International Journal of Mathematics and Computer Research

ISSN: 2320-7167

Volume 12 Issue 04 April 2024, Page no. – 4124-4130

Index Copernicus ICV: 57.55, Impact Factor: 8.316

DOI: 10.47191/ijmcr/v12i4.02

Soil Health Analysis and Classification of Micronutrients for Crop Suggestion Using Machine Learning

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ARTICLE INFO

Published Online:
04 April 2024

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ABSTRACT

An essential component of agriculture is soil. Many types of soil exists. Different parameters can be observed in each type of soil, and various crops can be grown on different types of soils. To understand which crops develop in certain types of soil, they need to be informed on the characteristics and features of various soil types. The capability to identify the inputs needed for productive and cost-effective farming was provided by soil analysis. A proper soil test will ensure that the proper amount of fertilizers are utilized, providing the crop to meet its needs while also profiting from the nutrients already available in the soil. The phrase "soil health" refers to the biological, chemical, and physical elements of the soil that are significant for plant nutrients. Soil analysis is a collection of different chemical processes that determines the amounts of available plant nutrients in the soil. The most important factors for producing a healthy crop are micronutrient analysis. The classification of soil's micronutrients is the primary objective of this analysis. In this case, machine learning methods may be helpful. It has made significant progress in recent years. Hence in this analysis, soil health analysis and classification of Micronutrients for crop suggestion using Machine Learning is presented. The coloured images of the soil samples are obtained and processed using a number of algorithms and filters. Color, texture, and other features can be extracted using these developed algorithms. Logistic Regression algorithm is used to classify micronutrients.

KEYWORDS: Agriculture, Soil, Micronutrients, Machine Learning

I. INTRODUCTION

For most developing countries, including India, agriculture is the primary and most important source of national income. The growth of the agriculture industry provides subsidies to a surplus that can be marketed. The majority of actions taken in the agricultural sector intended to increase crop productivity [1]. Considering that, India's economy depends heavily on agriculture. A significant portion of the world's population depended on agriculture for food and a livelihood of indispensable [6]. It is essential to the production of food as well as employment opportunities for a significant community. Crop production methods are harsh and suitable for the current conditions. The conditions of the environment and climate, the ecological characteristics of the soil, the availability of water, and farming practices have the greatest impact on the agriculture production systems. Of these, the soil has the most diverse and complex ecosystem, if it is not monitored, characterized, and managed in a timely manner, it will degrade, lose fertility, reduce plant growth and yields, and financial losses.

An important factor of agricultural success is soil. Soil composition varies from one soil to the next. These chemical characteristics of soil influence crop growth [9]. Since it provides as the supports for agriculture, food production, and health research, humans and all other living things depend on soil. There are several soil types, each of which may have distinct mineral, humus, organic matter compositions and different characteristics for a number of crops. There are many kinds of soil, each with its own set of characteristics. This type of soil has a significant impact on a crop's productivity. Choosing the proper crop for the right land type is one method that could increase productivity. This can be done by first analyzing the soil and then separating it into various groups of soil. One can decide which crop is best suited and beneficial based on these soil groups and the geographical conditions.

In Agriculture, soil is the main and basic thing. But now the farmers are using the standard methods due to the normal method and farmers didn't get satisfactory results i.e. the amount of crops isn't increasing to extend the amount of crops need good quality of soil. Soil testing is very important instead of the most task of farming the assembly and quality of crops totally based on the soil. Soil testing is crucial because it gives information on all nutrients which are present within the soil like Ca (Calcium), K (Potassium), and N (Nitrogen).

Pesticides and harmful chemicals can cause permanent damage to the crop, which can lead to improper crop growth in the agricultural sector. Whether crops would be the best choice for the soil could be determined basis on the information gathered from the soil samples collected from the fields. Farmers require accurate and timely access to information about the use of pesticides, fertilizers, weather, and to accurately choose which crops to sow and produce a good harvest, it is necessary to understand the soil. Farmers can increase crop productivity by analyzing the favourable conditions, which will reduce crop damage and loss caused on unfavourable conditions. A farmer faces the danger of losing money if he plants his farm without first choosing the correct crop for the soil and type of soil.
Climate, soil fertility, water availability, and disease or pests are the four main factors that affect crop production. Activation carbon content, nitrogen content, root health, and organic matter content are four biological factors. On a rage from 1 to 100, you can test the health of the soil. A soil health test report provides an integrative evaluation and also identifies particular constraints on the soil.

Testing of fundamental characteristics, also including texture, pH, the abundance of chemical components, physicochemical parameters, in the fields or in the laboratory is necessary for identifying soils and mapping about their conditions, qualities. This can be achieved with simple field methods like colorimetric determination of pH, macroscopic examination of soil texture, and hydrochloric acid dissolution allows for an easy determination of carbonate concentration. There is frequently a lack of access to a laboratory in land assessments and classifications, represents a greater risk of classification errors and limiting laboratory analysis. For improved management of soil resources, a fast and economical alternative for subjective determinations would be effective [5].

Agriculture has a number of budding technologies, including machine learning. The agricultural industry can utilize machine learning to increase crop quality and productivity [7]. It can be used to classify agricultural data into more meaningful categories and identify patterns in the data. Hence in this analysis, soil health analysis and classification of Micronutrients for crop suggestion using Machine Learning is presented.

The following is the structure of the remaining approach: The literature survey is described in section II. The section III demonstrates soil health analysis and classification of Micronutrients for crop suggestion using Machine Learning. The section IV evaluates the result analysis of presented approach. Finally the analysis is concluded in section V.

II. LITERATURE SURVEY

Vijay E V, Abdul Shabana Begum, Rajaneesh D, Navya Ch, Mahesh Babu B, et. al. [10] presents Soil Classification Using Modified Support Vector Machine. The conventional methods for classifying soils are examined in this analysis, and an image processing method for classifying soils with an effective classifier has been developed and tested. Here, seven classes of soil: Humus Clay, Clayey Peat, Peat, Clayey Sand, Clay, Silty Sand, Sandy Clay were taken into consideration for classification. Modified Support Vector Machine is used to classify these seven categories. Applications for real-time soil classification can be used from the developed model.

Madhumathi R, Shruthi R, Arumuganathan T, Sneha Iyer R, Shruthhi K et. al. [11] describes Soil Nutrient Analysis Using Machine Learning Techniques. The soil analysis prediction primarily consists of determining the soil's composition of Potassium (K), Nitrogen (N), and Phosphorus (P), content. These are the main nutrients that are required for crop growth. The system's goal is to offer a feasible solution that can be found in the machine learning model. The Multiple Linear Regression (MLR) algorithms are used to determine the soil's N, P, and K composition. Hence, this approach would support farmers in selecting the right crop and fertilizer for improved crop harvests. So, the country's overall economy would increase relative to other countries due to the soil nutrient content prediction method.

Kamel H. Rabab Hamed M. and Rahouma Aly et. al. [12] discusses Using Polynomial Learning for Soil Detection Based on Teager Kaiser Energy Operator and Gabor Wavelets. There are two main goals for this analysis. Following is the Teager-Kaiser Operator, and the primary goal is to enhance the Gabor wavelet transform-based extraction of soil features. The classification of soil types based on group method data management is the second goal (polynomial neural networks). They used various soil data sets to apply these methods. High accuracy is achieved in comparison to previous research and work.

Sk Al Zaminur Rahman, Kaushik Chandra Mitra, S.M. Mohidul Islam et. al. [15] describes the use of machine learning techniques for soil classification and the suggestion of crops based on soil series. Describes a pattern combined with land type, would predict soil series and suggest suitable crops. When classifying soils, a number of machine learning techniques are utilized, such as weighted K-Nearest Neighbor (K-NN), bagged trees, and Support Vector Machines (SVM) depending on a Gaussian kernel. Compared to many existing approaches, the accuracy of soils categorization and it is better to plant the recommended crops for a given soil.

Chandan, Ritula Thakur et. al. [16] describes a machine learning-based intelligent model for the classification of Indian soil. They gathered and prepared reliable images of the soils under examination. The feature-extracted information from the preprocessed images is utilized to develop the Support Vector Machine (SVM) classifiers. The generated classifier is then placed through tests can properly classify each class and whether it is accurate. Applications for real-time soil classification can be developed using the developed model.

S.Pudumalar, et. al. [19] describes the "Precision Agriculture Crop Recommendation System." Using Naive Bayes, Random Tree, CHAID, K-Nearest Neighbor, and K-Nearest Neighbor, they provide an ensemble of classifiers with qualified majority method as learners to accurately and effectively select a crops for the site-specific features. This analysis would help farmers in selecting the appropriate seeds depending on soil requirements to maximize profitability and productivity. So the farmer may plant the right crop, improving both his yield and the nation's overall productivity.

In recent years, incorrect crop and soil management practices have resulted in heavy loss of soil quality. This is primarily due to the use of too many chemical fertilizers, which disturbing the nutrients in the soil's balance. The soils productivity is significantly impacted by these factors. Because of the nature of soil, the presence or absence of particular elements will lead to soil erosion, imbalance, and other issues. This will reduce agricultural land production. Hence, soil conservation and management receive a lot of emphasis in systematic models. It is determined that integrating information technology with supporting inputs and services addresses the gaps in earlier methodologies.

III. SOIL HEALTH ANALYSIS AND CLASSIFICATION OF MICRONUTRIENTS FOR CROP SUGGESTION

In this section, soil health analysis and classification of Micronutrients for crop suggestion using Machine Learning is presented. Figure 1 represents a block diagram of soil health analysis and Micronutrient classification for crop suggestion using Machine Learning. A colour camera is used to capture a wide range of images of the soil samples that need to be categorised and provide them as input to the system. Every type of soil's features have been gathered and are stored in a separate database. In the final stage, this database is used to suggest crops and soils.

The image that is obtained at the acquisition phase includes errors. Pre-processing methods are used to produce an error-free image. In order to produce a better image for the future processes, this phase is also referred to as the enhancement of the image because the image is enhanced by improving its contrast and removing errors.

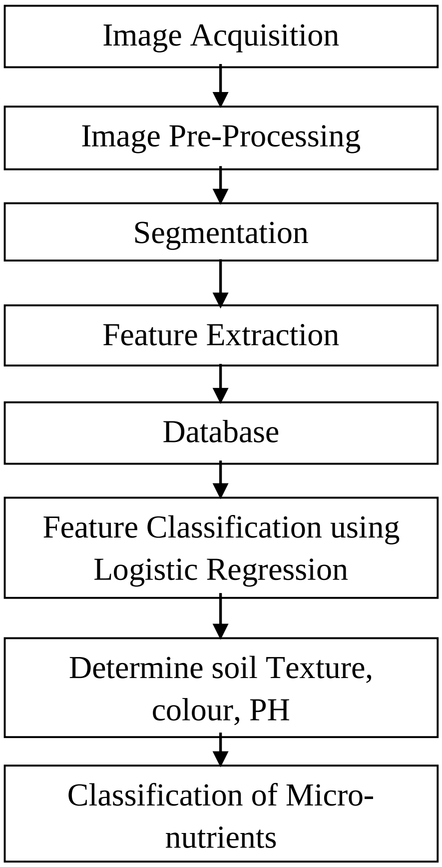

Fig. 1: Soil health analysis and classification of Micronutrients for crop suggestion

Before the further processes, the images must be recovered of any noise or artifacts such as comet tails, scratches, lap tracks etc. Bad line detection and restoration, geometric rectification or image registration, and radiometric calibration are all part of image preprocessing, the data conversion among different sources, atmospheric correction (topographic conversion) and quality evolution of data.

The image is segmented after being improved utilising image pre-processing methods in the previous stage. Currently the best evaluation is the clusters error criterion, it evaluates the squared distances of each step from the appropriate cluster centre before adding the locations of all the points in the data sets. Each image pixel is assigned to the cluster after the centre of the cluster is chosen. The average of all the pixels is used to re-computation the cluster's center. The next step in this iteration is to associate each point in a particular data set with the nearest centroid. The following is the K-means Algorithm:

i) Input: K, set of points x1........xn.
ii) Place the centroids

iii) Repeat until convergence

For each point xi:

Find nearest centroids C_j.arg min $D(x_i, c_j)$. Assign the point x_i to cluster j. For each cluster j=1……K:

$$C_j\ (a) = \frac{1}{nj}\text{xi}- >.Cj \sum \text{xi(a)for each a} = 1 \dots.\text{d} \quad (1)$$

j=1..K for each cluster. All points xi assigned to clusters j in the previous section are averaged to create the new centriod, Cj. iv) if none of the cluster assignments change, stop.

In this process, the first step is feature extraction. They have required all of the features necessary to classify the soil type. For the purpose of analyzing the type of soil, amount of features, such as intensity, color, texture, and hue, saturations are extracted. For extracting features, the Gabor Filter is used. A linear filter for detecting edges is the Gabor filter. A crucial step in implementing the soil image classification is the selection of suitable variables during feature extraction. In this step variables are selected which are most useful for a particular approach. A good representative dataset for each class is obtained by the end of this step. It has been observed that training samples for each class are refined and class separability is evaluated using deviance-related algorithms. Also additional characteristics like entropy, standard deviation, mean, etc.; utilizing the Gabor filter, can be extracted. To extract the soil's primary and crucial color, it is important. Hence, images are differentiated based on their color characteristics using a measure known as color moments. For tasks like image retrieval, these provide a color similarity between images that can be compared to the values of images indexed in the data base.

With information from the 1:5 000 000 scale FAO-UNESCO soil map of the world, the Harmonized World Soil Database combines regional and national updates of soil information from around the world for more than 15 000 different soil mapping units (SOTER [Soil Terrain Database], ESD [Soil Database of Ecuador], Soil Map of China, and WISE [World Inventory Soil Database]). The generated harmonised soil property data are linked to a raster database with 21600 rows and 43200 columns. Utilizing a standardized structure enables the integration of attribute data with raster maps for the display or query of the composition in terms of soil units and the characterization of particular soil parameters (organic Carbon, pH, soil depth, clay fraction's ability to exchange cation with the soil and other cation complete transferable nutrients, gypsum and limestone contents, saltiness, textured classes, and granulometry, percentages of sodium exchange, and salinity).

$$D(v) = \sqrt{\sum_{j=0}^{N} [fj(x) - fj(v)]^2} \quad (2)$$

N is the total number of features in f, and fj(x) and fj(v) are the jth and vth features, of the test sample's texture and texture class, respectively, in the library. Sequence window values calculated based on the distance vector function in eq.2. If the distance D(v) between all of the texture classes in the library table is the minimum, the test image is considered the vth texture. Minimum distance vector class is defined as soil texture.

A measure of a soil's acidity or basicity is its pH. The key characteristic of soil pH can be used to perform informative qualitative and quantitative analyses of soil properties. The negative logarithm of a solution's hydronium ion activity is the pH. A solution's pH is a significant indicator of its chemical structure. Chemical behavior, microbial activity, the availability of nutrients, and biological functions are all impacted by pH.

A physical characteristic of soils is colour, which provides information on a wide range of concepts, including the minerals that are present and the soil's age, chemically variations over time, carbonate development, the availability of moist organic matter. The behavior and use of soil are unaffected by color of the soil; otherwise, it can provide clues to the soil's composition and environmental conditions. There can be a wide range of colors in soil; white, grey, black, red, brown, yellow, and green texture and color identified which crops grow much faster in that soil based on feature extractor of soil pH and Logistic Regression (LR). Logistic regression classifier gives better accuracy than other algorithms.

Due to intense leaching and the loss of basic cautions, humid tropical soil generally has a high acidity. Plant growth will suffer as a result of this stressed environment. In addition, the use of fertilizers without lime has increased the soil's acidity also much more. The pH level can be categorized based on the soil's micronutrient content. The various pH ratings fall into four general categories: moderately acidic, slightly acidic, and strongly acidic, highly acidic. In addition, the pH is to identify, categorized the soil's microbial nutrients. Because plants require a proper balance of all essential nutrients for normal growth and optimal yield, micronutrients are necessary for the growth of plants.

Among the most widely used machine learning techniques, supervised learning includes the Logistic Regression (LR) method. Then use a determined collection of independent variables, it is utilized to determine a categorized variable. Compared to how they are implemented, logistic regression and linear regression are very similar. Regression challenges are also solved using linear regression. However, categorization issues are resolved using logistic regression. Potentially depends on the rat's weights to determine if it is fat or not, the logistic function's curve shows the possibility that the cells are cancerous or not. Due to the possibilities, it can present. Utilizing continuous discrete datasets, categorization of additional data is performed. Using logistic regression, it is simple to identify the factors that have the most classification effects when categorising observations using different data sources. The micronutrients are classified using this method. Because they are required in small quantities, the micronutrients are the essential nutrients that come from the soil. Copper (Cu), Molybdenum (Mo), Nickel (Ni), Chloride (Cl), Boron (B), Manganese (Mn), and Zinc (Zn), Iron (Fe). Crops that are suitable suggested if the micronutrients are correctly classified. The result is an increase in crop growth.

IV. RESULT ANALYSIS

In this section, soil health analysis and classification of Micronutrients for crop suggestion using Machine Learning is implemented using python. Firstly the soil images from different soils are collected. Next segmentation and feature extraction is performed for soil health analysis as well as micronutrients classification. The Logistic Regression algorithm is used in this approach for micronutrients classification. In this approach, the micronutrients are classified as boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni) and zinc (Zn).

The result analysis of presented approach is evaluated using confusion matrix parameters namely: False Positive (FP), False Negative (FN), True Positive (TP), True Negative (TN) are defined as follows:

True Positive (TP): A true positive is a instance in which a micronutrient has been correctly classified.
True Negative (TN): if a food is instance categorized as a micronutrient even though actually a non-micronutrient.
False Positive (FP): If an instance is incorrectly labeled as a micronutrient even though actually a non-micronutrient.
False Negative (FN): If an instance is incorrectly labeled as non-micronutrient even though actually micronutrient. Performance metrics including precision, sensitivity, and accuracy are measured using these parameters as follows:
Precision: The ability of a classification model to identify data points that are relevant. Precision is determined by dividing the overall number of true positives by the total number of true positives and false positives.

$$Precision = \frac{TP}{TP + FP} \times 100 \quad (3)$$

Sensitivity: The ratio of true positive instances to actual positive instances, also known as the True Positive Rate (TPR) or recall, gives other examples of these terms

$$TPR = \frac{TP}{TP + FN} \times 100 \quad (4)$$

Accuracy: It is given as the ratio of instances correctly detected to the total number of instances.

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} \times 100 \quad (5)$$

The evaluation of performance metrics is shown in table 1.

Table 1: Performance Metrics Evaluation

Methodologies	Precision (%)	Sensitivity (%)	Accuracy (%)
Soil texture classification using multi class support vector machine	86.7	88.76	91.37
Presented approach using LR	95.6	96.8	97.85

The accuracy, precision, and sensitivity of the presented Logistic Regression algorithm are evaluated. When utilizing a multi-class support vector machine approach to classify soil texture, it is compared whether any the provided technique performs. The presented LR algorithm has better results to the previous [Soil texture classification using multi class support vector machine] method. The performance comparison in terms the sensitivity and precision is shown in Fig. 2.

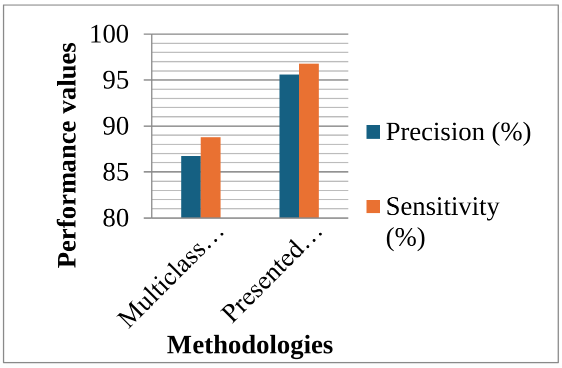

Fig.2: Performance Comparison Graph

In Fig.2 the x-axis represents different methods and y-axis represents the performance values. Compared to Soil texture classification using multi class SVM approach, presented LR algorithm has high precision and sensitivity. The Fig. 3 shows the accuracy comparison between earlier and presented approach.

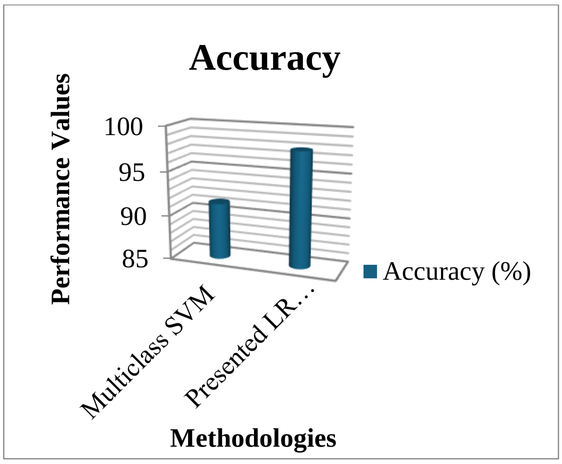

Fig. 3: Accuracy Comparative Graph

The various methods are shown on the x-axis and the performance values are shown on the y-axis in Fig. 3. Compared to Soil texture classification using multi class SVM approach, presented LR algorithm has high accuracy. In this approach, the micronutrients are classified effectively and accurately.

V. CONCLUSION

In this work, soil health analysis and classification of Micronutrients for crop suggestion using Machine Learning is implemented. The Harmonized World Soil Database, a 30 arc-second raster database is utilized in this approach. Color cameras are used to capture various soil image samples that require to be classified and are provided into the system as input. Image pre-processing and segmentation are carried out following the collection of samples. For the purpose of determining the type of soil, a range of extracted features including colour, texture, intensity, hue, saturation, etc. Using LR algorithm, the features like soil texture, pH, color of soils are determined. Based on the results, the micronutrients are detected and classified as different types. The performance of presented system is evaluated in terms of sensitivity, precision and accuracy. The presented LR algorithm achieves better results in terms of precision, sensitivity, and accuracy than the previous method.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. G. Murugesan, B. Radha, “Crop Rotation based Crop Recommendation System with Soil Deficiency Analysis through Extreme Learning Machine”, International Journal of Engineering Trends and Technology Volume 70 Issue 4, 122-134, April 2022, doi: 10.14445/22315381/IJETT-V70I4P210
2. E.U. Eyo, S.J. Abbey, T.T. Lawrence, F.K. Tetteh, “Improved prediction of clay soil expansion using machine learning algorithms and meta-heuristic dichotomous ensemble classifiers”, Geoscience Frontiers 13 (2022) 101296, doi:10.1016/j.gsf.2021.101296
3. Lihong Wan, Shihua Li, Yao Chen, Ze He and Yanli Shi, “Application of Deep Learning in Land Use Classification for Soil Erosion Using Remote Sensing”, Frontiers in Earth Science, www.frontiersin.org 1 April 2022, Volume 10, Article 849531, doi: 10.3389/feart.2022.849531
4. Machbah Uddin, Md. Rakib Hassan, “A novel feature based algorithm for soil type classification”, Complex & Intelligent Systems (2022) 8:3377–3393, doi:10.1007/s40747-022-00682-0
5. Stanisław Gruszczy´nski, Wojciech Gruszczy´nski, “Supporting soil and land assessment with machine learning models using the Vis-NIR spectral response”, Geoderma 405 (2022) 115451, Elsevier, doi: 10.1016/j.geoderma.2021.115451
6. Sanjay Motia and SRN Reddy, “Exploration of machine learning methods for prediction and assessment of soil properties for agricultural soil management: a quantitative evaluation”, ICMAI 2021, Journal of Physics: Conference Series, doi:10.1088/1742-6596/1950/1/012037
7. Janez Trontelj ml, and Olga Chambers, “Machine Learning Strategy for Soil Nutrients Prediction Using Spectroscopic Method”, Sensors 2021, 21, 4208, doi:10.3390/s21124208
8. A. Suruliandi, G. Mariammal, and S. P. Raja, “Crop prediction Based on Soil and Environmental Characteristics using Feature Selection Techniques”, Mathematical and Computer Modelling of Dynamical Systems. 27(1) (2021) 117-140.
9. shravani v, uday kiran s, yashaswini j s, and priyanka d, “Soil classification and crop suggestion using machine Learning”, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, Volume: 07 Issue: 06, June 2020
10. Vijay E V, Navya Ch, Abdul Shabana Begum, Rajaneesh D, Mahesh Babu B, “Soil Classification Using Modified Support Vector Machine”, International Journal of Research in Advent Technology, Vol.8, No.9, September 2020 E-ISSN: 2321-9637
11. Madhumathi R, Arumuganathan T, Sneha Iyer R, Shruthi R, Shruthhi K, “Soil Nutrient Analysis Using Machine Learning Techniques”, National E-Conference on Communication, Computation, Control and Automation (CCCA-2020), ISSN : 2581-7175
12. Kamel H. Rahouma and Rabab Hamed M. Aly, “Applying Polynomial Learning for Soil Detection Based on Gabor Wavelet and Teager Kaiser Energy Operator”, Springer Nature Switzerland AG 2020,

doi:10.1007/978-3-030-14118-9_75

13. Barman U, Choudhury RD, "Soil texture classification using multi class support vector machine", Inform Process Agric 7(2):318–332, 2019, Elsevier, doi: 10.1016/j.inpa.2019.08.001
14. Motia S, Reddy SRN, "Conceptual Framework of a Prototype Data Driven Decision Support System for Farmland Health Assessment using Wireless Sensor Network", In 2019 9th Annual Information Technology, Electromechanical Engineering and Microelectronics Conference (IEMECON) pp. 215-222. IEEE.
15. Sk Al Zaminur Rahman, Kaushik Chandra Mitra, S.M. Mohidul Islam, "Soil Classification using Machine Learning Methods and Crop Suggestion Based on Soil Series", 2018 21st International Conference of Computer and Information Technology (ICCIT), 21-23 December, 2018, 978-1-5386-9242-4/18
16. Chandan, Ritula Thakur, "An Intelligent Model for Indian Soil Classification using various Machine Learning Techniques", ISSN (e): 2250–3005, Volume, 08, Issue, 9, Sepetember 2018, International Journal of Computational Engineering Research (IJCER)
17. Hement Kumar Sharma, Shiv Kumar, "Soil Classification & Characterization Using Image Processing", 2018 Second International Conference on Computing Methodologies and Communication (ICCMC)
18. Ashwini Rao, Janhavi U, Abhishek Gowda N S, Manjunatha, Mrs.Rafega Beham, "Machine Learning in Soil Classification and Crop Detection", IJSRD - International Journal for Scientific Research & Development, Vol. 4, Issue 01, 2016 ,
19. S.Pudumalar, "Crop Recommendation System for Precision Agriculture",2016 IEEE Eighth International Conference on Advanced Computing (ICoAC), DOI: 10.1109/ICoAC.2017.7951740
20. Rakesh Kumar, "Crop Selection Method to Maximize Crop Yield Rate using Machine Learning Technique" 2015
21. International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), 6-8 May 2015. pp.138-145.