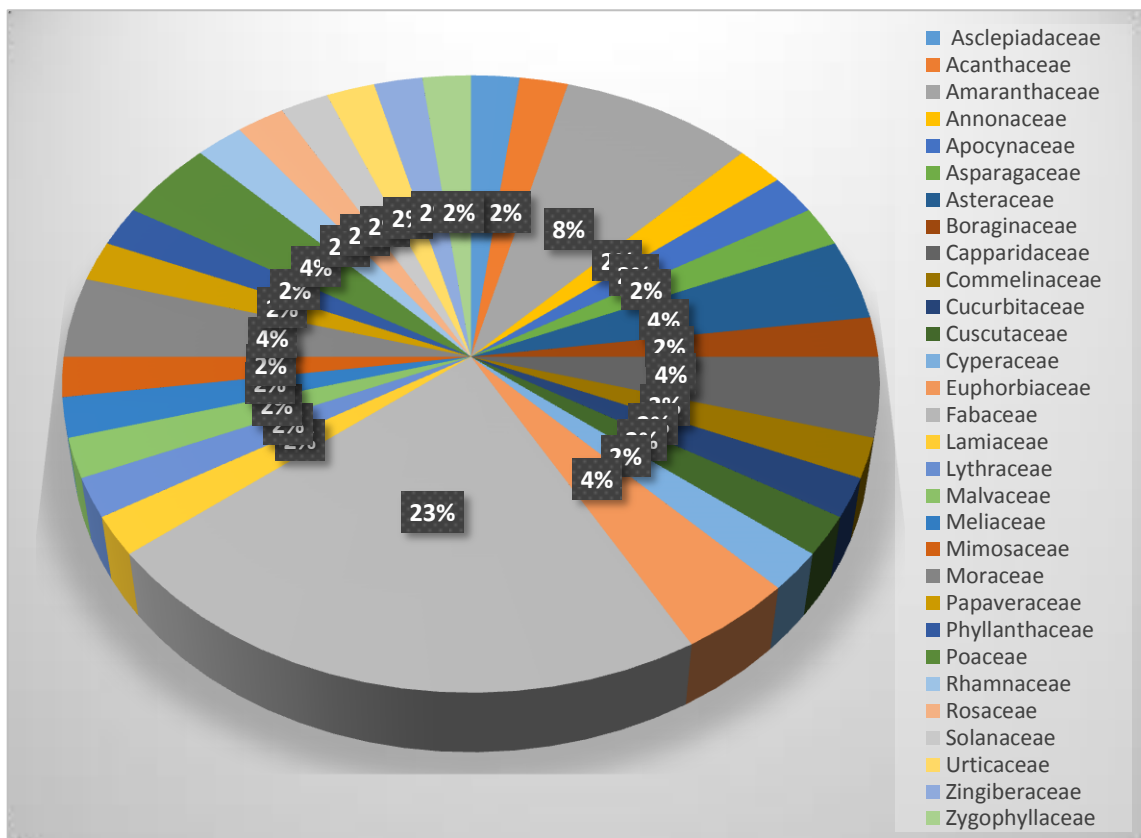


Figure 9: Family wise distribution of the plant species recorded

### Shannon Diversity:

Shannon diversity of each micro-catchment was calculated. S1 has the highest value. Figure 10 graphically represents the micro-catchment wise Shannon diversity.

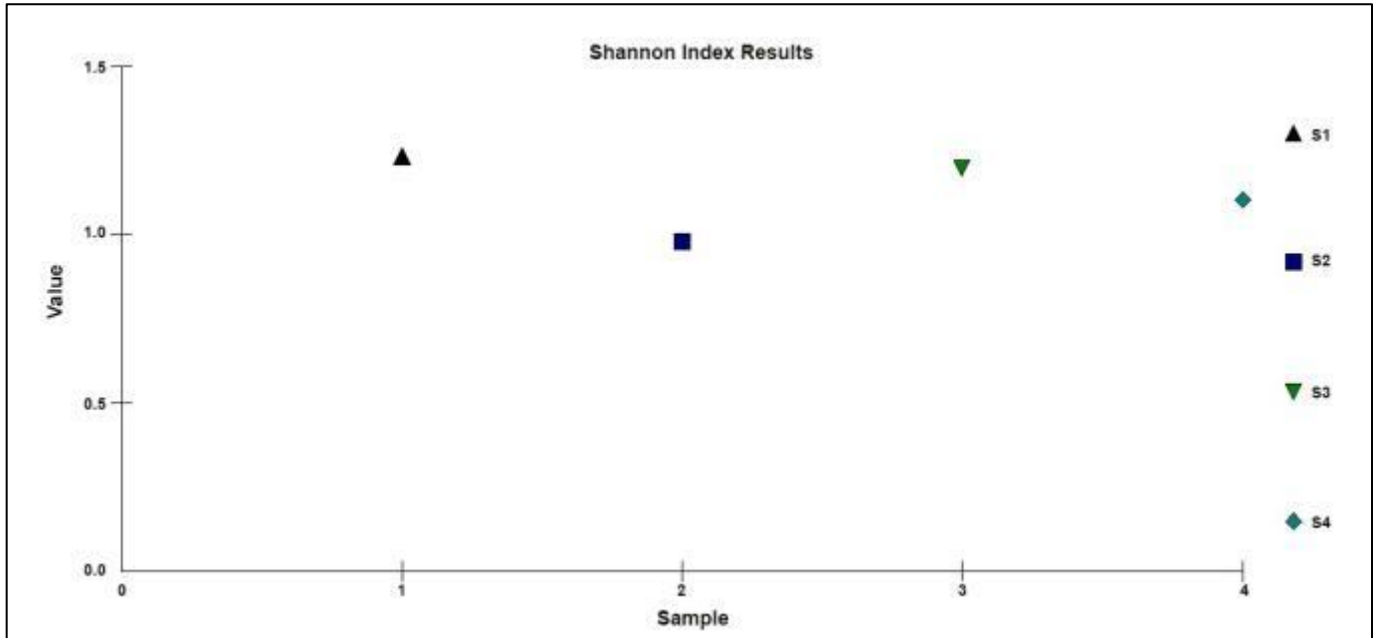


Figure 10: Microcatchment-Wise Shannon Diversity

Name of the micro-catchment	Shannon Diversity Index
S1	0.764
S2	0.635
S3	0.721
S4	0.746

Table 2: Shannon Diversity Index of different micro-catchments in Solapur

### Simpson's Diversity:

Simpson's diversity of each micro-catchment was calculated. S2 has the highest value. Figure 11 graphically represent the micro-catchment wise Simpson's diversity.

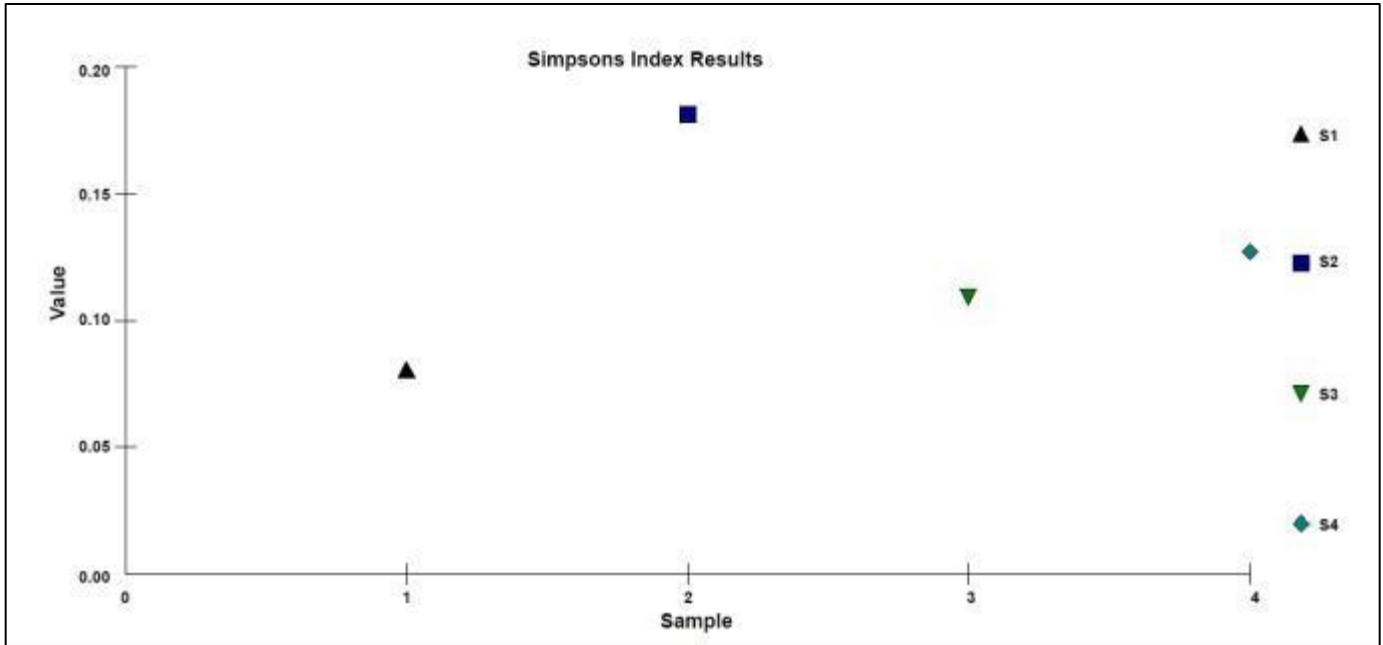


Figure 11: Micro- catchment-Wise Simpson's Diversity

Name of the micro-catchment	Simpson's Diversity
S1	0.081
S2	0.181
S3	0.109
S4	0.127

Table 3: Simpson's Diversity Index of different micro-catchments in Solapur



### Bray Curtis Similarity Matrix:

Figure 12 represents the Bray Curtis Similarity Matrix. The matrix clearly demarcates the level of closeness between the micro-catchments with respect to the floral species found in each of them.

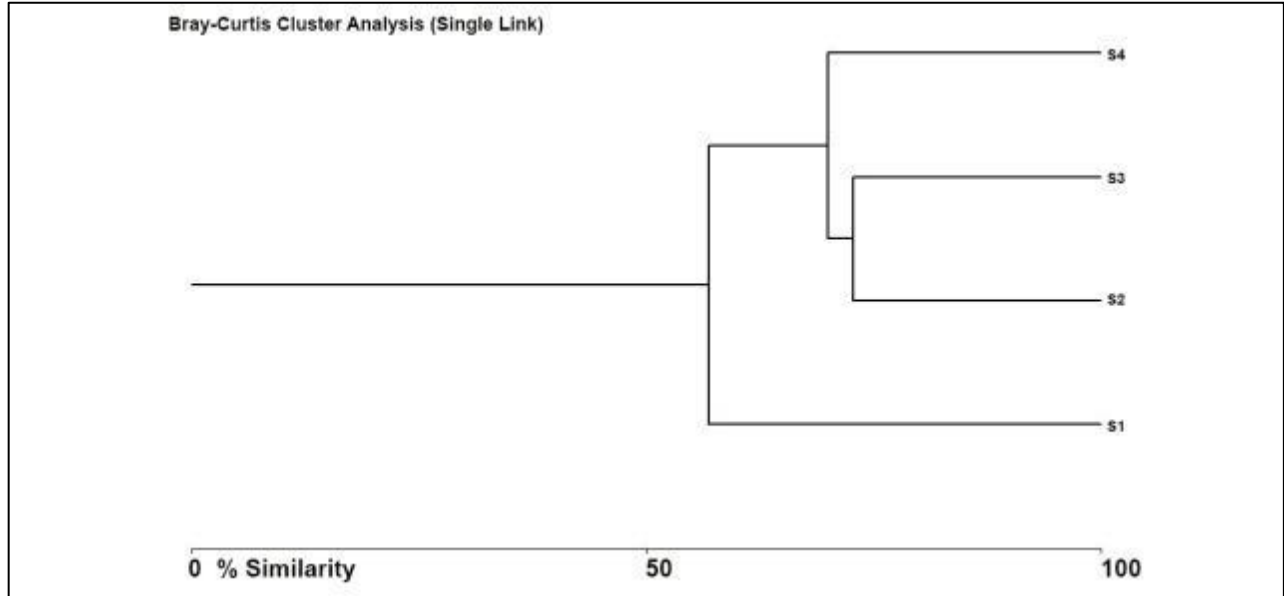


Figure 12: Bray Curtis Similarity Matrix

### Species Richness:

An analysis of the species richness gives an insight into the aggregation pattern of the individual species recorded from the entire study area. Table 2 details the same. The distribution pattern is not of one type and nearly an equal distribution between random and aggregated pattern of distribution among the individual species across all the four micro-catchments.

Table 4: Aggregation Patterns

Species	Aggregation	Species	Aggregation
<i>Azadirachta indica</i>	Random	<i>Commelina benghalensis</i>	Aggregated
<i>Acacia nilotica</i>	Random	<i>Argemona mexicana</i>	Aggregated
<i>Zizyphus mauritiana</i>	Random	<i>Securinega virosa</i>	Aggregated
<i>Tamarindus indica</i>	Aggregated	<i>Cuscuta reflexa</i>	Aggregated
<i>Thespesia populnea</i>	Random	<i>Spiraea lindleyana</i>	Aggregated
<i>Prosopis cineraria</i>	Random	<i>Vetiveria zizanoides</i>	Aggregated
<i>Sesbania sesban</i>	Random	<i>Girardinia diversifolia</i>	Aggregated
<i>Pithecellobium dulce</i>	Random	<i>Cyperus rotundus</i>	Aggregated
<i>Curcuma caesia</i>	Random	<i>Securinega virosa</i>	Random
<i>Annona squamosa</i>	Random	<i>Cuscuta reflexa</i>	Random
<i>Ficus bengalensis</i>	Random	<i>Lawsonia inermis</i>	Random
<i>Ficus racemosa</i>	Random	<i>Lantana camera</i>	Aggregated
<i>Cassia auriculata</i>	Random	<i>Coccinea grandis</i>	Random

Species	Aggregation	Species	Aggregation
<i>Calotropis gigantea</i>	Aggregated	<i>Dischrostachys cinerea</i>	Random
<i>Caesalpinia decapetala</i>	Random	<i>Ricinus communis</i>	Aggregated
<i>Barleria prionitis</i>	Random	<i>Sansiviera sp.</i>	Random
<i>Ocimum sanctum</i>	Aggregated	<i>Phoenix sylvestris</i>	Random
<i>Tephrosia purpurea</i>	Aggregated	<i>Aegel marmelos</i>	Random
<i>Amaranthus paniculatus</i>	Aggregated	<i>Euphorbia sp.</i>	Aggregated
<i>Cassica auriculata</i>	Aggregated	<i>Cardia dichotoma</i>	Random
<i>Tridax procumbens</i>	Random	<i>Bauhinia racemosa</i>	Random
<i>Parthenium hysterophorus</i>	Random	<i>Pongamia pinnata</i>	Random
<i>Cynodon dactylon</i>	Aggregated	<i>Adhatoda vasica</i>	Aggregated
<i>Achyranthes aspera</i>	Aggregated	<i>Ceropegia bulbosa</i>	Random
<i>Solanum stramonifolium</i>	Aggregated	<i>Santalum album</i>	Random
<i>Tribulus terrestris</i>	Aggregated	<i>Sporobolus sp.</i>	Aggregated
<i>Alteranthera triandra</i>	Aggregated	<i>Capparis decidua</i>	Random
<i>Amaranthus sp.</i>	Aggregated	<i>Capparis sepiaria</i>	Random
<i>Euphorbia hypericifolia</i>	Aggregated	<i>Balanites aegyptica</i>	Random

### Rarefaction Curves:

These curves help to extrapolate the data and predict the scenario over a period of time. Figure 13 depicts the rarefaction curves obtained for the present data set.

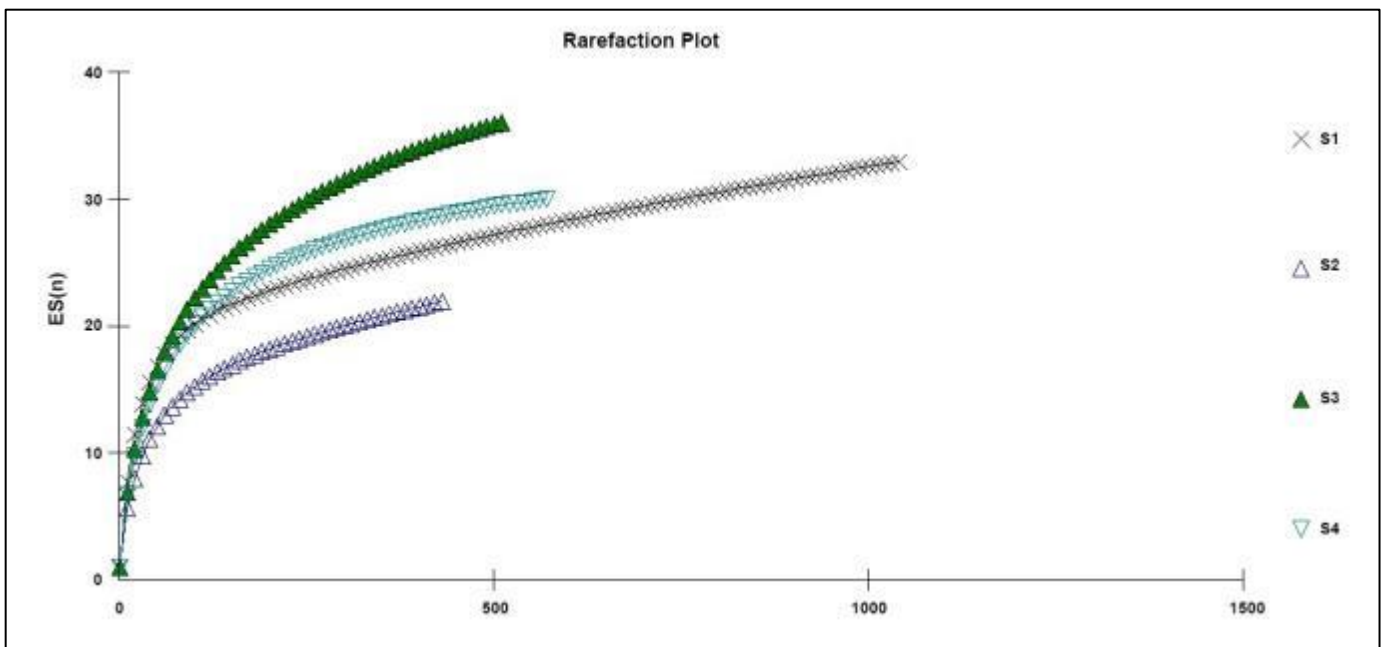


Figure 13: Rarefaction Plot

## Preliminary Findings from Quadrat Study in Vijayawada Micro-catchments

There were four micro-catchments delineated in Vijayawada and quadrats were laid out in all of them, covering different villages in the micro-catchments. The following sections provide the details of the quadrat study of each micro-catchment. Table 5 provides the complete list of species in the micro-catchments.

**Table 5: List of species recorded in each micro-catchment in Vijayawada**

Name of the species	V1	V2	V3	V4
<i>Ficus religiosa</i>				
<i>Acacia nilotica</i>				
<i>Azadirachta indica</i>				
<i>Ricinus communis</i>				
<i>Abutilon indicum</i>				
<i>Antidesma acidum</i>				
<i>Datura innoxia</i>				
<i>Atalantia monophylla</i>				
<i>Ixora coccinea</i>				
<i>Chenopodium album</i>				
<i>Dactyloctenium aegypticum</i>				
<i>Plumbago zeylanica</i>				
<i>Digitaria ciliaris</i>				
<i>Chrysopogon zizanioides</i>				
<i>Cynodon dactylon</i>				
<i>Cyperus rotundus</i>				
<i>Plantago ovata</i>				
<i>Parthenium hysterophorus</i>				
<i>Poa annua</i>				
<i>Buchnanania lanzans</i>				
<i>Phoenix sylvestris</i>				
<i>Mangifera indica</i>				
<i>Thespesia populnia</i>				
<i>Diospyros melanoxylon</i>				
<i>Ficus benjamina</i>				
<i>Tamarindus indica</i>				
<i>Mimosa pudica</i>				
<i>Ocimum sanctum</i>				
<i>Lantana camera</i>				
<i>Hibiscus rosa-sinensis</i>				
<i>Opuntia sp.</i>				
<i>Amaranthus indica</i>				

Name of the species	V1	V2	V3	V4
<i>Ipomoea crassisepta</i>				
<i>Andrographis paniculata</i>				
<i>Cocos nucifera</i>				
<i>Eucalyptus globulus</i>				
<i>Melia azadirach</i>				
<i>Moringa oleifera</i>				
<i>Ficus virens</i>				
<i>Ficus krishnae</i>				
<i>Calotropis procera</i>				
<i>Cassia tora</i>				
<i>Jatropha curcas</i>				
<i>Tragus biflorus</i>				
<i>Eclipta alba</i>				
<i>Sida ovata</i>				
<i>Amaranthus viridis</i>				
<i>Bacopa monnieri</i>				
<i>Commelina benghalensis</i>				
<i>Clitoria ternatea</i>				
<i>Coccinea grandis</i>				
<i>Polyalthia longifolia</i>				
<i>Prosopis juliflora</i>				
<i>Cassia fistula</i>				
<i>Sesbania sesban</i>				
<i>Alternanthera</i>				
<i>Delonix regia</i>				



## Microcatchment V1

3 tree species, 6 shrub and 10 herb species were recorded from this micro-catchment (Figure 14), belonging to 15 families (Figure 15). Poaceae is the most dominant family.

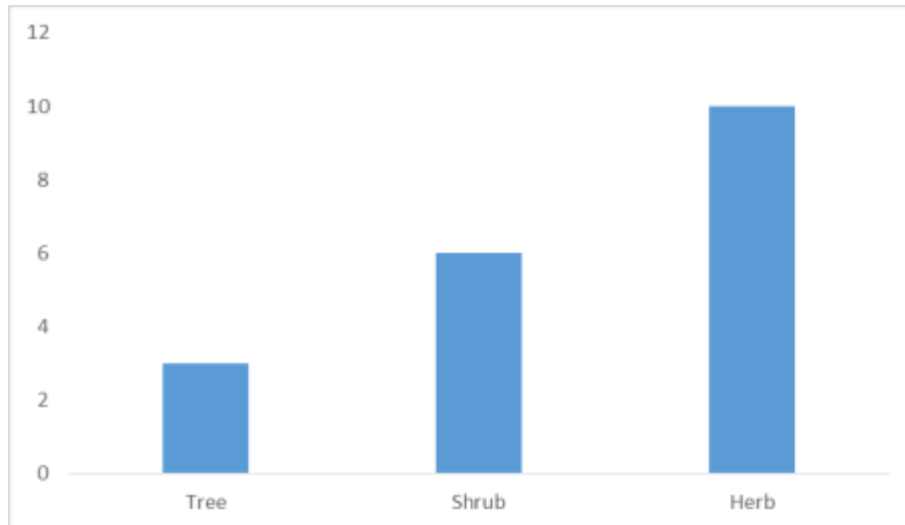


Figure 14: Vegetational lifeforms recorded

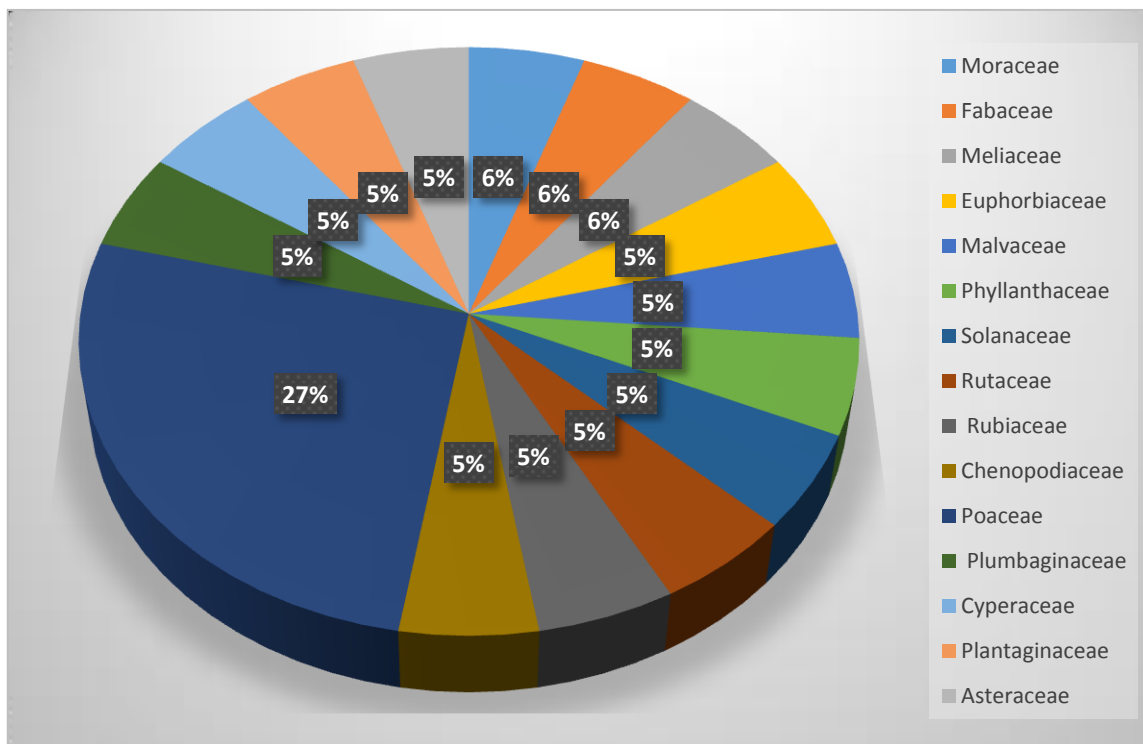


Figure 15: Family wise distribution of the plant species recorded

## Microcatchment V 2

9 tree species, 5 shrub and 9 herb species were recorded from this micro-catchment (Figure 16), belonging to 15 families (Figure 17). Poaceae is the most dominant family.

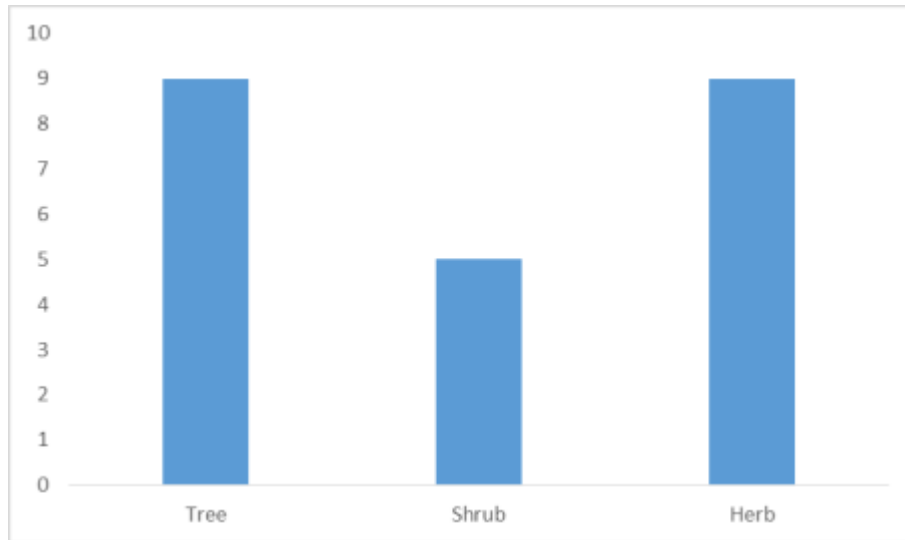


Figure 16: Vegetational lifeforms recorded

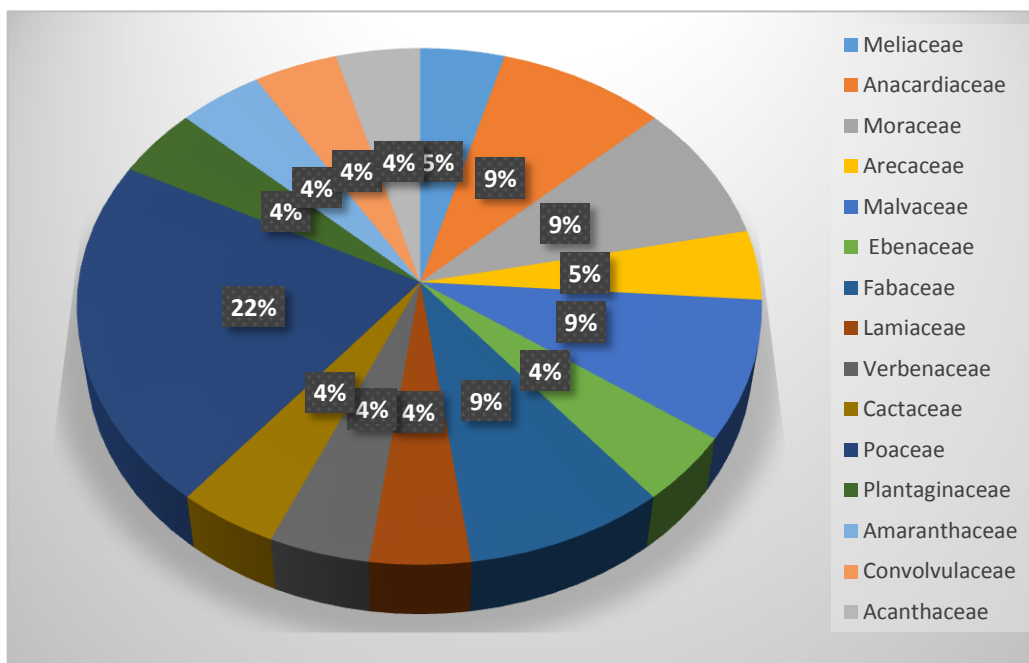


Figure 17: Family wise distribution of the plant species recorded

### Microcatchment V 3

8 tree species, 6 shrub and 16 herb species were recorded from this micro-catchment (Figure 18), belonging to 19 families (Figure 19). Poaceae is the most dominant family.

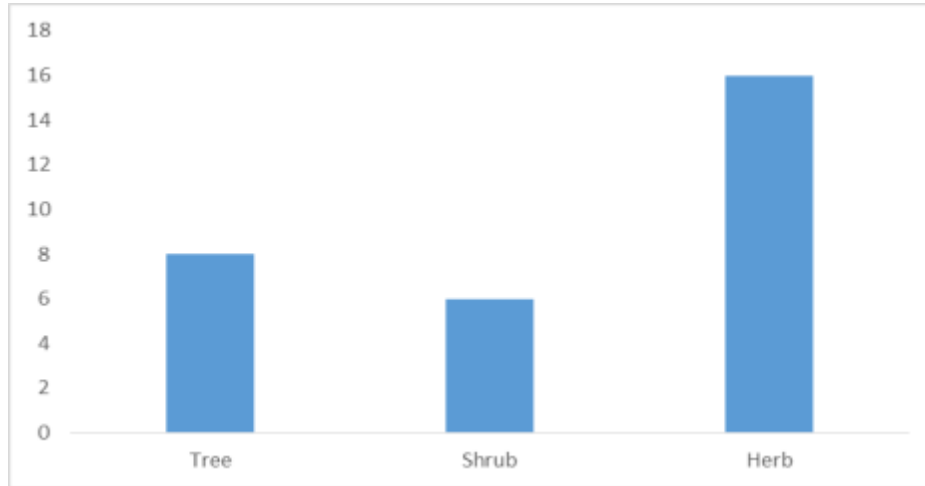


Figure 18: Vegetational lifeforms recorded

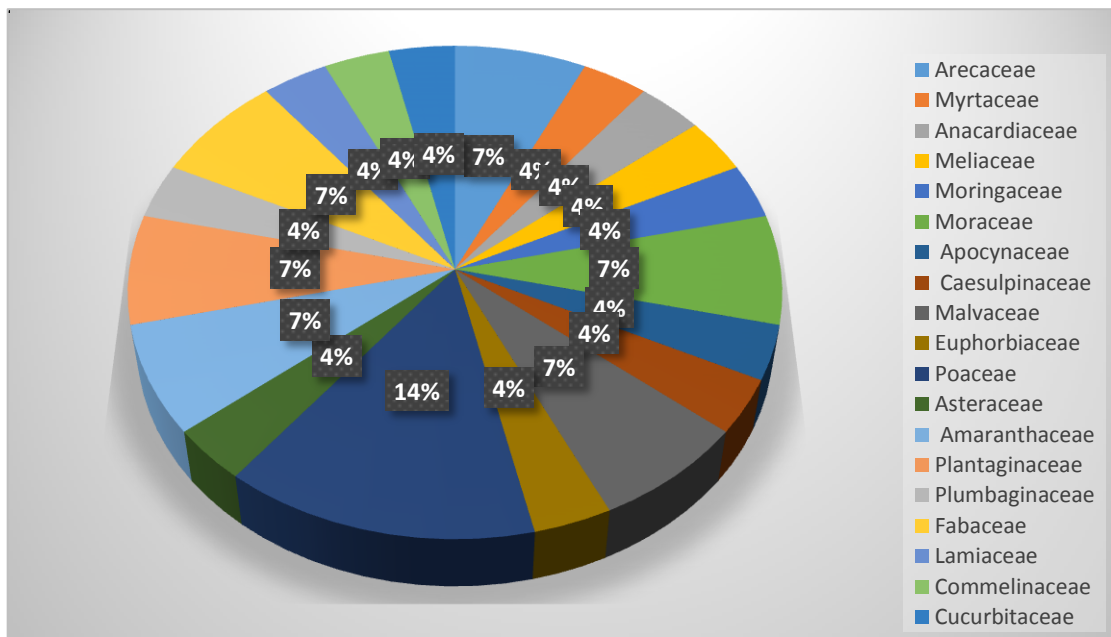


Figure 19: Family wise distribution of the plant species recorded

### Microcatchment V 4

7 tree species, 5 shrub and 11 herb species were recorded from this micro-catchment (Figure 20), belonging to 18 families (Figure 21). Amaranthaceae is the most dominant family.

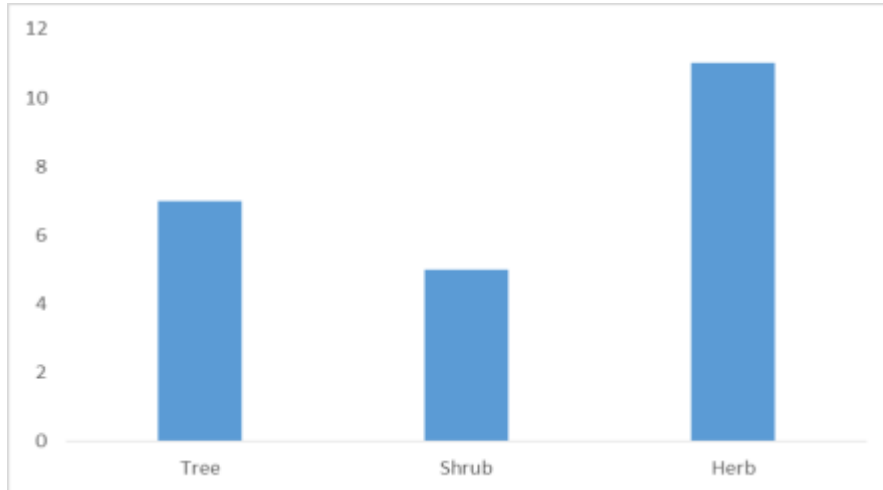


Figure 20: Vegetational lifeforms recorded

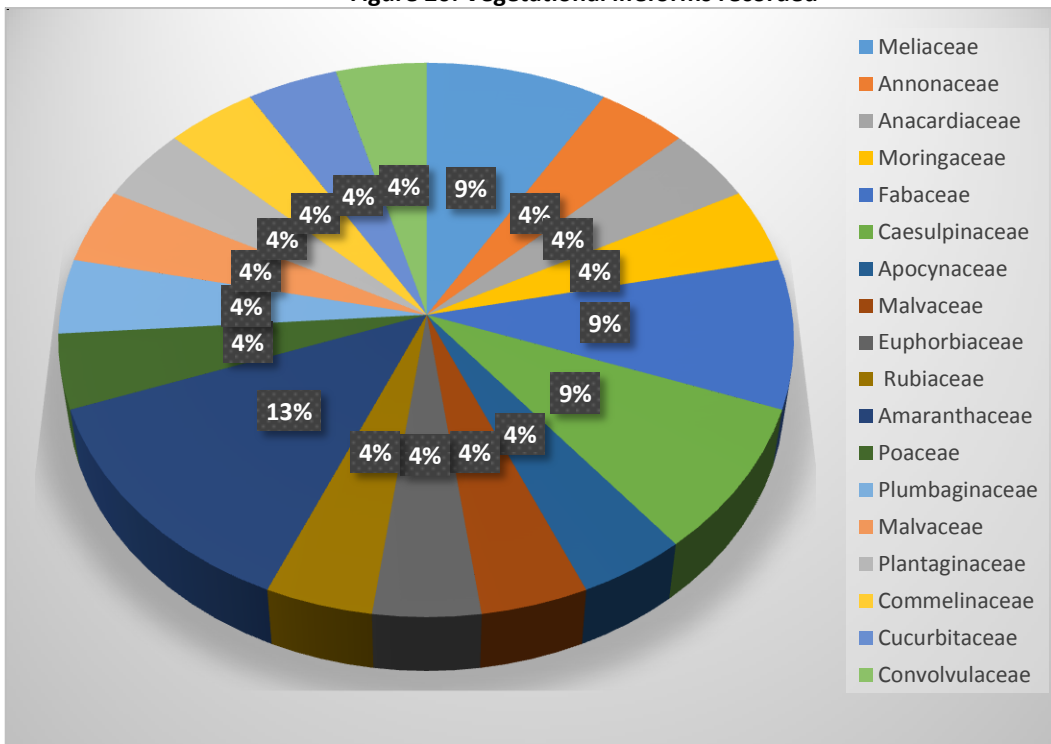


Figure 21: Family wise distribution of the plant species recorded



### Shannon Diversity:

Shannon diversity of each micro-catchment was calculated. V4 has the highest value. Figure 22 graphically represent the micro-catchment wise Shannon diversity.

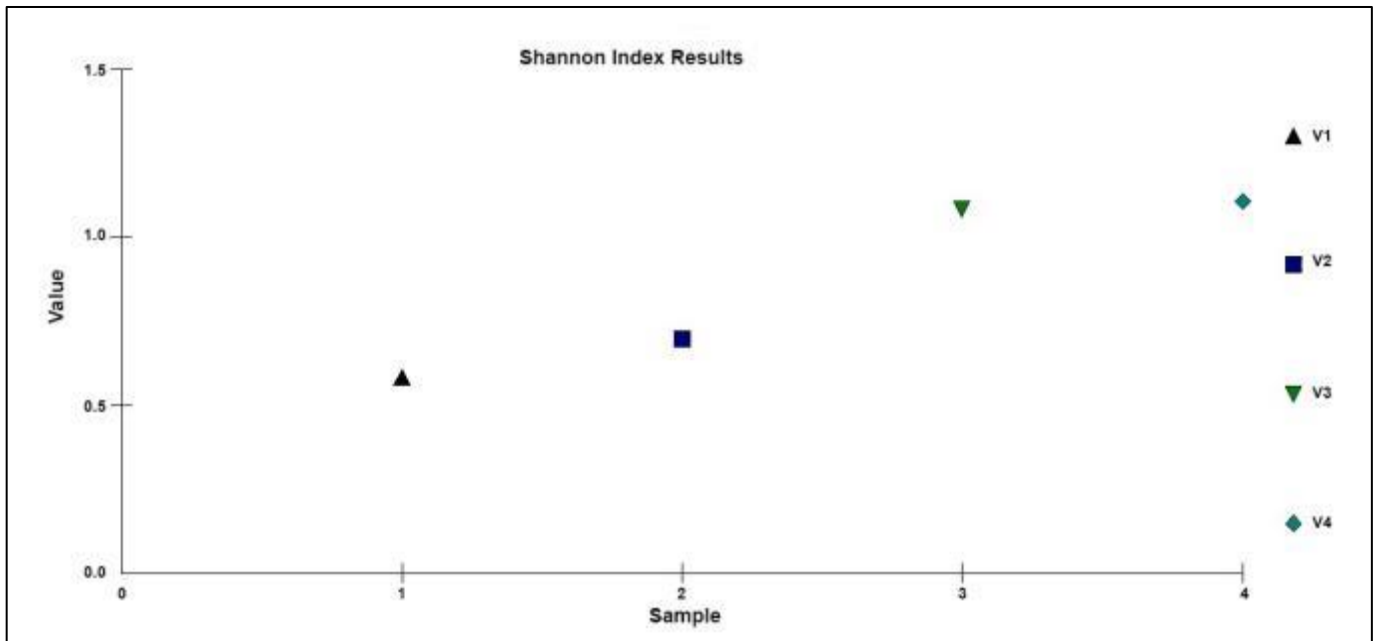


Figure 22: Microcatchment-Wise Shannon Diversity

Name of the micro-catchment	Shannon Diversity Index
V1	0.457
V2	0.528
V3	0.742
V4	0.836

Table 6: Shannon Diversity Index of different micro-catchments in Vijayawada

### Simpson's Diversity:

Simpson's diversity of each micro-catchment was calculated. V1 has the highest value. Figure 23 graphically represents the micro-catchment wise Simpson's diversity.

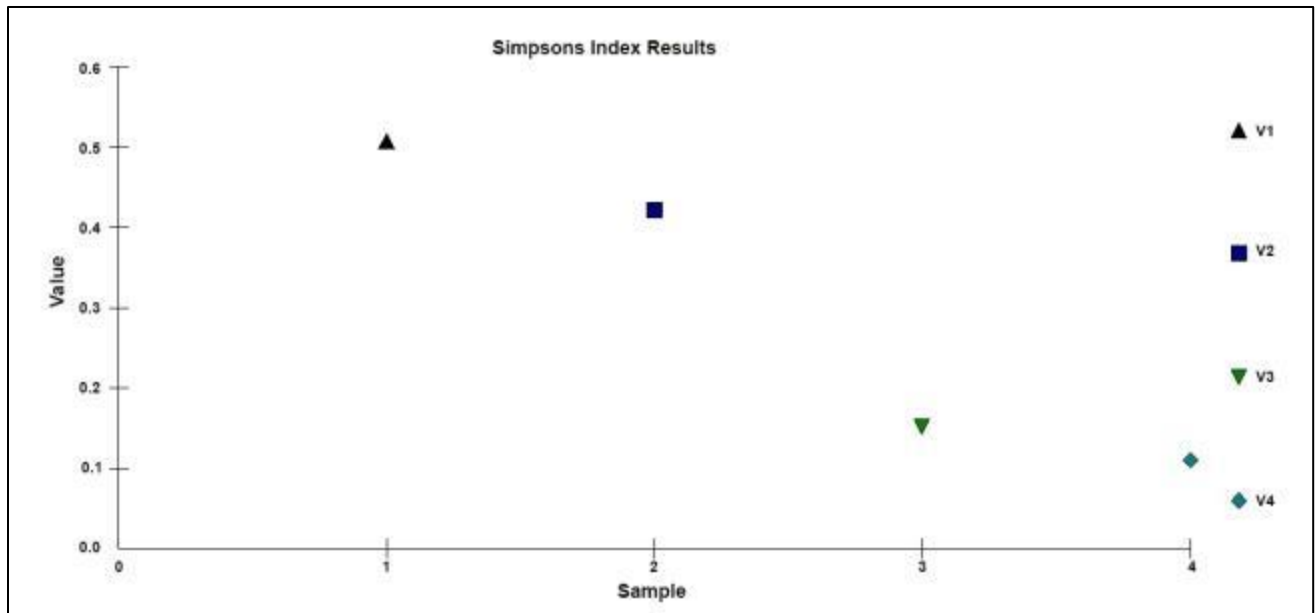


Figure 23: Micro- catchment-Wise Simpson's Diversity

Name of the micro-catchment	Simpson's Diversity
V1	0.507
V2	0.422
V3	0.152
V4	0.111

Table 7: Simpson's Diversity Index of different micro-catchments in Vijayawada

### Bray Curtis Similarity Matrix:

Figure 24 represents the Bray Curtis Similarity Matrix. The matrix clearly demarcates the level of closeness between the micro-catchments with respect to the floral species found in each of them.

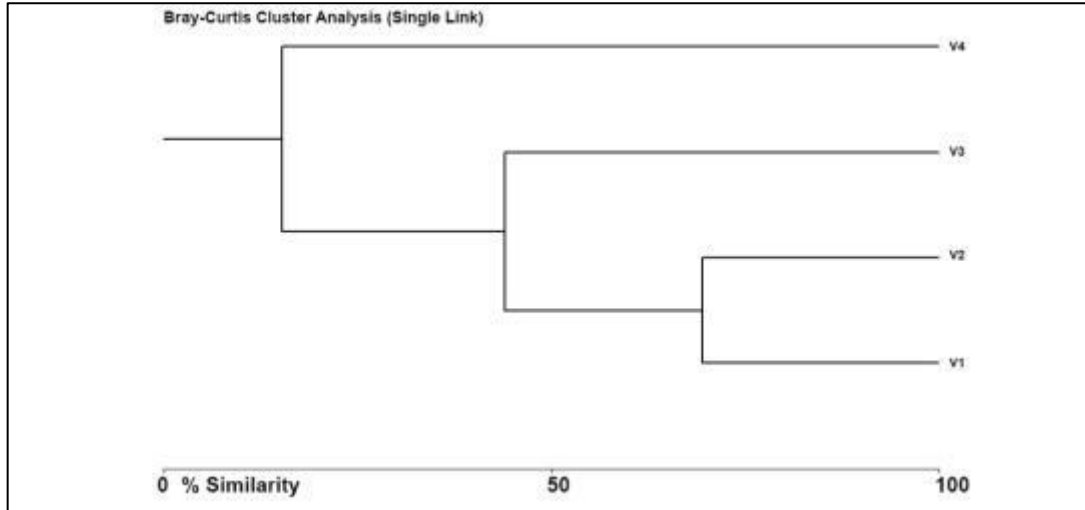


Figure 24: Bray Curtis Similarity Matrix

### Species Richness:

An analysis of the species richness gives an insight into the aggregation pattern of the individual species recorded from the entire study area. Table ..... details the same. The distribution pattern is not of one type and nearly an equal distribution between random and aggregated pattern of distribution among the individual species across all the four micro-catchments.

Table 8: Aggregation Patterns

Species	Aggregation	Species	Aggregation
<i>Ficus religiosa</i>	Random	<i>Hibiscus rosa-sinensis</i>	Aggregated
<i>Acacia nilotica</i>	Random	<i>Opuntia sp.</i>	Random
<i>Azadirachta indica</i>	Random	<i>Amaranthus indica</i>	Aggregated
<i>Ricinus communis</i>	Aggregated	<i>Ipomoea crassisepts</i>	Aggregated
<i>Abutilon indicum</i>	Aggregated	<i>Andrographis paniculata</i>	Aggregated
<i>Antidesma acidum</i>	Random	<i>Cocos nucifera</i>	Aggregated
<i>Datura innoxia</i>	Random	<i>Eucalyptus globulus</i>	Random
<i>Atalantia monophylla</i>	Aggregated	<i>Melia azadirach</i>	Random
<i>Ixora coccinea</i>	Random	<i>Moringa oleifera</i>	Random
<i>Chenopodium album</i>	Aggregated	<i>Ficus virens</i>	Random
<i>Dactyloctenium aegypticum</i>	Aggregated	<i>Ficus krishnae</i>	Random
<i>Plumbago zeylanica</i>	Random	<i>Calotropis procera</i>	Random
<i>Digitaria ciliaris</i>	Random	<i>Cassia tora</i>	Aggregated

Species	Aggregation	Species	Aggregation
<i>Chrysopogon zizanioides</i>	Random	<i>Jatropha curcas</i>	Aggregated
<i>Cynodon dactylon</i>	Aggregated	<i>Tragus biflorus</i>	Aggregated
<i>Cyperus rotundus</i>	Aggregated	<i>Eclipta alba</i>	Random
<i>Plantago ovata</i>	Aggregated	<i>Sida ovata</i>	Random
<i>Parthenium hysterophorus</i>	Aggregated	<i>Amaranthus viridis</i>	Aggregated
<i>Poa annua</i>	Aggregated	<i>Bacopa monnieri</i>	Aggregated
<i>Buchnanania lanzans</i>	Aggregated	<i>Commelina benghalensis</i>	Aggregated
<i>Phoenix sylvestris</i>	Aggregated	<i>Clitoria ternatea</i>	Aggregated
<i>Mangifera indica</i>	Aggregated	<i>Coccinea grandis</i>	Aggregated
<i>Thespesia populnia</i>	Random	<i>Polyalthia longifolia</i>	Random
<i>Diospyros melanoxylon</i>	Aggregated	<i>Prosopis juliflora</i>	Aggregated
<i>Ficus benjamina</i>	Random	<i>Cassia fistula</i>	Random
<i>Tamarindus indica</i>	Random	<i>Sesbania sesban</i>	Aggregated
<i>Mimosa pudica</i>	Random	<i>Alternanthera</i>	Aggregated
<i>Ocimum sanctum</i>	Aggregated	<i>Delonix regia</i>	Random
<i>Lantana camara</i>	Random		

### Rarefaction Curves:

These curves help to extrapolate the data and predict the scenario over a period of time. Figure 25 depicts the rarefaction curves obtained for the present data set.

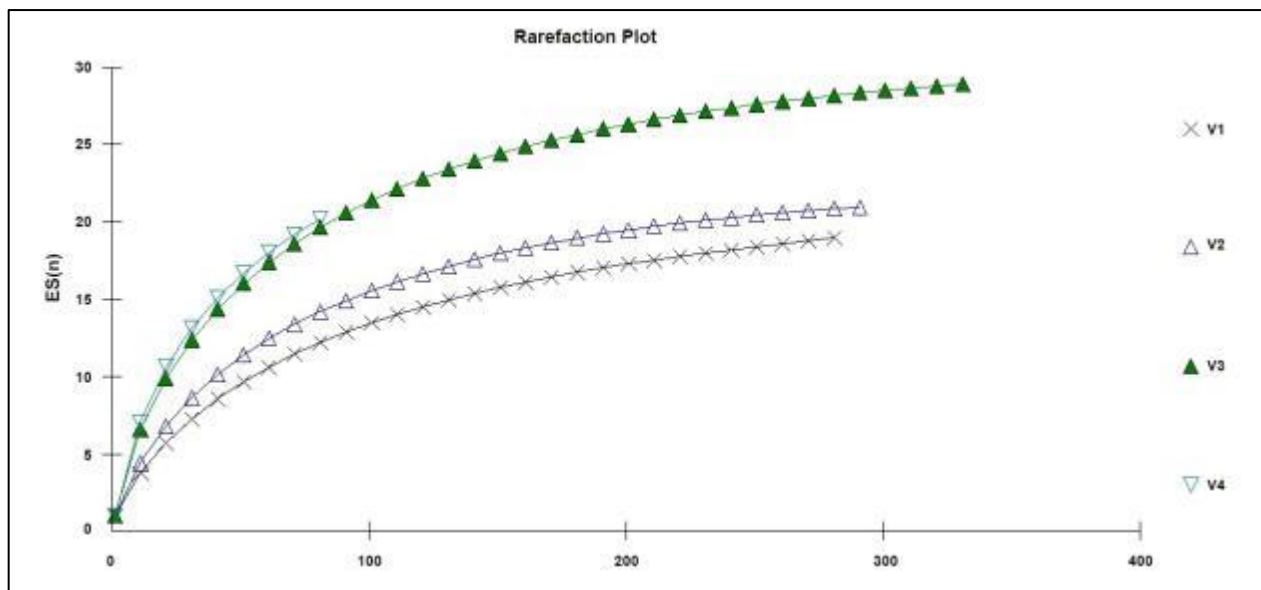


Figure 25: Rarefaction Plot



## **Way Forward**

The information that has been collected through the quadrat study in the micro-catchments will be analysed together with the information collected regarding the micro-catchments through the FGDs and discussions with the local administration. The information will be analysed in the context of the hydrological and topographical map of the catchment area to finally select the micro catchment area near Solapur and Vijayawada by conducting a SWOT analysis of the information collected. The detailed project activities will be carried out in this selected micro-catchment in the next.