Exploratory Data Analytics to Study the Impact of Parameters to Enhance the Population of House Sparrow (*Passer Domesticus*).

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Research Article

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Abstract

To achieve a sustainable conservation or adaptation strategy, it is necessary to understand the impacts of habitat and weather on particular species. Hence the study was focused to analyze the parameters that influence the population of house sparrow in various locations of Madurai Dist. Furthermore, its present and future suitable habitats have been predicted using computational tools. Statistical analysis and correlation were performed with data gathered through random sampling. Using correlation analysis, the association between various parameters was studied. Hierarchical clustering of data was performed by a Kendall Correlation coefficient to identify the suitable habitat and weather. Subsequently the Selection of the major parameters of a study was determined using Principal Component Analysis approach. The study highlights the significance of utilizing data mining and computational analysis to precisely understand the influence of various geographical parameters on the distribution and survival of the house sparrow population in an area. Based on the results obtained, abundance and distribution of house sparrow were closely related to the area of habitat in which house sparrows were found. The preference of particular habitat can be briefly explained using Kendall Correlation Matrix and cluster analysis. Using the Principal Component Analysis (PCA) technique, the population density of the house sparrow was studied. Taking these computational analyses into account will provide a new perspective on predicting the species distribution in the specific area thereby conserving it.

Introduction

House sparrow (*Passer domesticus*) plays a vital role in our ecosystem. Sparrows serve as an insect collector (pests) and helps in plant survival, they also act as an important agent for germination. They are abundantly found near the human habitats, like farms, suburban, and urban areas. The main food resources of house sparrow are the insects like caterpillar, grains, vegetables and fruits. They are uncommon in uninhabited woodlands, deserts, forests, and grasslands. Sparrows generally prefer smaller and confined places to construct nests, in man-made structures like rolling shop shutters (Balakrishnan .P et al. 2011; Nath et al. 2015), wall crevices of thatched roofs, electric pipelines, in ventilation holes and space available on the electricity meters as they are not exposed to the vagaries of nature, competitors and predators. (Ali 1996; Balaji et al. 2014). Though they are widespread, "State of India's Birds 2020" reported a gradual decline in the abundance of house sparrows, in urban areas.

Population Studies:

Fewer studies have been done on the observation and identification of house sparrow habitats. The standard methods of data collection for avian population studies are the 1. Point Count Method (Ralph et al. 1993), 2. Line Transect Method (Bibby et al. 1998). Point Counts Method was used to study the house sparrow population in 10 villages of Tiruchengode and Erode Taluks, Tamil Nadu, India from October 2017 to March 2018; wherein the study area was divided into grids of 1 sq.km and the population of house sparrow with respect to habitat structure and agricultural practice were analyzed (Deepalakshmi et al. 2019). Similarly, the population density of house sparrow in Moodbidri and Mijar from August 2016 to

September 2016 was studied using point count method (SurajPrabhakar Naik 2016). The former method was used the study the population density of house sparrow in Virudhunagar District from December 2011 to December 2013 (Balaji et al. 2013). Generally, Point Count Method was used to compare the relative population of birds recorded in different sites. A sparrow survey was conducted in May 2007, using the Line Transect Method, with 18 transects, each of 50 m distance in different alleys of the township; wherein the abundance of the species was studied with respect to vegetation, nests, and number of houses, shops, and the characteristics of roofs, open areas, fencings, wells, and water pipes (Dhanya et al. 2010). The population pattern estimation in different localities was widely studied using Line Transect method and the Point Count method (Gavimath et al. 2016). The population data collection has also been done through eBird.org database, which has a collection of house sparrow distribution data from 2014 to 2018. In order to understand the reasons for the decline of the house sparrow, population study was widely conducted. Based on the population density studies, it was evident that the population of house sparrow was hugely dependent on the environmental parameters like the geographical location, vegetation, weather, food availability and nesting grounds (Mcgillivray Wb 1981; Shaw 2009; Sharma P et al. 2020). A decline in house sparrow population has been reported due to the absence of nesting sites within urban localities (Rajashekar and Venkatesha 2008). Similarly, It was claimed that monoculture farming could be a limiting factor for house sparrow nesting and breeding (Suraj Prabhakar Naik 2016). However, an increase in the sparrow population in urban localities with abandoned buildings was observed (Balaji et al. 2014). Several field studies have been carried out only to identify the various environmental parameters that influence the population density of the house sparrow, but the correlation of the specified parameter with the population density has been lacking. To date, no data were available on the status and habitat of House sparrow in the Madurai District. In the present study, an attempt has been made to correlate the impact of various environmental parameters on the population of house sparrow in various localities of this District and to stipulate a computational algorithm to predict the sparrow population given a specific parameter in an area. Using computational analytic tools, the reason for decline in house sparrow population could be identified and reversed with proper recovery strategies. Parameters which contribute to the prevalence of the house sparrow in a specified area were analyzed using Principal Component Analysis

Methods

Study Area

The area chosen for the present study was Madurai District; which is a popular destination for tourists and pilgrims in Tamil Nadu. It is one of the oldest and continuously inhabited cities of India. The geographical location of Madurai is ~ 10 N, 78 E, with an average elevation of 101 meters. The study was undertaken for a period of 13 months, from Jan 2019 to Feb 2020. The district comprises of 13 blocks viz. Madurai East, Madurai West, Thirupparankundram, Melur, Kottampatti, Vadipatti, Alanganallur, Usilampatti, Chellampatti, T.Kallupatti, Sedapatti, Thirumangalam and Kallikudi comprising of 420 Village Panchayats [1]. The survey was carried out in all the 13 blocks of Madurai District represented in the

Fig. 1^[2]. A total of 168 random places within the study area was surveyed, which comprised of urban, semi-urban and rural habitats.

Method of study: In the present study, population based monitoring method was adopted which involves point count stations at random across a geographic area or along roadways (Mark et al. 2000). As suggested by Hostetler et al. 2016, this method consists of standing in a specific point location and counting birds, recording the number of birds, nests or other relevant objects such as burrows, droppings and footprints, etc. The study was conducted for a stipulated period of 14 months from January 2019 to February 2020 in 168 study areas in Madurai Dist. In each study site, the population density of house sparrow was observed by standing in a circle of 20 m radius and counting the number of birds, nests, burrows, droppings and foot prints for 10 minutes. The observation was done from 08:00 h to 12:00 h and 15:00 h to 17.30 h (IST). The study area was carefully observed and documented the presence of natural and artificial nesting sites, feeding grounds and other social activities of the sparrow.

Data Analysis: Data was analyzed using Microsoft Excel and QGIS (3.0.0) was used for a schematic representation of the maps. The population density of house sparrow observed through field survey was represented in the form of the Habitat patch area in Google map. The various parameters analyzed in the dataset include Block name, Day, Name of the Place, Status of House Sparrow, No. of Male, No. of Female, Weather and Habitat. The correlation between the number of male and the female sparrow population was done using scatter plot. The density and distribution of the male and the female sparrow population was analyzed with joint plot. To understand the distribution of data in the data set, Box plot was applied. The relation between the various parameters viz., status of house sparrow, number of male and female sparrow population density, weather and habitat were studied using correlation analysis. Since the collected dataset was ungrouped, hierarchical clustering analysis was performed to identify the similarities and differences within the studied parameters. The clustering correlation was analyzed using Kendall and Spearman technique; which is a rank-based correlation coefficient method.

Kendall Correlation coefficient is determined using the formula

$$\tau = \frac{\text{Number of concordant pairs} - \text{Number of discordant pairs}}{n(n-1)/2}$$

- **Concordant Pair:** A pair of observations (x1, y1) and (x2, y2) that follows the property
 - x1 > x2 and y1 > y2 or
 - x1 < x2 and y1 < y2
- **Discordant Pair:** A pair of observations (x1, y1) and (x2, y2) that follows the property
 - x1 > x2 and y1 < y2 or
 - x1 < x2 and y1 > y2
- **n:** Total number of samples

Note: The pair for which x1 = x2 and y1 = y2 are not classified as concordant or discordant and are ignored.

In order to validate the precision of the cluster groups, clustering algorithm was applied to the data points. The clustering algorithm assigns data points in a cluster such that the sum of the squared distance between the data points and the cluster's centroid (arithmetic mean of all the data points that belong to that cluster) is at the minimum. The lesser the variation within clusters, the more homogeneous (similar) the data points are within the same cluster. The Principal Component Analysis (PCA) technique was performed to the given data set of house sparrow population count to analyze the major factors or parameters which contribute to the prevalence of the house sparrow in a specified area. A feature selection method is proposed to select a subset of variables in principal component analysis that preserves as much information present in the complete data as possible. The information was measured by means of the percentage of consensus in the generalized Procrustes analysis.

Results

Population Density Prediction: Out of the 168 data collection points in Madurai District, the prevalence of house sparrow was observed in 109 study sites (**Fig. 2**).

Using Point count summary statistics, different assumptions about behavioral and population processes were reflected (i.e) Population mean abundance, maximum abundance, frequency and presence/absence (Matthew et al. 2005) .

In **Fig. 3**, the population density of house sparrow as observed by the point count method was represented with respect to the various parameters viz., Block, Date, Day, Place, Status of the house sparrow, Number of males, Number of female, Weather and Habitat. In all the 168 data collection sites, all the 10 parameters were recorded simultaneously to avoid statistical error during sampling.

The number of male population against the female population in the study area was represented using Scatter plot, Joint Plot and Box Plot respectively (**Fig. 4, 5 & 6**). In the Joint plot (**Fig. 5**), both the male and female population showed right-skewed distribution with outliers. The densest area of population distribution was in the range of -10 to 45 scale units.

Prediction of Habitat type Effect: The correlation matrix (**Fig. 7**) Indicates that the status of the house sparrow, no. of male, no. of female, weather and habitat are highly correlated with one another.

In **Fig. 8**, the cluster analysis of the obtained data set was represented, wherein the Kendall and Spearman correlation was employed to obtain clusters for the available data set. The Kendall and Spearman correlation is a rank-based correlation coefficient method. The Kendall Correlation Matrix illustrates the impact of various parameters on the population of house sparrow in the study area (**Fig. 9**).

Precision and Cluster Analysis : Based on the cluster analysis of the available data set, maximum data points were plotted using three clusters (**Fig. 10**). The influence of habitat and weather conditions on the house sparrow population was illustrated in **Fig. 11**.

Principal Component Analysis was performed on the available data set of house sparrow count to analyze the major factors or parameters which contribute to the population of the house sparrow in the study area (**Fig. 12**).

Discussion

Using the population-based monitoring method, the observed population density indicates that it is apparent that the House sparrow was prevalent in damp weather compared to clear weather. The increase in the population of house sparrows during the North East monsoon season might be due to the availability of insect larva for its nestlings. Similarly, Rajashekar and Venkatesha 2008, has reported an increase in the number of birds during the South West monsoon (June–September) followed by the North-East monsoon (October–November) in Bangalore. **Figures 4, 5 & 6**, represents the number of male population against the female population in the study area using Scatter plot, Joint Plot and Box Plot respectively. In the Joint plot (**Fig. 5**), both the male and female population showed right-skewed distribution with outliers. The densest area of population distribution was in the range of -10 to 45 scale units. The Boxplot (**Fig. 6**) Clearly illustrates the variation in the occurrence of male and female population between different study sites. This shows that the sampling was not similar, but extensively varied. The correlation matrix (**Fig. 7**) Indicates that the status of the house sparrow, no. of male, no. of female, weather and habitat are highly correlated with one another. Choudhary S et al. 2019, stated that habitat variables like the presence of old buildings, residential areas, vegetation, water, grocery shops, food provision, open drainage system and open household waste dump influenced the selection of habitat by house sparrows. The population of male and female house sparrow is highly correlated with one another; hence a decline in male population would be directly reflected in the occurrence of the female population and vice versa (**Fig. 13**). In the statistical interpretation (**Fig. 14**) it was evident that the number of male house sparrow was more than the female in a given location. Despite the statistical interpretation, it was

scientifically proven that variation in the primary sex ratio in house sparrow population was potentially influenced by seasonal variation in parental quality where good quality mother were more likely to produce, when bred late in the breeding season (Trivers and Willard 1973).

Habitat plays a vital role in the survival of an organism. House sparrows have been spotted in both rural and urban habitats. In the present study, **Fig. 15** illustrates the correlation between house sparrow population and the type of habitat (rural, semi urban and urban). Based on the above results it could be stated that the house sparrow population was more dominant in the rural habitat, followed by the semi urban habitat. A study emphasized that though sparrow showed least preference to urban habitats, the introduction of artificial nesting boxes could be a suitable measure to increase the house sparrow population in the urban habitat (Balaji et al. 2014).

The correlation between weather and population density of house sparrow in the study area was signified in **Fig. 16**. The number of sparrows counted in sunny weather was 81, while in clear and rainy weather conditions, the number of sparrows was 46 and 41 respectively. The data clearly show the preference of house sparrow towards sunny weather condition. Among the 13 study blocks surveyed in Madurai district, the maximum number of house sparrow count was recorded in Madurai West followed by Thiruparankundram, Madurai East, Thirumangalam, T.Kallupatti and Alanganallur (**Fig. 17**).

The average house sparrow count of the Madurai West block was 12.92. In the Kendall and Spearman correlation the endpoint was a set of clusters, where each cluster is distinct from other cluster, but broadly similar data are clustered together. The Kendall Correlation Matrix illustrates that the number of male, the number of female, status of house sparrow was found to be influenced by the habitat and weather of the study area. Based on the data points obtained from the cluster analysis, Cluster 0, indicated that during clear weather, the male and female population count lies within 1–25 and were seen predominantly in rural areas compared to urban habitat. In Cluster 1, the data were grouped with reference to sunny weather, wherein the population count ranged from 1–35. Lastly in Cluster 3, rainy weather was taken into consideration, with the population ranging from 1–35. Performance evaluation of clustering indicated that a 100% precision and recall score was obtained and the data points correctly fall under the three clusters (**Fig. 18**).

Based on the computational analysis, the population of house sparrow in an area, was found to be directly influenced by the block location, habitat and weather conditions of the region. Hence, by further monitoring of these parameters, the decline in house sparrow population can be revived using suitable revocation strategies. Principle Component Analysis has selected five major features (Block, Habitat, Weather, No. of the female and No. of male) which plays a vital role in the prevalence of a house sparrow was explained in **Fig. 12**. Various studies were performed to obtain strong evidence that temperature, it acts as a cue for this plasticity in breeding timing, the exact nature of the cue and response remain unexplained. Matthysen et al. 2021 investigated that small-scale variation in egg laying date, explained by local tree phenology, tree species composition around its habitat. Hence such study can be

incorporated for further clarification with response to species of trees and insect diversity with house sparrow population.

Conclusion

The study highlights the significance of utilizing data mining and computational analysis to precisely understand the influence of various geographical parameters on the distribution and survival of the house sparrow population in an area. Based on the Kendall Correlation Matrix and cluster analysis, the house sparrow population has been identified to prefer rural habitat. Using the Principal Component Analysis (PCA) technique, the major parameters influencing the population density of the house sparrow has been identified. The three important features or parameters which play a vital role in increasing the house sparrow population are block location; habitat and weather conditions of the area. By monitoring these parameters and providing ideal habitats, the declining number of house sparrows in other localities can be improved. The future perspective of computational analysis involves extensive data collection, such as architectural changes, agricultural practices, food availability, environmental factors and other bird diversity with reference to the surroundings of house sparrow by using habitat based point count method. Ecological modelling of house sparrow can be done through remote sensing and geographical imaging system too.

Declarations

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Consent to participate: Not applicable.

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Websites

¹. <https://madurai.nic.in/district-profile/>

².Madurai District map block wise: <https://madurai.nic.in/administrative-setup/development-administration/#villpan>

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Figures

Figure 1

Block wise representation of the Madurai District

Figure 2

Map of Madurai District illustrating the present (blue) and absent (red) sites of data collection Courtesy: Google Map

S.No	Block name	Date	Day	Name of the place	Status of House Sparrow	No.of. Male	No.of. Female	Weather	Habitat	
0	1	Madurai East	25.2.2019	Monday	Andarkottaram	Absent	0	0	Clear	Rural
1	2	Madurai East	25.2.2019	Monday	Karseri	Absent	0	0	Clear	Rural
2	3	Madurai East	26.2.2019	Tuesday	Ilandaikkulam	Absent	0	0	Clear	Rural
3	4	Madurai East	26.2.2019	Tuesday	Kalikappan	Absent	0	0	Clear	Rural
4	5	Madurai East	26.2.2019	Tuesday	Ulaganeri	Absent	0	0	Clear	Rural
...	...	...	...	...	...	...	...	...	...	
163	166	Kallikudi	14.8.2019	Wednesday	Thoombakulam	Present	11	7	Rainy	Rural
164	167	Kallikudi	14.8.2019	Wednesday	Kallanai	Present	14	13	Rainy	Rural
165	168	Kallikudi	14.8.2019	Wednesday	Nedungulam	Present	34	24	Rainy	Rural
166	169	Kallikudi	14.8.2019	Wednesday	Periya ulagani	Present	1	1	Rainy	Rural
167	170	Kallikudi	14.8.2019	Wednesday	Koodakovil	Present	2	1	Rainy	Rural

168 rows × 10 columns

Figure 3

Population density of house sparrow with respect to various parameters (168 study sites x 10 parameters)

Figure 4

Scatter plot representing the correlation between the male and female population of house sparrow in the study area

Figure 5

Joint plot representing the correlation between the male and female population of house sparrow in the study area

Figure 6

Box plot representing the correlation between the male and female population of house sparrow in the study area

Figure 7

Correlation matrix of the various parameters (Block, Date, Day, Place, Status, Number of male, Number of female, Weather, and Habitat) influencing the population of house sparrow in the study area

Figure 8

Cluster representation of the collected data with respect to the various parameters.(X-axis represents samples and Y-axis represents the distance between these samples. There are 3 cluster solutions possible for the given dataset which is indicated by Blue, Green and red colours)

Figure 9

Kendall Correlation matrix of the various parameters (Block, Date, Day, Place, Status, Number of male, Number of female, Weather, and Habitat) influencing the population of house sparrow in the study area

Figure 10

Cluster algorithm representing the number of clusters obtained from the available data

Figure 11

Cluster analysis of the population density of the house sparrow with respect to weather and habitat in the study area

	feature0	feature1	feature2	feature3	feature4	feature5	feature6	feature7	feature8	feature9	feature10
163	1.636348	-1.0711	-0.692569	1.091516	1.226891	0.726135	0.270303	-0.068415	-0.246803	-0.390946	-0.053816
164	1.656632	-1.0711	-0.692569	1.091516	-0.896971	0.726135	0.552943	0.511100	-0.246803	-0.390946	-0.053816
165	1.676916	-1.0711	-0.692569	1.091516	0.072170	0.726135	2.437209	1.573544	-0.246803	-0.390946	-0.053816
166	1.697199	-1.0711	-0.692569	1.091516	0.319610	0.726135	-0.671831	-0.647930	-0.246803	-0.390946	-0.053816
167	1.717483	-1.0711	-0.692569	1.091516	-0.567050	0.726135	-0.577617	-0.647930	-0.246803	-0.390946	-0.053816

0 1

0	PC0	Block name
1	PC1	Habitat
2	PC2	Weather
3	PC3	No.of. Female
4	PC4	No.of. Male

Figure 12

Principal Component Analysis (PCA) of the 10 parameters to choose the five major parameters influencing the population density of house sparrow in the study area

Figure 13

Correlation matrix between the male and female population of house sparrow in the study area

```
[11]: import seaborn as sns
      corr = data.corr()
      corr
```

Out[11]:

	No.of. Male	No.of. Female
No.of. Male	1.000000	0.976558
No.of. Female	0.976558	1.000000

Figure 14

Statistical interpretation of the correlation between the population of male and female house sparrow in the study area

	count	mean	std	min	25%	50%	75%	max
Habitat								
Rural	143.0	7.776224	10.501790	0.0	0.00	2.0	13.5	52.0
Semi urban	15.0	10.533333	11.673331	0.0	1.50	3.0	23.0	28.0
Urban	10.0	2.500000	2.321398	0.0	1.25	2.0	3.0	8.0

	count	mean	std	min	25%	50%	75%	max
Habitat								
Rural	143.0	8.307692	10.852553	0.0	0.00	2.0	15.0	47.0
Semi urban	15.0	10.066667	11.253359	0.0	1.50	4.0	19.5	28.0
Urban	10.0	2.700000	2.869379	0.0	1.25	2.0	3.0	10.0

Figure 15

Statistical interpretation of the correlation between the population of house sparrow and the habitat (rural, semi urban and urban) in the study area

	count	mean	std	min	25%	50%	75%	max
Weather								
Clear	46.0	7.282609	10.847761	0.0	0.0	1.0	13.75	33.0
Rainy	41.0	10.146341	9.918571	0.0	1.0	9.0	17.00	29.0
Sunny	81.0	6.716049	10.275255	0.0	0.0	2.0	9.00	52.0

	count	mean	std	min	25%	50%	75%	max
Weather								
Clear	46.0	7.217391	10.605896	0.0	0.0	1.0	14.75	30.0
Rainy	41.0	11.365854	10.806841	0.0	1.0	12.0	18.00	34.0
Sunny	81.0	7.012346	10.383272	0.0	0.0	2.0	11.00	47.0

Figure 16

Statistical interpretation of the correlation between the population of house sparrow and the weather (clear, rainy and sunny) in the study area

	count	mean	std	min	25%	50%	75%	max
Block name								
Alanganallur	14.0	4.928571	5.967402	0.0	0.00	3.0	10.50	16.0
Chellampatti	12.0	13.583333	14.588030	0.0	0.00	8.0	27.75	33.0
Kallikudi	12.0	9.083333	10.166418	0.0	1.00	4.5	15.50	26.0
Kottampatti	10.0	4.000000	9.104334	0.0	0.00	0.0	0.75	28.0
Madurai East	17.0	3.176471	6.511867	0.0	0.00	0.0	3.00	24.0
Madurai West	18.0	6.722222	9.778762	0.0	1.25	2.5	4.00	28.0
Melur	12.0	10.250000	15.731410	0.0	1.50	2.5	14.00	52.0
Sedapatti	9.0	15.777778	10.509255	0.0	8.00	15.0	24.00	29.0
T. Kallupatti	15.0	12.733333	10.109873	0.0	2.00	12.0	21.00	27.0
Thirumangalam	16.0	5.062500	7.397916	0.0	1.00	2.0	5.25	26.0
Thiruparankundram	18.0	5.111111	7.729918	0.0	0.00	1.5	10.50	26.0
Usilampatti	8.0	8.000000	12.340410	0.0	0.00	0.5	12.75	28.0
Vadipatti	7.0	6.571429	11.133390	0.0	0.00	0.0	8.50	29.0

	count	mean	std	min	25%	50%	75%	max
Block name								
Alanganallur	14.0	5.214286	6.553667	0.0	0.00	2.0	11.50	16.0
Chellampatti	12.0	12.833333	13.730082	0.0	0.00	7.5	28.00	30.0
Kallikudi	12.0	11.750000	13.108810	0.0	1.75	6.5	17.75	34.0
Kottampatti	10.0	4.100000	8.710785	0.0	0.00	0.0	0.75	25.0
Madurai East	17.0	3.470588	7.151203	0.0	0.00	0.0	4.00	28.0
Madurai West	18.0	6.666667	9.573247	0.0	1.25	3.0	3.75	26.0
Melur	12.0	9.500000	14.761744	0.0	1.50	2.0	12.00	47.0
Sedapatti	9.0	16.222222	10.022198	0.0	13.00	16.0	23.00	29.0
T. Kallupatti	15.0	13.733333	11.151340	0.0	2.50	13.0	23.00	30.0
Thirumangalam	16.0	6.750000	8.925619	0.0	1.00	3.0	7.00	28.0
Thiruparankundram	18.0	5.166667	8.031189	0.0	0.00	1.5	9.00	28.0
Usilampatti	8.0	8.000000	11.988089	0.0	0.00	0.5	13.50	29.0
Vadipatti	7.0	6.714286	10.873734	0.0	0.00	0.0	9.50	28.0

Figure 17

Statistical interpretation of the correlation between the population of house sparrow and the study blocks (Madurai East, Madurai West, Thirupparankundram, Melur, Kottampatti, Vadipatti, Alanganallur, Usilampatti, Chellampatti, T.Kallupatti, Sedapatti, Thirumangalam and Kallikudi) in Madurai Dist

```
[[71  0  0]
 [ 0 52  0]
 [ 0  0 45]]
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	71
1	1.00	1.00	1.00	52
2	1.00	1.00	1.00	45
accuracy			1.00	168
macro avg	1.00	1.00	1.00	168
weighted avg	1.00	1.00	1.00	168

Figure 18

Precision analysis of the clustered groups obtained from the available data