

# Applications of Clustering Algorithms for Analysis of Agriculture Data for Different Districts in Karnataka

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## Abstract

Data Mining Algorithms plays a significant role for the data analysis in many disciplines like Agriculture, Food, Medicine, Twitter Data etc. Data Clustering Algorithms are falls under the unsupervised classification category. Clustering is a very challenging task because of little or no prior knowledge. Data Clustering Algorithms are essential approaches to analyse the agricultural data and also to achieve the practical and effective solutions for agricultural problems such as suitable crop for the particular soil type, crop which can produce maximum production the environments like more temperature, less rain fall, less nitrogen content in the soil etc. Variations in the environmental conditions like sudden raises in temperature, reduced / increased rainfall, variations in the market prices, etc with all these aspects it is difficult for formers to take critical farming decisions. The environmental parameters like temperature, Rainfall, Humidity, season (kharif, rabi, summer) and soil parameters of different states of Karnataka are analysed in this paper for maximizing the Rice and Wheat crop production using data clustering methods like DBSCAN and CLIQUE. The Cluster Quality metrics used to measure the well posed structure and goodness of the clusters formed by different clustering algorithms. Few of the external quality metrics parameters are Completeness, Purity, Homogeneity and V-measure.

**Keywords:** Data Clustering, DBSCAN, CLIQUE, Purity, Homogeneity, Completeness, V-measure

## 1. Introduction

The Indian Agriculture has history of 10,000 years dates back. In India, Agriculture and other allied activities contribute significantly to the Gross Domestic Product, which has direct impact on the Indian economy [1]. Recently, India is the second country in world in the farm output. Agriculture plays an important role in India's Social and economic fabric and is demographically the broadest economic sector. Agriculture is considered as unique business crop production which is more directly affected by many of the climatic and economic factors. Few of the climatic conditions and other parameters those affects the agriculture crop production are temperature, rainfall,

Irrigation, fertilizers, soil types and its content, pesticide weeds and etc, [2].

Data clustering methods are also called as unsupervised classifiers. Clustering refers to the process of grouping of similar data/ objects in relatively homogeneous class such as data points within the cluster have greater similarity and data points between different clusters have greater dissimilarity. Clustering approaches distributes data into well-formed and structured clusters. Capturing

the natural structure of the data is one of the major characteristic of the well-structured cluster [3]. The Clustering methods can be broadly categorised into five major categories those are Partitioned based clustering, Hierarchical, Density Based Clustering, Grid Clustering and Model Based Clustering. In present work, DBSCAN and CLIQUE clustering methods are used to analyse the agriculture data.

## 2. Literature Survey

Several different clustering methods are implemented and assessed by the researchers throughout the world in the agricultural field for the agricultural data analysis. Some of such studies are: Researchers like H. Basavaraja, L. B. Kunnal, S. B. Mahajanashetti, and A. R. S. Bhat are analysed the agriculture data and productivity of the major crops of Karnataka[1]. Many classification methods like K Nearest Neighbour, Artificial Neural Network, Support Vector Machine (SVM), Decision Tree, Fuzzy Logic and many more methods are used for knowledge discovery in the agriculture field[4]. Authors and Researchers Tianzhuo and Libaicheng are analysed and clustering is performed using the soil Electrical Conductivity (ECa) and yield of Punjab Agriculture in order to determine the optimal soil types for the particular crop. The aim of their work was to focus the soil-yield collaboration in the field[5].

Soil characteristics play an important role in the crop production. Soil parameters are analysed using the Iterative Knowledge Discovery Process [6]. Authors have done the appreciated analyses on the several varieties of rice crops in the state of Bangladesh. Along with the soil characteristics, analysis of rainfall and temperature in the state of Bangladesh and its influence on the rice productivity has been done [7]. The data sources for the analyses of the rice crop production “Bangladesh Agricultural Research Council (BARC)”. The following attributes are involved in the data has been collected for past 20 years: Humidity, maximum and minimum rainfall, sunlight, maximum and minimum temperature, wind speed, and “cloud-coverage”. The whole dataset was partitioned into three stages (March to June, July to October, and November to February). Pre-processing has been done for each kind of rice variety data gathered from each stage by taking the average range of the each attribute and associate the average range to the respective attribute.

The research for creation of management zones in the field of agriculture using Gustafson-Kessel-like clustering algorithms has been carried out by Krishna Priya C.B and Dr. S.Venkateswari [8]. Partitioned clustering like Fuzzy C Means and Hierarchical clustering algorithms are used for the purpose of Precision Agriculture [9]. The foremost goal for using FCM in environment of this work is associated with the fact that sudden changes do not occurs in soil this helps to use input data and the obtained clusters to consider a membership degree of Fuzzy C Means.

Data Mining Techniques are integrated with Precision Agriculture [10]. Fuzzy C Means Clustering Algorithm was used to link the management areas formed by the soy productivity. Expectation Maximization and K Means clustering are also used to cluster the soil samples based on its physical and chemical data before and after applying the Principal Component Analysis.

Many of the researchers [11] have used the machine learning algorithms and sensing techniques to analyse wheat yield prediction. The objective of their research is to predict the wheat yield in different field variations by analysing the satellite imagery crop growth features and multi-layer soil data.

### 3. Methods

Analyzing the climatic condition and soil parameters for rice crop productivity is the objective of proposed work, using data clustering methods like Density Based Spatial Clustering with Noise (DBSCAN) and CLusteringInQUEst (CLIQUE). The data has been collected from the several sources those are referred in the research paper [2].

#### 3.1 Study Area and Parameters Used

Soil types and its content, climatic conditions and other data are collected from the Karnataka agricultural region. Figure 1 refers to the geographical location map of the study area. Input dataset consist of following attributes: Minimum and Average Rainfall, Minimum and Average Temperature, different seasons (kharif, rabi and summer), Soil parameters like PH value of soil, soil contents like Nitrogen(Kg/Ha), Prosperous(Kg/Ha), and Potassium(Kg/Ha), Water Requirement(mm), Area(in hectors), Production(Tons/Hector), Production year, Production state (Karnataka), Production areas (Districts of the Karnataka State), Fertilizers required.

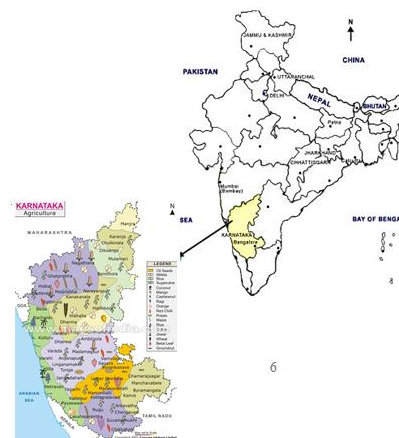


Fig.1. Location map of the study area [Image obtained from Compare Infobase Limited]

#### 3.2 Methods used for the analysis

Prior to applying data clustering methods to analyse the rice crop productivity, the data is pre-processed to reduce possible inconsistencies. The gathered data showed no outliers, missing values and inconsistencies were found. The objective of the present work is to analyse the Rice crop productivity of different states of the Karnataka State. A modified DBSCAN algorithm [2][12] and CLIQUE grid based data clustering algorithms are used to analyse and cluster the rice productivity data as districts having the high rice production and low rice production with by considering the other factors like temperature, rainfall, soil content, soil type, PH value, water requirement and fertilizers required.

#### Modified approach of DBSCAN[2][12]

DBSCAN is one of the clustering methods of Density based clustering methods. The working principle of DBSCAN algorithm is depends on the 2 user defined parameters those are radius (Eps) and minimum number of points to be present within the threshold radius (MinPts). Determining the optimal EPs value is challenging task and difficult for the user who has no prior knowledge about the database. Figure 2 depicts the modified approach of the DBSCAN method in which Eps value is determined automatically.

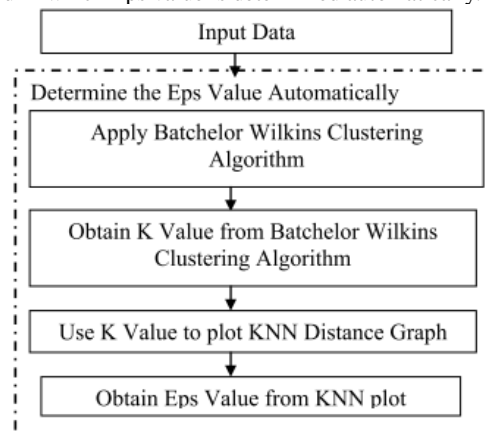


Fig.2. Determining the Epsilon value automatically [2]

## CLustering In QUEst (CLIQUE)

CLIQUE is grid based data clustering algorithm. Distinct necessities are placed by data mining applications on clustering algorithms, which includes: the ability to find clusters embedded in subspaces of high dimensional data, scalability, end-user comprehensibility of the results, non-presumption of any canonical data distribution, and insensitivity to the order of input records. All these requirements are satisfied by CLIQUE clustering algorithm. CLIQUE operates on multidimensional data by operating on single dimension at a time and not on all the dimensions at a time and then grows upwards. Figure 3 depicts the steps involved in CLIQUE clustering algorithm.

The CLIQUE clustering process involves:

1. According to the given grid size the d- dimensional data space is partitioned into grids and then according to a given threshold value the dense region is found. If the data points in this are exceeding the threshold value, then a unit is dense.
2. Clusters formation is done by considering the threshold value. The same procedure is repeated until all the cells covered.

Algorithm: CLIQUE Algorithm

Input: Rice Crop Dataset

Output: The instances are read from the file and clusters are formed from the given agriculture dataset.

Steps[13-14]:

1. High-dimensional space of the point is converted to a subunit and read the file.
2. Then find the unit density which is number of points per subunit. When the sub-cell density exceeds density threshold which is initialized, then unit has to be clustered.
3. Clustering is started and the cells are scanned. When a point with a density greater than the given threshold is found, a new cluster is created.
4. Then checks its neighbour points when the density of the neighbour points exceeds than the given threshold and the ratio of its density to the entire cluster density is checked
5. If it exceeds the given density Ratio Threshold, then the point is absorbed
6. All the cells are checked by performing the above steps. If all the cells are processed then clustering ends.

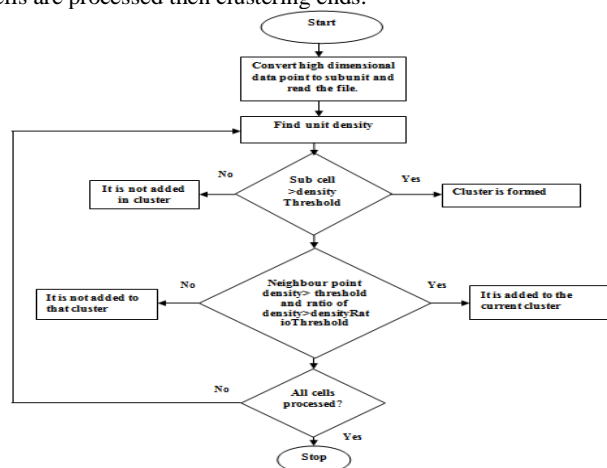


Fig.3. Flowchart of clique algorithm

## 3.3 Methods of Evaluation

Quality Metrics methods are used to ensure well-structured and goodness measure of the clusters. Proposed work adopts the

external quality metrics [3] like Purity, Completeness, Homogeneity and V Measure to evaluate DBSCAN and CLIUE clustering algorithms.

## 4. Experimental Results

In present work, 11 year (1998-2009) rice crop data has been collected and analysed to derive the ideal climatic parameters range and soil parameters to increase the rice productivity. Table 1 depicts the results obtained by the analysing the agriculture data of the duration 1998-2009. The result consists of average climatic and soil content parameters for 11 year in 28 different districts of Karnataka state. Table 2 shows the different soil types in different districts of Karnataka.

### 4.1 Modified DBSCAN Results

Modified DBSCAN Clustering method is applied to the dataset to cluster the districts which are having similar range of temperature, rainfall, similar soil types and districts which are having high rice production. As result of analysing the temperature and rainfall of different districts of Karnataka using DBSCAN Method following results are formed. Table 3 depicts the districts of Karnataka those are having similar range of temperature. Table 4 represents the districts of Karnataka those are having similar range of rainfall. Table 5 depicts the districts of Karnataka those are having maximum Rice Crop Production.

**Table 1.** Average Temperature, Rainfall, PH value, Water requirement and Nitrogen content of the soil for the year 1998-2009

Districts of Karnataka State	Average Temperature(°C)	Average Rainfall(cm)	PH value	Water required(mm)	Nitrogen (Kg/Ha)
BELLARY	24.1	636	7.6	2000	459
BIDAR	26.65	847	6	1780	481
BIJAPUR	24.28	578	7	1780	380
CHAMARAJNAGAR	29.5	751	8	1150	281
CHITRADURGA	29.9	573	7.8	1500	373
DAKSHINA KANNADA	30.85	3789	7.8	1780	575
DAVANAGERE	30.8	607	7	1150	600
DHARWAD	27	998	6	2300	562
GADAG	27.75	612	8.2	2000	562
GULBARGA	29.8	832	6	1150	372
HASSAN	28.2	977	7	1150	562
KODAGU	26.95	2598	8	1780	267
KOLAR	29.5	743	6.5	1150	199
KOPPAL	31.5	572	7	2300	527
MANDYA	31.2	646	6.2	2300	281
MYSORE	30.2	782	7.5	1780	199
BAGALKOT	26.7	830	4.5	2300	370
BANGALORE(RURAL)	26.7	817	4.5	2000	357
BANGALORE(URBAN)	26.7	867	4.5	2000	388
BELGAUM	26.99	808	6.2	2300	470
SHIMOGA	27.2	1813	5.5	2300	491
CHIKMAGLUR	30.04	1925	7	2000	363
RAICHUR	30.2	688	7.5	2300	627

**Table 2.** Soil types in Karnataka State

Soil Name	Properties	Areas
Black soil	Generally it is neutral to alkaline in nature and it has Ca, Mg, k content. Black soil has good shrinking and swelling properties.	Bellary, Bidar, Bijapur, Gulbarga, Raichur, Belgaum
Laterite soil	It is acidic in nature and has poor absorbing capacity. Contains required content of organic matter.	Dakshinakannada, Dharwad, Chikmaglur, Kodagu
Brown soil	Clayey in nature and rich in the contents of organic matter.	Mysore, Hassan, Shimoga, Uttarakannada
Mixed soil	Productive in nature. Mostly suitable for forest areas.	Kolar, Bijapur, Chikmaglur, Hassan
Granetic soil	It is grey or light brown in colour. Acidic in nature	Gadag, Davanagere, Haveri, Raichur
Red soil	Acidic to neutral in nature. Poor aggregating capability.	Udupi, Tumkur, Mandya, Kolar, Koppal

**Table 3.** Clusters formed by DBSCAN algorithm to cluster the districts those are having similar range of temperature

Cluster	Districts	Temperature Range	No of instances in the Cluster
Cluster 1	Bellary, Bijapur	24.1 – 24.28	204
Cluster 2	Bidar, Bangalore(Rural), Bangalore (Urban), Kodagu, Belgaum, Dharwad, Uttarakanda, Bagalkot, Shimoga, Gadag, Udpi, Hassan, Haveri, Chamarajnagar, Kolar, Gulbarga, Chitradurga, Chikmagalur, Mysore, Raichur, Tumkur, Davanagere, Dakshinakannada, Koppal, Mandya,	26.65 – 31.2	2240

**Table 4.** Clusters formed by DBSCAN algorithm to cluster the districts those are having similar range of Rainfall

Cluster	Districts	Rain fall Range	No of instances in the Cluster
Cluster 1	Bagalkot, Raichur, Gadag, Koppal, Chitradurga, Bijapur, Tumkur, Mandya, Koppal, Kolar, Bellary, Bagalkot, Udupi, Chamarajnar, Davanagere, Belgaum, Kodagu, Haveri, Mysore, Bangalore(Rural), Bangalore (Urban), Bidar, Chikmagalur, Dakshinakannada, Dharwad, Gulbarga, Hassan, Kodagu, Shimoga, Udupi, Uttarakannada	262 – 2027	2174
Cluster 2	Belgaum, Bellary, Chikmagalur, Dharwad, Davanagere, Gadag, Kodagu, Shimoga, Uttarakannada	2275– 2386.3	65
Cluster 3	Belgaum, Gadag, Gulbarga, Hassan, Haveri, Kodagu, Uttarakannada,	2537– 2886	94
Cluster 4	Kodagu, DakshinaKannada, Uttarakannada	3040 – 3124	4
Cluster 5	Belgaum, Dakshinakannada, Davanagere, Gulbarga, Gadag, Hassan, Haveri, Kodagu, Uttara kannada	3407– 3812.6	50
Cluster 6	Dakshina kannada, Gulbarga, Gadag, Haveri, Kodagu, Udupi	3975– 4180	46
Cluster 7	Udupi, Hassan	4657.4	08

**Table 5.** Clusters obtained from the DBSCAN Algorithm to represent Districts as per Rice Productivity Status

Cluster	Districts	Rice Production range (Kg/Ha)
Cluster 1 (High Productivity)	Koppal, Davangere, Bellary, Chamaraj Nagar, Mandya, Mysore, Raichur, Bangalore (R), Bangalore (U), Tumkur, Kolar, Gadag, Chitradurga, Hassan	2508 -3462 Kg/Ha
Cluster 2 (Medium Productivity)	Chikmagalur, Bagalkot, Bijapur, Kodagu, Shimoga	2278-2420 Kg/Ha
Cluster 3 (Medium –Low Productivity)	Dakshina Kannada, Uttara Kannada, Udupi, Gulbarga, Haveri, Belgaum	1679-1979 Kg/Ha
Cluster 4 (Low Productivity)	Dharwad, Bidhar	637 -1156 Kg/Ha

As result of the DBSCAN clustering algorithm 3 clusters are formed. Cluster 1 represents the districts having the high rice production in the range of 2508-3462 Kg/Ha. Districts belongs to the high production cluster are Koppal, Davangere, Bellary, Chamaraj Nagar, Mandya, Mysore, Raichur, Bangalore (R), Bangalore (U), Tumkur, Kolar, Gadag, Chitradurga, Hassan. Cluster 2 represents the districts having the medium rice production in the range of 2278-2420 Kg/Ha. Districts belongs to the medium production cluster are Chikmagalur, Bagalkot, Bijapur, Kodagu, Shimoga. Cluster 3 represents the districts having the medium to low range rice production in the range of 1679-1979 Kg/Ha. Districts belongs to the medium to low production cluster are Dakshina Kannada, Uttara Kannada, Udupi, Gulbarga, Haveri, Belgaum. Cluster 4 represents the districts having the low rice

production in the range of 637 -1156 Kg/Ha. Dharwad, Bidhar districts belongs to the cluster 4

### 4.2 Results of CLIQUE Clustering

CLIQUE clustering algorithm is implemented on the database to form the clusters for the districts of Karnataka those are having High, Medium and Low rice crop production. Five clusters are formed as the results of applying CLIQUE clustering algorithm on the dataset those are labeled as High Production Cluster, Medium Production Cluster, Medium-Low Production, Low Production Cluster and Very Low Production cluster. Table 6 depicts the result of the CLIQUE clustering algorithm.

**Table 6.** Clusters obtained from the CLIQUE Algorithm to represent Districts as per Rice Productivity Status

Cluster	Districts	Rice Production range (Kg/Ha)
Cluster 1 (High Productivity)	Bellary, Bidar, Bijapur, Chamarajnar, Chitradurga, Dakshinakannada, Davanagere, Dharwad, Gadag, Gulbarga, Hassan, Kodagu, Kolar, Koppal, Mandya, Mysore	2993-3462 Kg/Ha
Cluster 2 (Medium Productivity)	Bagalkot, Bangalore(rural and urban), Belgaum, Kodagu, Shimoga	2851-2420 Kg/Ha
Cluster 3 (Low Productivity)	Bangalore(rural and urban), Belgaum, Dharwad, Shimoga	1156 Kg/Ha

Cluster 4 (Medium to Low Productivity)	Chikmagalur, Chitradurga, Mysore, Raichur, Tumkur	1679-1979 Kg/Ha
Cluster 5 (Very Low Productivity)	Chikmagalur, Chitradurga, Mysore, Raichur, Tumkur	637 Kg/Ha

From above result, cluster 1 represents the high rice productivity with range 2993-3462. Districts belongs to cluster 1 are Bellary, Bidar, Bijapur, Chamarajnar, Chitradurga, Dakshinakannada, Davanagere, Dharwad, Gadag, Gulbarga, Hassan, Kodagu, Kolar, Koppal, Mandya, Mysore. Cluster 2 represents the medium rice productivity with range 2851-2420 Kg/Ha. Districts belongs to cluster 2 are Bagalkot, Bangalore(rural and urban), Belgaum, Kodagu, Shimoga. Cluster 3 represents the low rice productivity with range 1156 Kg/Ha. Districts belongs to cluster 3 are Bangalore(rural and urban), Belgaum, Dharwad, Shimoga. Cluster 4 represents the medium-low rice productivity with range 1679-1979 Kg/Ha. Districts belongs to cluster 4 are Chikmagalur, Chitradurga, Mysore, Raichur, Tumkur. Cluster 5 represents the very low rice productivity with range 637 Kg/Ha. Districts belongs to cluster 5 are Chikmagalur, Chitradurga, Mysore, Raichur, Tumkur.

By analysing the temperature, rain fall, soil types and rice crop productivity in the different districts of the Karnataka optimal agriculture parameters are derived. Table 7 shows the optimal parameters to achieve increased rice production.

**Table 7.** Optimal parameters to obtain high rice crop productivity

Parameters	Range
Optimal Temperature	30°C
High Temperature	20° to 40°C
PH Value	5.0-8.0
Rain Fall	570-640

### 4.3 Clustering Methods Evaluation

Comparison of clustering algorithms has done using four external performance quality metrics as mentioned earlier. Table 8 depicts the performance analysis of DBSCAN and CLIQUE algorithm. Better clustering quality is indicated by higher quality metric values. CLIQUE has higher value for most of the quality metrics parameter. Better quality of clustering is achieved in CLIQUE than DBSCAN. Fig 4 shows the comparison of the well-formed structure analysis of DBSCAN and CLIQUE algorithm.

**Table 8.** Clustering structure analysis using Quality Metrics

Quality Metrics	DBSCAN (K=4)	CLIQUE (K=5)
Purity	0.865	0.924
Homogeneity	0.882	0.935
Completeness	0.915	0.925
V-measure	0.898	0.929



**Fig 4.** Comparison of Goodness Measure of DBSCAN and CLIQUE algorithm

## 5. Conclusion

To achieve the maximum rice production several data clustering methods are implemented on the input data. The present work used

DBSCAN and CLIQUE clustering algorithm to obtain the optimum requirement of climatic conditions for rice, like optimum range of best temperature, high temperature, rainfall and PH value to obtain maximum production of rice crop. CLIQUE clustering algorithm is best suitable for the high dimensional data and which gives better result than DBSCAN. Quality metrics is used compare these clustering methods. According to the cluster quality metrics values CLIQUE has achieved better quality of clustering than DBSCAN. The proposed work can be extended to analyze the soil and other crop factors and to maximize the crop production under the different climatic conditions.

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