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Azhagu Raj R
Department of Zoology, St. Xavier's College (Autonomous), (Autonomous), Palayamkottai, Tamil Nadu, India

Patrick F
Department of Mathematics, St. Xavier's College (Autonomous), (Autonomous), Palayamkottai, Tamil Nadu, India

Jude D
Department of Zoology, St. Xavier's College (Autonomous), (Autonomous), Palayamkottai, Tamil Nadu, India

Jenifer Wency S
Department of Mathematics, Servite Arts and Science College for Women, Thogaimalai. Tamil Nadu, India

Joy Beaula F
Department of Mathematics, St. Xavier's College (Autonomous), (Autonomous), Palayamkottai, Tamil Nadu, India

Divyanadam I
Department of Mathematics, St. Xavier's College (Autonomous), (Autonomous), Palayamkottai, Tamil Nadu, India

Corresponding Author:
Azhagu Raj R
Department of Zoology, St. Xavier's College (Autonomous), (Autonomous), Palayamkottai, Tamil Nadu, India

Assessing avian biodiversity in Swamithoppu saltpan with the fuzzy matrix approach

Azhagu Raj R, Patrick F, Jude D, Jenifer Wency S, Joy Beaula F and Divyanadam I

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Abstract
Fuzzy matrix is an invaluable tool in determining the biodiversity of a particular area. It is used to measure the species richness and abundance of a given area, as well as account for the presence of rare species. This study used fuzzy matrix analysis Initial Raw Data Matrix (IRDM), Average Quantity Dependent Data Matrix (AQDM), Refined Quantity Dependent Data Matrices (RQDMs), and Combined Effect Quantity Dependent Data Matrix (CEQDM) to determine the distribution and diversity of wetland birds in Samythoopu. The results showed that the maximum number of birds chose the sites of J1, J2,J3, S4, and S5, while the S2 point was identified as the most disturbed site and the birds were facing threats in sites including J4, S2, S3, S5, U1, U2, and U3. This fuzzy matrix can help predict the exact places with more anthropogenic disturbance to disturb the diversity and distribution of wetland birds.

Keywords: Fuzzy matrix, biodiversity, wetland and dependent data matrix

Introduction

Birds are ideal bio-indicators and useful models for studying a variety of environmental problems; hence, the condition of local landscape must be investigated to identify crucial determinants of the bird community structure for avian conservation. Wetlands in India cover an area of 58.2 million hectares [1]. Of 1340 bird species found in India [2] 310 species are known to be dependent on wetlands [3]. India has totally 27403 wetlands of which 23444 are inland wetlands and remaining 3959 are coastal wetlands. Nowadays, Wetlands are one of the most threatened habitats because of their vulnerability to exploitation for development. Study of avifaunal diversity is an essential ecological tool, which acts as an important indicator to evaluate different habitats both qualitatively and quantitatively. Unfortunately, global diversity of birds is decreasing incessantly primarily due to anthropogenic disturbances and climate change. Seasonal variations in the food availability also determines the regular pattern of migration and local movements. Food availability is the major factor determining the seasonality of breeding [4].

Threats to saltpan birds include loss of habitat, competition from invasive species, altered hydrology, climate change, and disturbance from recreational activities and pollution from agricultural runoff, industrial emissions, and sewage. Additionally, increasing urbanization and development in coastal areas can reduce the amount of suitable habitat available to saltpan birds [5, 6].

Fuzzy matrix can be used to accurately represent the species richness of a given area. This makes it an invaluable tool in determining the biodiversity of a particular area. Fuzzy matrix can also be used to measure the relative abundance of each species in a given area. This allows for more accurate and in-depth analysis of bird populations. Fuzzy matrix can also be used to account for the presence of rare species in an area. This is important for conservation and management of bird populations. Fuzzy matrix can also help identify areas with the highest concentrations of bird species, allowing for more targeted conservation efforts [7, 8].

Simpson and Shannon-Weiner indices are limited by the number of species captured in the sample. If the sample does not capture a full representation of the species present, the index values may not accurately reflect the true bird diversity of the area. Both the Simpson and Shannon-Weiner indices are limited by the size of the area being sampled. If the sample area is too small, the index values may not accurately reflect the diversity of birds in the larger area. Fuzzy matrix does not account for the genetic diversity of each species, as it only looks at the species as a whole.

Fuzzy matrix can also help identify areas with the highest concentrations of bird species, allowing for more targeted conservation efforts. Lastly, fuzzy matrix can be used to compare the species richness and abundance of different areas, allowing for better management of bird populations across large regions. The fuzzy matrix allows for more precise measurement of bird biodiversity due to its ability to account for factors such as similarity between species. Finally, the fuzzy matrix is more suitable for rare species, as it can account for their presence even if they are present in small numbers [8].

Fuzzy matrices and fuzzy cognitive maps were used by Vasantha Kandasamy [9]. They studied on socioeconomic and psychological problems using theory of fuzzy matrices and fuzzy based models. They assumed four categories of matrices such as, initial raw data matrix (IRDM), average time dependent data matrix (ATDM), refined time dependent data matrix (RTDM), and combined effect time dependent data matrix (CETDM), respectively. Afterward these concepts were successively applied in medical sciences, engineering sciences, Industry and biological diversity studies.

Victor Devadoss *et al.*, [10] worked on dimensions of women personality in Chennai using combined effect time dependent data matrix. Narayanamoorthy [11] estimated the maximum age group of silk weaver as bounded labours using fuzzy combined effect time dependent data matrix. Narayanamoorthy *et al.*, [12] obtained maximum age group of endosulfan pesticide victims in Kerela using fuzzy combined effect time dependent-data-matrix. Kokila [13] worked on student's information gathering attitude by applying fuzzy matrix combined effect time dependent data matrix. Jon Arockiaraj and Murali [14] reported that the using fuzzy matrix analysis of seasonal fishing in Cuddalore. Iftikhar *et al.*, [15] estimated the maximum age group of stressed students studying in Higher Education using combined effect time dependent data matrix. Radhika, *et al.*, [16, 17] studied that the risk factor of breast cancer and uses in aquaculture by using CETD data matrix analysis. In this study, we used the combined effect time quantity dependent data matrix for the predication of distribution and diversity of wetland birds in Samythoopu. The present study focus on whether the anthropogenic factors and landscape patterns disturb the diversity and distribution of wetland birds by using fuzzy combined effect time quantity dependent data matrix.

2. Study Area

Swamythoppu saltpan is the name of a village that lies near the southeast of the city of Nagercoil, located at the extreme southern tip of India. Swamythoppu is located at 8.12°N 77.49°E. It receives both set of rainfall from the Southwest monsoon and Northeast monsoon. The saltpan is situated adjacent to the Manakudy estuary, which get its water from the river Palayar, Perennial River.

3. Observed Attributes with Short Descriptions

Bird survey was conducted, when birds are most active during day from 06:00 to 10:00 hrs. Fourteen-point count points were plotted randomly using Qgis software. The study site was grouped into 3 Stations namely Disturbed Site with 3 points namely U1, U2 and U3, Partially Disturbed site with 6 points namely J1, J2, J3, J4, J5 and J6 and Undisturbed Site with 5 points namely S1, S2, S3, S4 and S5.

4. Formulation of Problem: Total number of birds was 3158 in 14 sites. From the collected data, we have chosen sites having 50 or >50 birds count were used for this analysis.

5. Preliminaries

This section includes some basic definitions and notations on different types of fuzzy matrices.

Definition 2.1 An initial raw data matrix (IRDM) is the collection of initial data into matrix form by taking birds common name as rows and point count sites as the columns.

Definition 2.2 An average quantity dependent data matrix (AQDM) is derived by transforming initial raw-datamatrix by dividing each row with the percentage difference in given point count sites.

Definition 2.3 A number of refined quantity dependent data matrices (RQDMs) are derived by varying a parameter $\alpha \in$ [0, 1] and using mean and standard deviation methods. The only entries of refined quantity dependent data matrices are -1, 0 or 1.

Definition 2.4 A transformation of average quantity dependent data matrix into a number of refined quantity dependent data matrices by varying a parameter$\alpha \in$ [0, 1] and using mean and standard deviation isobtained using thefollowing mathematical formulae:

If $a_{ij} \le \mu_j - \alpha\sigma_j$ then $b_{ij} = -1$

Else $a_{ij} \ge \mu_j + \alpha\sigma_j$ then $b_{ij} = 1$

Elseif $a_{ij} \in (\mu_j - \alpha\sigma_j, \mu_j + \alpha\sigma_j)$ then $b_{ij} = 0$

Where $\mu_j$simple mean and$\sigma_j$is standard deviationof corresponding to each column of the average quantity dependent-data-matrix, respectively.

Definition 2.5 A combination of different refined quantity dependent-data-matrices by varying $\alpha \in$ [0, 1] gives cumulative effect of all the entries, and known as combined effect quantity dependent-data-matrix (CETDM).

6. Methodology

Step 1. Using entries of a bird's common name as rows and point count locations as columns, we provide the raw data as a matrix.

Step 2. The initial matrix is transformed into an average quantity dependent data (AQD) matrix in the second stage.

Step 3. To make the computations simpler and easier, we apply basic average techniques in the third step to transform the above-average quantity-dependent data matrix into a matrix with entries $b_{ij} \in \{-1,0,1\}$.This matrix has the term Refined Quantity Dependent Data Matrix (RQD Matrix).

Step 4. Using the RQD matrices, we create the Combined Effect Quantity Dependent Data Matrix (CEQD Matrix), which shows the cumulative effect of all these entries.

Step 5. Finally, we derive the CEQD matrix's row sums. Each stage's tables are self-explanatory. The graphs of the RQD matrix and CEQD matrix are shown using python software.

Table 1: Initial raw data matrix of order 15 x 15 based on number of Birds observed in Swamythoopu Saltpan

Common Name	J1	J2	J3	J4	J5	J6	OS	S1	S2	S3	S4	S5	U1	U2	U3
Asian Palm Swift	2	11	20	36	32	17	13	2	0	0	2	0	16	2	0
Barn swallow	0	0	3	0	3	0	14	95	23	3	30	315	0	37	0
Blue tailed beefeater	19	2	2	0	3	9	8	18	15	0	0	2	0	22	0
Brahminy starling	8	19	5	9	7	2	10	3	0	0	0	0	0	0	0
garganey	0	0	0	0	0	0	12	0	8	37	46	25	0	0	50
Green bee eater	0	0	14	10	5	2	1	0	17	3	1	2	1	0	1
Grey francolin	20	4	5	0	1	3	28	0	0	4	0	0	0	0	0
Jungle crow	11	18	3	0	17	2	1	12	1	1	1	0	14	0	1
Lesser crested tern	0	0	3	0	0	0	37	56	0	0	0	0	0	0	0
Little cormorant	13	0	1	0	0	0	0	0	2	44	15	3	0	18	0
Little egret	7	3	2	0	0	0	0	8	4	52	15	1	14	0	6
Northern pintailed duck	0	36	0	0	0	12	147	0	0	0	55	27	0	83	0
Red wattled lapwing	0	0	1	14	0	12	1	0	9	0	5	5	6	1	12
Spot billed duck	0	0	15	0	0	0	4	0	17	13	8	3	0	0	0
Whiskered tern	0	3	0	0	0	0	0	0	15	26	3	0	31	0	0

Table 2: Average Quantity Dependent Data Matrix (AQDM) of order 15 x 15 based on number of Birds observed in Swamythoopu Saltpan

Common Name	J1	J2	J3	J4	J5	J6	OS	S1	S2	S3	S4	S5	U1	U2	U3
Asian Palm Swift	0.02	0.11	0.2	0.36	0.32	0.17	0.13	0.02	0	0	0.02	0	0.16	0.02	0
Barn swallow	0	0	0.03	0	0.03	0	0.14	0.95	0.23	0.03	0.3	3.15	0	0.37	0
Blue tailed bee eater	0.19	0.02	0.02	0	0.03	0.09	0.08	0.18	0.15	0	0	0.02	0	0.22	0
Brahminy starling	0.08	0.19	0.05	0.09	0.07	0.02	0.1	0.03	0	0	0	0	0	0	0
garganey	0	0	0	0	0	0	0.12	0	0.08	0.37	0.46	0.25	0	0	0.5
Green bee eater	0	0	0.14	0.1	0.05	0.02	0.01	0	0.17	0.03	0.01	0.02	0.01	0	0.01
Grey francolin	0.2	0.04	0.05	0	0.01	0.03	0.28	0	0	0.04	0	0	0	0	0
Jungle crow	0.11	0.18	0.03	0	0.17	0.02	0.01	0.12	0.01	0.01	0.01	0	0.14	0	0.01
Lesser crested tern	0	0	0.03	0	0	0	0.37	0.56	0	0	0	0	0	0	0
Little cormorant	0.13	0	0.01	0	0	0	0	0	0.02	0.44	0.15	0.03	0	0.18	0
Little egret	0.07	0.03	0.02	0	0	0	0	0.08	0.04	0.52	0.15	0.01	0.14	0	0.06
Northern pintailed duck	0	0.36	0	0	0	0.12	1.47	0	0	0	0.55	0.27	0	0.83	0
Red wattled lapwing	0	0	0.01	0.14	0	0.12	0.01	0	0.09	0	0.05	0.05	0.06	0.01	0.12
Spot billed duck	0	0	0.15	0	0	0	0.04	0	0.17	0.13	0.08	0.03	0	0	0
Whiskered tern	0	0.03	0	0	0	0	0	0	0.15	0.26	0.03	0	0.31	0	0

Table 3: Column wise mean and standard deviation of AQDM.

	J1	J2	J3	J4	J5	J6	OS	S1
Mean	0.05333	0.064	0.04933	0.046	0.04533	0.03933	0.184	0.129333
Standard Deviation	0.07277	0.10439	0.06227	0.0984	0.08855	0.0565	0.372018	0.26988

	S2	S3	S4	S5	U1	U2	U3
Mean	0.074	0.122	0.12067	0.25533	0.05467	0.10867	0.04667
Standard Deviation	0.08025	0.18237	0.1775	0.80557	0.09249	0.22834	0.12971

Obtaining various refined quantity dependent data matrices by taking $\alpha = 0.3, 0.6, 0.9$ and computing their related row sums as column matrices

Obtained RQD matrix for $\alpha = 0.3$
Obtained Row
Sum Matrix

$$\begin{bmatrix} -1 & 1 & 1 & 1 & 1 & 1 & 0 & -1 & -1 & -1 & -1 & -1 & 1 & -1 & -1 \\ -1 & -1 & -1 & -1 & 0 & -1 & 0 & 1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 \\ 1 & -1 & -1 & -1 & 0 & 1 & 0 & 0 & 1 & -1 & -1 & 0 & -1 & 1 & -1 \\ 1 & 1 & 0 & 1 & 0 & -1 & 0 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & 0 & 0 & -1 & 0 & 1 & 1 & 0 & -1 & -1 & 1 \\ -1 & -1 & 1 & 1 & 0 & -1 & -1 & -1 & 1 & -1 & -1 & 0 & -1 & -1 & 0 \\ 1 & 0 & 0 & -1 & -1 & 0 & 0 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & 1 & -1 & -1 & 0 & -1 & -1 & -1 & -1 & 1 & -1 & 0 \\ -1 & -1 & -1 & -1 & -1 & -1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 0 & 0 & -1 & 1 & -1 \\ 0 & -1 & -1 & -1 & -1 & -1 & -1 & 0 & -1 & 1 & 0 & -1 & 1 & -1 & 0 \\ -1 & 1 & -1 & -1 & -1 & 1 & 1 & -1 & -1 & -1 & 1 & 0 & -1 & 1 & -1 \\ -1 & -1 & -1 & 1 & -1 & 1 & -1 & -1 & 0 & -1 & -1 & 0 & 0 & -1 & 1 \\ -1 & -1 & 1 & -1 & -1 & -1 & -1 & -1 & 1 & 0 & 0 & 0 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & -1 & -1 \end{bmatrix} = \begin{bmatrix} -2 \\ -3 \\ -3 \\ -6 \\ -6 \\ -6 \\ -9 \\ -5 \\ -11 \\ -7 \\ -7 \\ -4 \\ -6 \\ -8 \\ -9 \end{bmatrix}$$

Obtained RQD matrix for $\alpha = 0.6$
Obtained Row
Sum Matrix

$$\begin{bmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & -1 & -1 & 0 & 0 & 1 & 0 & 0 \\ -1 & -1 & 0 & 0 & 0 & -1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & -1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & -1 & -1 & 0 & 0 & 0 & 1 \\ -1 & -1 & -1 & 0 & 0 & -1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ -1 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & -1 & -1 & -1 & 0 & 1 & 0 & 0 \\ -1 & -1 & 0 & 0 & 0 & -1 & 0 & 1 & -1 & -1 & -1 & 0 & 0 & 0 & 0 \\ 1 & -1 & -1 & 0 & 0 & -1 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ -1 & 1 & -1 & 0 & 0 & 1 & 1 & 0 & -1 & -1 & 1 & 0 & 0 & 1 & 0 \\ -1 & -1 & -1 & 1 & 0 & 1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ -1 & -1 & 1 & 0 & 0 & -1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & -1 & 0 & 0 & -1 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \\ 1 \\ -2 \\ -1 \\ -1 \\ -1 \\ 1 \\ -5 \\ -2 \\ 1 \\ 1 \\ -2 \\ -1 \\ 0 \end{bmatrix}$$

Obtained RQD matrix for $\alpha = 0.9$
Obtained Row
Sum Matrix

$$\begin{bmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & -1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 4 \\ 5 \\ 2 \\ 0 \\ 3 \\ 2 \\ 0 \\ 3 \\ 0 \\ 2 \\ 2 \\ 4 \\ 2 \\ 2 \\ 2 \end{bmatrix}$$

Finally, by combining all three matrices, the Combined Effect Quantity Dependent Data Matrix (CEQD - Matrix) is generated, which provides the Cumulative effect of all these entries. This yields the CEQD-Matrix as well as the CEQD Row matrix:

Obtained CEQD Matrix
Obtained Row
Sum Matrix

$$\begin{bmatrix} -1 & 1 & 3 & 3 & 3 & 3 & 0 & -1 & -3 & -2 & -1 & -1 & 3 & -1 & -1 \\ -2 & -2 & -1 & -1 & 0 & -2 & 0 & 3 & 3 & -1 & 3 & 3 & -1 & 3 & -1 \\ 3 & -1 & -1 & -1 & 0 & 2 & 0 & 0 & 3 & -2 & -2 & 0 & -1 & 1 & -1 \\ 1 & 3 & 0 & 1 & 0 & -1 & 0 & -1 & -3 & -2 & -2 & -1 & -1 & -1 & -1 \\ -2 & -2 & -2 & -1 & -1 & -2 & 0 & -1 & 0 & 3 & 3 & 0 & -1 & -1 & 3 \\ -2 & -2 & 3 & 1 & 0 & -1 & -1 & -1 & 3 & -1 & -2 & 0 & -1 & -1 & 0 \\ 3 & 0 & 0 & -1 & -1 & 0 & 0 & -1 & -3 & -1 & -2 & -1 & -1 & -1 & -1 \\ 2 & 3 & -1 & -1 & 3 & -1 & -1 & 0 & -2 & -2 & -2 & -1 & 3 & -1 & 0 \\ -2 & -2 & -1 & -1 & -1 & -2 & 1 & 3 & -3 & -2 & -2 & -1 & -1 & -1 & -1 \\ 3 & -2 & -2 & -1 & -1 & -2 & -1 & -1 & -2 & 3 & 0 & 0 & -1 & 1 & -1 \\ 0 & -1 & -1 & -1 & -1 & -2 & -1 & 0 & -1 & 3 & 0 & -1 & 3 & -1 & 0 \\ -2 & 3 & -2 & -1 & -1 & 3 & 3 & -1 & -3 & -2 & 3 & 0 & -1 & 3 & -1 \\ -2 & -2 & -2 & 3 & -1 & 3 & -1 & -1 & 0 & -2 & -1 & 0 & 0 & -1 & 1 \\ -2 & -2 & 3 & -1 & -1 & -2 & -1 & -1 & 3 & 0 & 0 & 0 & -1 & -1 & -1 \\ -2 & -1 & -2 & -1 & -1 & -2 & -1 & -1 & 3 & 2 & -1 & -1 & 3 & -1 & -1 \end{bmatrix} = \begin{bmatrix} 5 \\ 4 \\ 0 \\ -8 \\ -4 \\ -5 \\ 10 \\ -1 \\ -16 \\ -7 \\ -4 \\ 1 \\ -6 \\ -7 \\ -7 \end{bmatrix}$$

7. Plotting Graphs with Different Values of $\alpha \in [0, 1]$ to Indicate the Greatest Bird Area in the Swamythoopu Saltpan

Using the technique of fuzzy matrices, the depicted graphs reflect the largest bird area in Swamythoopu Saltpan by altering $\alpha \in [0, 1]$.

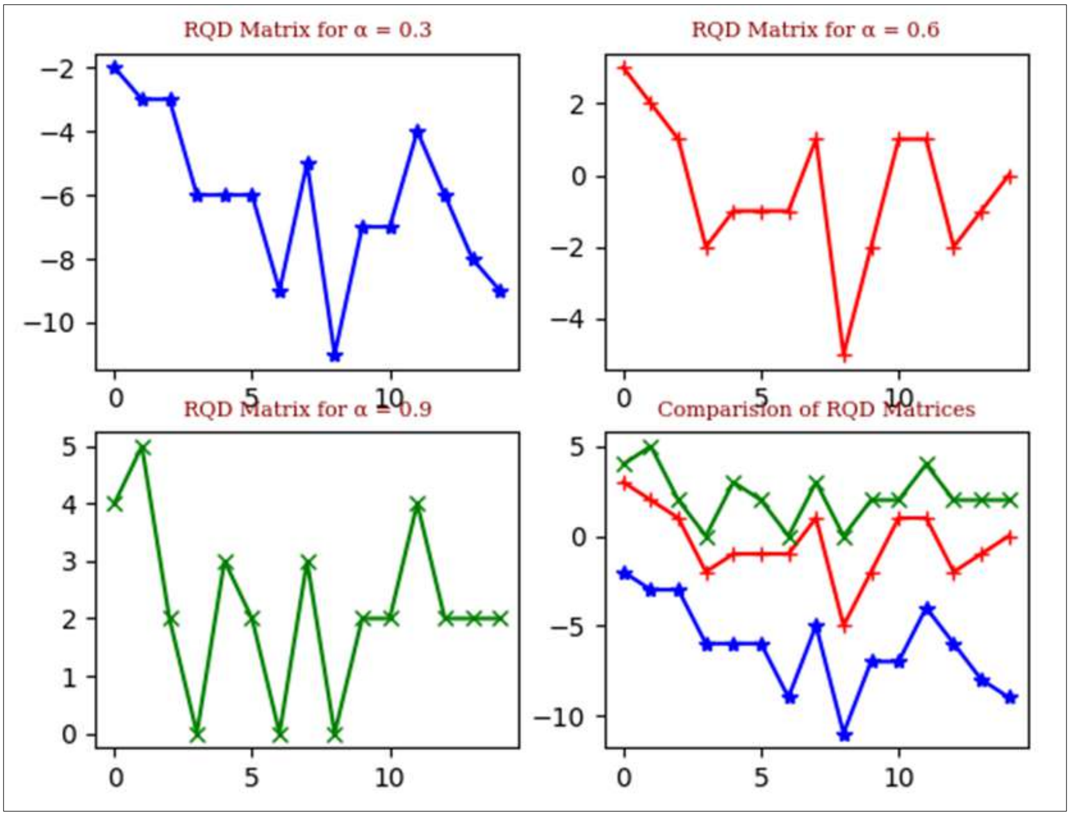

Fig 1: Refined quantity dependent matrices

8. Plotting Graph for the CEQD to Depicting Birds Area in Swamythoopu Saltpan

Combining distinct refined quantity dependent data matrices by altering $\alpha \in [0, 1]$ yields a combined effect quantity dependent data matrix, which represents the cumulative impact of all the entries. The combined effect quantity dependent data matrix is essential in showing the combine effect of all produced RQD matrices for various values of $\alpha = 0.3, 0.6$ and 0.9.

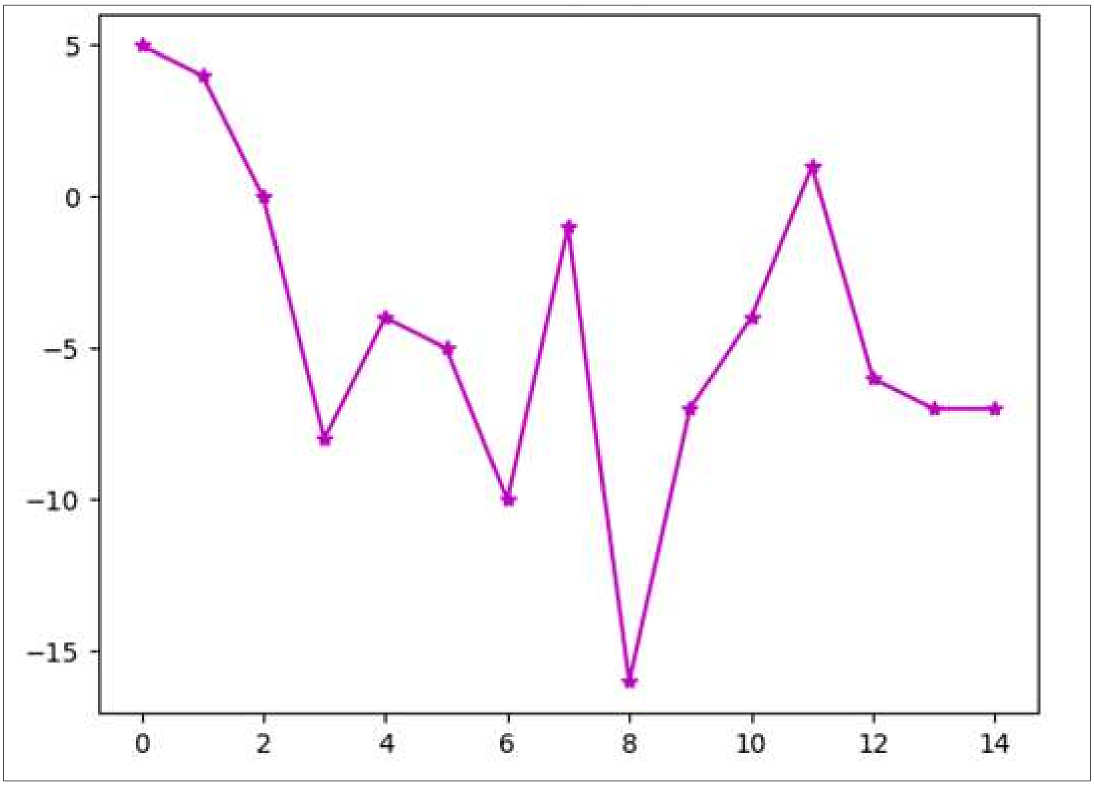

Fig 2: Combined effect quantity dependent data matrix

9. Conclusion

From the above studies and depicted graphs for different values of α = 0.3, 0.6, and 0.9 on the diversity of birds, we concluded that the maximum number of birds chosen the sites of J1, J2, J3, S4, and S5 amongst the total 15 sites in Samythoopu saltpan. From the cumulative effect of all the

RTD matrices showed that the birds of Asian Palm Swift, Barn swallow, Blue tailed bee eater, Brahminy starling, garganey, Green bee eater, Grey francolin, Jungle crow, Lesser crested tern Little cormorant, Little egret, Northern pin tailed duck, Red wattled lap wing, Spot billed duck, and Whiskered tern preferred the sites of J1, J2, J3, S4 and S5. It can be easily extracted from the above plots that the birds are not preferred site was S2 because this site was identified as most anthropogenic disturbance site. The negative values in the sites of J4, S2, S3, S5, U1, U2, and U3 simply indicate that birds are facing threats in these sites as compared to the obtained results. This fuzzy combined effect time quantity dependent data matrix predict the exact place has more anthropogenic disturbance to disturb the diversity and distribution of wetland birds.

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