



A Review of Indian Soils and Detection of Key features of Fruits production using K-Means Clustering

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Abstract-

India has a diverse climatic conditions with a variety of crop production such as rice, wheat, fruits, vegetation and cotton. Different landforms and climatic realm leads to development of huge variety of soil types. The depth of the soil varies from region to region. Indian Agricultural Research Institute has classified Indian soil into 27 types which are further broadly categorized into 12 categories. However, in the past no such research is available where a detailed study is presented on different soil type of India. Research paper presents a detailed survey on Indian Soil types and its features which are suited for various crops type. In addition to this paper gives a brief survey on fruit production in India and its features set. Two different types of parameters are considered for the detection of features of fruit production (1) Internal parameter for Soil (2) External parameter such as Rainfall, humidity and Temperature. Based on these parameters, research paper evaluates the optimum values of these parameter fit for maximum growth of fruit production. K-Means Clustering is used to find the ideal value of these features for five fruits such as Banana, Mango, Grapes, Apple, Orange with an accuracy of 94.6.

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Keywords: Indian Soil; Soil Nutrients; K-means clustering; Fruit production

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1. INTRODUCTION

A thin top most layer of earth's surface is known as soil. It is of utmost significance as it is natural resource for the existence of several plants and animals. It consists of inorganic particles and organic matter and a mixture of rock particles, minerals, air, water and bacteria. The formation of soil is due to force exerted by several natural factors such as temperature, climate, rain, waves, wind and time, on rocks and breaks them into several tiny pieces over a long duration of time. Along with these natural factors, solar radiations and management inputs are also significant factors in soil formation [1]. Soil particles occur in varied sizes, shapes and chemical composition

which are categorized as: sand, silt and clay. Various types of soil consist diverse minerals, nutrients and micronutrients such as chlorite, Illite, Sodium, Phosphate, Zinc, Iron, Manganese and others that help in the growth of the plants [2]. The optimum growth of plants and crops yields is dependent on soil nutrient as well as other external factors such as temperature, soil texture, rain, pH and electrical conductivity. Soil health is of utmost importance which includes physical, chemical and biological properties of soil. It also signifies the capacity of soil in order to meet standard parameters such as water storage and supply, resistance to degradation and biological diversity [3].





Figure 1. Indian Soil Type

In India, due to diverse climatic conditions with a variety of relief features such as vegetation types, landforms and climatic realm leads to development of huge variety of soil types. Also, the depth of the soil varies from region to region. It can range from few centimeters to 30 meters [4]. Due to this diversification, India is considered as a predominantly agricultural country with wide variety of flora and fauna. Based on the soil structure, color and places, Indian Agricultural Research Institute has classified Indian soil into 27 types which are further broadly categorized into 12 categories. Diverse soil types include alluvial soil, laterite soil, red soil, black soil, coastal alluvial soil, desert soil, deltaic soil, terai soil, mountain soil, glacial soil, alpine grassland soil and grey and brown soil [1]. In India, this diversity in soil type and soil health ensures the availability and production of vast variety of crops, fruits and vegetables. As per Agricultural and Processed Food Products Export Development Authority, eISSN1303-5150

India is ranked second in fruit production in the world. India produced 99.07 million metric tones of fruits during 2019-2020 over 6.66 million hectares of cultivation land. Among several variety of fruits, India ranks first in the production of Apples, Banana (26.08%), Mangoes (45.89%), grapes and oranges. The main export of fruit production goes to countries such as Bangladesh, UAE, Netherlands, Nepal, Malaysia, UK, Sri Lanka, Oman and Qatar.

Hence, there is a need to determine and analyze the various factors that promotes and influence the production of fruits in India. Therefore, in this work, lot of research has been done on diversification of soil, available nutrients, minerals and other external factors that enhances the fruit production in India. Further, various nutrients and external factors are



clustered based on the type of fruit production, which is an important aspect for the agriculture of fruits in India.

2. Related Work

In literature, numerous studies have been done on assessing soil, soil quality, nutrients availability for crop production. In this section, the work done on assessing soil and soil properties is focused which yielded an improved production of fruits in India. S.A. Siddiqui and N. Fatima studied about Indian soils, the authors classified Indian soils in diverse types such as alluvial, desert, black, red and others [4]. Research proposed soil horizons which depict distinct physical and chemical properties of soil and presents vertical layers of soil as O horizon, A horizon, E horizon, B horizon, C horizon and R. Horizon. Further, soil was classified based on various factors such as rock particle size, textural classification, Indian soil classification and others. H.S. Jat et al. focused on Conservation Agriculture which is essential to improve the quality of soil. The authors assessed the physical properties such as bulk density, penetration resistance, infiltration and chemical properties such as N, P, K and other micronutrients over the period of 4 years in region of North-West India. Four different scenarios were proposed by authors which significantly improved the soil properties and quality that reduces the use of external fertilizers [5].

Dixit et al. introduced a new concept of tillage in agricultural operations that enhances the soil properties and environment, thus improving crop yield. The author worked on nine combinations of three tillage practices namely; Conventional Tillage, Minimum Tillage and Zero Tillage for the production of sorghum and cowpea over the period of 5 years on clay loam soil. Authors faced a constraint of limited irrigation facilities and concluded that zero tillage significantly improves

the soil properties and increases crop production with efficient energy utilization in semi-arid agroecosystems [6].

Rekhi et al. studied the soil properties and crop yields after 13 cycles of rice-wheat production in the area of Ludhiana, India. The study was conducted at Punjab Agricultural university farm on a loamy sand. The authors concluded that the production of rice and wheat was significantly improved with the application of Phosphorus (P) along with Nitrogen (N) [7]. M Kumar et al. evaluated the status of micronutrients such as Fe, Cu, Zn, Mn and B and their relation with soil properties. The experiment was conducted for wheat grains and straw in the field of Jhunjhunu, Tehsil. The author concluded that straw and wheat grains are positively correlated with silt, clay and organic carbon [8].

S.K. Reza et al. studied the variability in soil properties spatially in the region of Brahmaputra plains of Northeastern India. The study was conducted using geostatistical method for 767 soil samples at a depth of 0-25 cm. The samples were collected at an interval of 1 Km to analyze soil properties such as pH, organic carbon, available nitrogen, available phosphorus and potassium. They concluded that organic carbon and nitrogen has a similar spatial variability. The variability decreased in southern part of Brahmaputra plains and increased in central, southwest and southeast parts [9].

An extensive survey on soil classification has been presented by B.B. Mishra [1]. The author has surveyed the classification of soil based on broad soil association groups of Bihar. Based on distribution of soil of India in soil maps, based on Dominant clay and clay minerals

Further, they proposed a new approach for soil classification based on Pedogenesis and Fluvials. Table 1 shows the various soil type in India and its pH value and other characteristics

Table 1. Various Soils and its different Parameters

Soil type	pH range	Characteristics	Extent in ha	Extent in %	Major states	Dominant clay minerals	Major crops
Alluvial Soil	6.5-8.4	Siliceous and light in color	100,006	30.4	J&K, Gujarat, UP, Delhi, Haryan	Illite	Wheat, Rice, Oilseeds, Sugarcane



					a, Punjab, Wes t Bengal and Bihar		
Coastal Alluvial soil	5.0-9.0	Marine origin, sandy and clayey	10,049	3.1	Karnataka, Tamil nadu, Kerala, Odisha, Pondicherry	Illite, Chlorite	Sugarcane, cotton, Jute, Rice
Desert soil	7.6-8.4	Rich in phosphate and high percentage of soluble salts	26,283	8	Rajasthan, Gujarat, Haryana, Punjab	Illite, montmorillonite	Wheat, long grams, melon, bajra
Black soil	6.5-8.4	Consists of titanium, iron, calcium and magnesium carbonate	54,682	16.6	Maharashtra, Malwa plateau, Telangana, Andhra Pradesh	Illite, montmorillonite	Cotton, Millets, Tobacco, sugarcane
Red soil	5.5-7.5	Siliceous and aluminium in nature	87,989	5.5	Karnataka, Tamil nadu, Kerala, Odisha, Pondicherry, Manipur, Nagaland, Mizoram, Tripura, Delhi, Uttar Pradesh	Illite, montmorillonite	Wheat, rice, sugarcane, cotton, pulses
Laterite soil	<5.5	Consists of hydrated oxides of iron and aluminium	18,094	5.5	Assam hills, hills of Karnataka, kerala	Kaolinite, Halloysite	Coffee, rubber, cashew nut, tapioca
Mountain soil	5.0-6.5	Rocky in nature	60	-	J&K, Himachalpradesh, Uttaranchal, Sikkim	Humus	Fruit, tea
Terai soil	4.0-4.9	Swampy lowland with silty soil	326	0.1	Uttar prades h, Sikkim	Mollisols, Entisols	Wheat, rice, sugarcane, jute
Grey and brown soil	7.6-8.5	-	540	0.2	Karnataka, Maharashtra	Mollisols, Inceptisols	Cotton, oilseeds



Deltaic soil	6.5-8.0	Silt and clay	142	-	Eastern coastal plain	Illite	Wheat, rice, tobacco, jute, maize
Alpine grassland soil	7.6-8.8	High organic carbon and clay minerals	in 1000	38.9	Tibettan plateau	Clay minerals	Wool, cotton
Glacial soil	7.0-9.5	Rocky terrain with ice blocks	-	-	Nepal	-	-

3. Fruit Production in India

Fruits provide essential vitamins and minerals. Fruits are high in fibre, which is necessary for the digestive system to function properly. Among the most prominent and healthful fruits of Indian Origin to include in our daily diet are:- Mango, Banana, Grapes, Orange and Apple.

The quality of fruit production especially in terms of nutrients is highly dependent upon the quality of the soil. A healthy soil is the most fundamental element for providing the adequate environment for the plant's growth and its fruit production which in turn will lead to appropriate fruit nutrient absorption. It is extremely vital to understand that soil sustainability is a regulatory metaphysical model which focuses on the soil nutrients like N,P,K etc. that further formulate the quality of the soil [10]. Soil function fertility is defined as the soil's ability to stimulate and perpetuate plant growth which in turn is facilitated by the presence of the required amount nitrogen in the soil for precise absorption. It is because the presence of the required amount nitrogen in the soil would ensure conservation of other organic carbon materials, converting biological nutrients into plant-available mineral nutrients and pharmacologic mechanisms which govern their adaption [11]. Controlled soils are an expeditiously changing arrangement that allows the soil to function and supply humans with ecological benefits. Finally, soil quality and productivity are influenced by relationships between the soil crystalline lattice, plants, and microbes. They are the responsible for the production and chemical conversion/ decaying of

the organic matter, and so the production of nutrients in soils should always be preserved [12]. Soil health considers the mechanical, biochemical, and microbiological properties of the soil, as well as the perturbation and remedial behaviors of land managers. Hence it is important to understand the soil dynamics and also to improve its quality so the nutrient contents present in the fruits can also be elevated. Cropping patterns and crop yield vary from location to region due to a variety of factors such as soil type, climatic conditions, available nutrients, and economic reasons. To study the trend analysis of soil type, climatic conditions and available nutrients. This work focusses on five major fruits namely, Apples, Banana, Grapes, Mango and Oranges (Kinoo).

1. Mango-It is the most important fruit of India which is cultivated in the largest area of 2,312 thousand ha. It produces 15.03 million tons which contributes to 40.48% of the total world production. It is mainly cultivated in several states such as Uttar Pradesh (23.86%), Andhra Pradesh (22.14%), Karnataka (11.71%), Bihar (8.79%), Gujarat (6.00%) and Tamil Nadu (5.09%).
2. Banana-The second most important fruit in India which is grown in many tropical and subtropical regions. It is cultivated in 830.5 thousand ha area and produces 29,779.91 thousand tons of production in Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh and Karnataka.
3. Grapes- It is a sub-tropical crop which is



cultivated in an area of 111.4 thousand ha with a total production 1,234.9 thousand tons. The leading state is Maharashtra with Nasik and Sangli as main districts. It is cultivated in 86 thousand ha and produces 774 thousand tons.

4. Orange- it is the most common among citrus fruits grown in India which occupies nearly 40% of the total area under citrus cultivation. It is cultivated in 0.62 million ha. area with the total production of 4.79 million tonnes. It is mainly found in states of Maharashtra, Madhya Pradesh, Tamil Nadu, Assam, Orissa,

West Bengal, Rajasthan, Nagaland, Mizoram, Arunachal Pradesh.

5. Apple- It is the most important temperate fruit which is cultivated in 2.42 lakh ha. It is mostly grown in the states of Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Arunachal Pradesh and Nagaland [13,14].

The quality of fruit production especially in terms of nutrients is highly dependent upon the quality of the soil. Table 2. presents Nutrient Requirements (Kg/Ha) for different Fruits and Table 3. tabulates the Nutrition per gram for different Fruits

Table 2. Showing different Nutrient Requirements for different Fruits

Type of Fruit	N	P2O5	K2O	Yield (tons/ha)
Apple	100	45	180	25
Banana	250	60	100	40
Grapes	170	60	220	20
Mango	100	25	110	15
Orange (Kinnow)	2.4	0.57	2.35	1

Table 3. Showing different Nutrition per gram for different Fruits

Type of Fruit	Calories (kcal)	Carotene Vit.A(IU)	Vit.B1 (mg)	Vit.B2 (mg)	Niacin (mg)	Vit.C (mg)	Ca (mg)	P (mg)	Fe (mg)	K (mg)
Apple	56	0	120	30	0.2	2	0.01	0.02	1.7	144
Banana	153	0	150	30	0.3	1	0.01	0.05	0.4	396
Grape	45	15	40	10	0.3	3	0.03	0.02	0.4	0.15
Mango	50	4800	40	50	0.3	13	0.01	0.02	0.3	0
Sweet orange	53.8	0	0	0	0	50	42	23	0.4	177

The revenue generated in any normal business operations is defined as the average sales price times the number of units sold. It is the basic fundamental of any economy as it shows the direct relation between the sales and quantity of any product. Figure 2. depicts the revenue generated by India's fruit exports which explains the trend of the revenue generation from the form the fruit export over the years. It can be clearly seen from the figure that there is a 72 % increase in revenue generated from the sale of Bananas from the year 2013 to 2021. Figure 3. shows the Revenue Generated Per Capita from Export of Fruits (Till Oct. 2021) from India. It can

be seen that for Banana the revenue generated per capita is increased from 12.09 millionUSD in the year 2013 to 19.15 million USD in the year 2021 (till Oct. 2021). Similarly for Citrus fruits it is increased from 7.53 million USD in the year 2013 to 11.85 million USD in the year 2021 (till Oct. 2021) and other fruits also show a similar rise in Revenue Generated Per Capita from Export of Fruits over the course of years. Figure 5. Volume shows the consumption of the selected Fruit (Till Oct. 2021) in millions for each year. It can be seen that for average consumption of banana has increased from 29, 082 million kg in the year 2013 to 37,181.4 Million kg in the year 2021 (till



Oct. 2021). Figure 4. Shows the Average Income Per capita of the selected Fruit (Till Oct. 2021) in millions for each year. It can be seen that for Average Income Per capita of the all the fruits (as

an average) is increased from 4.01 million USD in the year 2013 to 6.01 million USD in the year 2021 (till Oct. 2021) [15].

Figure 2. Revenue Generated from Export of Fruits (Till Oct. 2021)

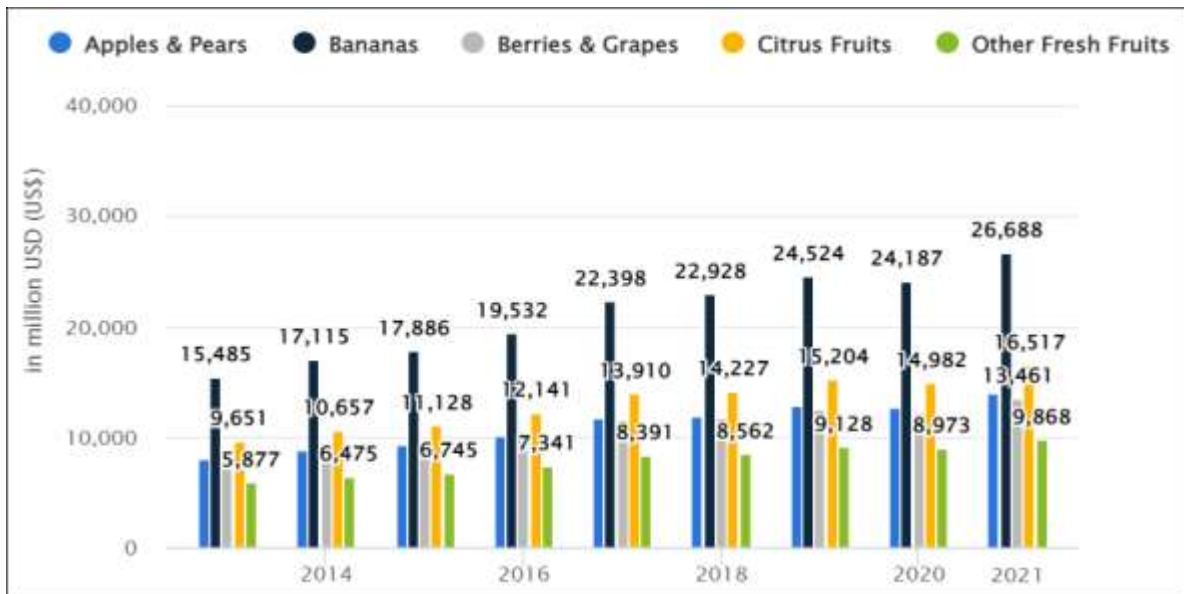
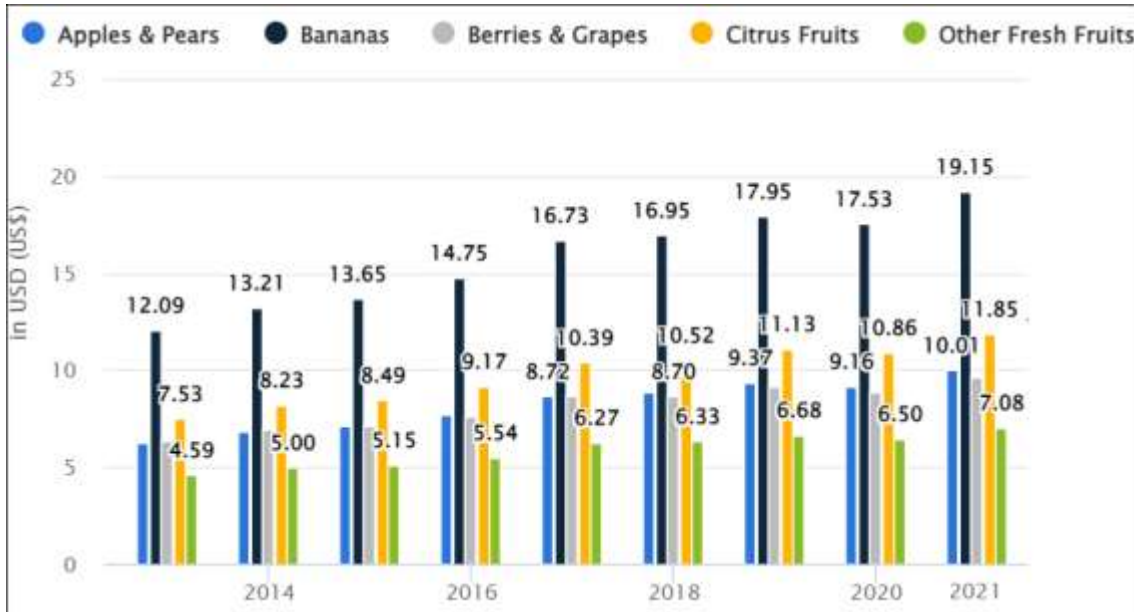


Figure 3. Revenue Generated Per Capita from Export of Fruits (Till Oct. 2021)



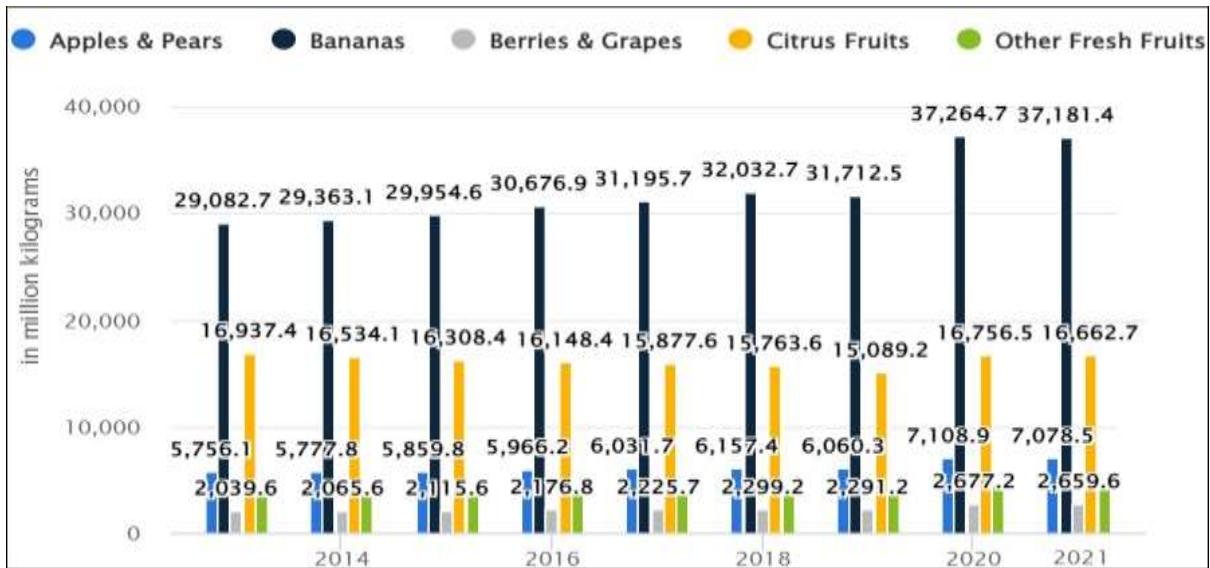


Figure 4. Consumption of the selected Fruit (Till Oct. 2021) in millions for each year

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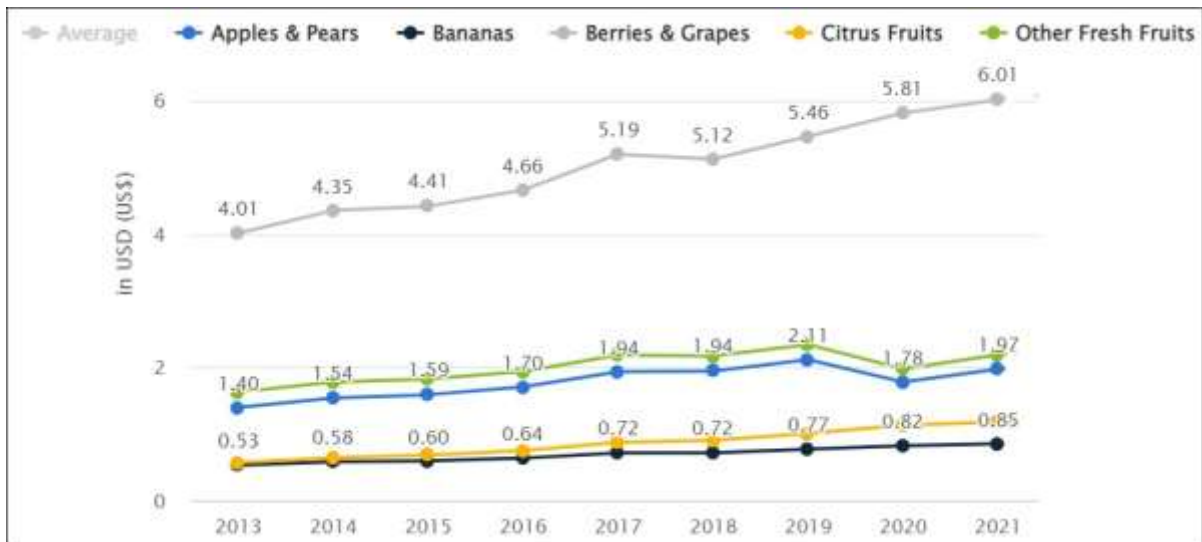


Figure 5. Average Income Per capita of the selected Fruit (Till Oct. 2021) in millions for each year

4. Implementation and Results

For analysing the soil data of and fruit applicability data collection is done using Kaggle repository. CROP Recommendation data from the Kaggle [16] is used for analysis. It has 7 parameters 4 parameters are soil parameters (N, P, K and ph) value however 3 are external parameter such as Temperature, Humidity and rainfall and one label, which is defined for the crop or fruit and vegetables. In the dataset, having 22 eISSN1303-5150

labels and each has 100 sample size. Among the 2200 samples, for this research selected the sample of 5 fruits such as Banana, Mango, Grapes, Apple, Orange. All fruits have grown in the different climate and soil condition. Table 3 shows the sample dataset of selected 5 fruits from the Crop Recommendation dataset



Table 3. Fruit Soil parameters and External features

N	P	K	Ph	TEMPERATURE	HUMIDITY	RAINFALL	LABEL
91	94	46	6.149934	29.36792	76.249	92.82841	BANANA
7	31	27	6.524114	31.32864	47.5932	94.67345	MANGO
9	122	201	5.570291	29.58748	80.91934	68.06417	GRAPES
16	143	197	5.904026	22.61712	93.51978	116.9257	APPLE
18	23	8	6.413548	21.49119	93.4395	101.482	ORANGE

In order to find the soil parameters and optimized external conditions for the selected fruits applied the clustering algorithm in R. K-means clustering is performed for 5 different samples of fruits with having 100 sample each, now performed the clustering on 500 samples after removing the labels.

K means cluster is an unsupervised approach to identify the features of the samples. In K means clustering a random centroid is created with a selected sample than repetitive iteration has to done to find the near-by data points. Once the centroid is fixed all the other near data point are captured with the counted number of iteration [17,18].

To implement the K-means clustering R Language is being used . First dataset is read in the R language and few libraries are included to perform clustering and statistical analysis and calculating the optimum number of cluster for the above dataset. Different library used are (*tidyverse*), (*cluster*), (*factoextra*), (*ggplot2*), (*kableextra*). After including the all the libraries and removing the labels from the data and for the statistical analysis to show how these parameters are distributed among these samples. Fig 2 shows the statistical distribution of these parameters. The value of P lies range in between (0-40, 70-90 and 120-150) whereas ph lies (0-50 and 180-200) and the temperature lies 10-35 for the above chose dataset.

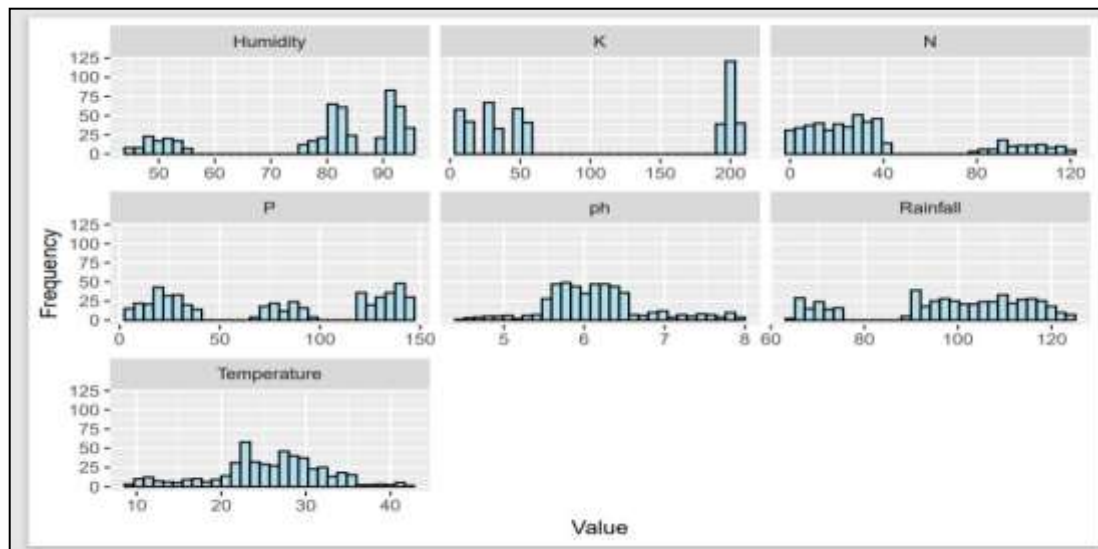


Figure 6 Statistical Distribution of Different Parameters

After performing the statistics analysis and to find the optimum number of cluster present in data, applied the Gap Statistical method to compute the value of cluster. In this method total number of within inter-clustering is performed to find best number of clusters.



$$\text{Gap}(k) = E_n * \{\log(W_k)\} - \log(W_k) \dots\dots\dots(1)$$

Where W_k is the pooled within-cluster sum of squares around the cluster means, E_n is the expectation under a sample of size n.

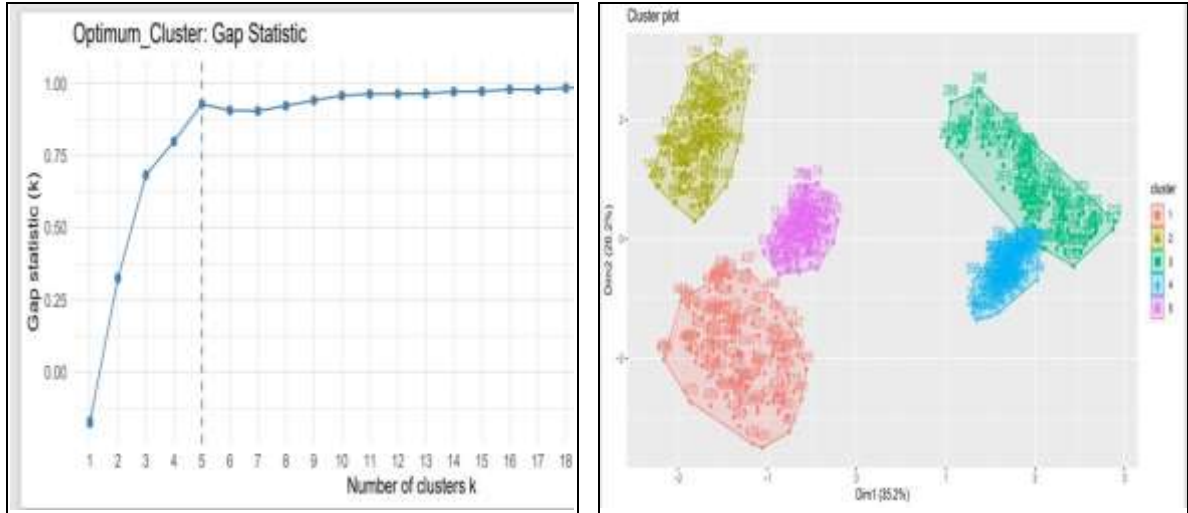


Figure 7 Shows the Result of Gap Statistical method and Cluster formed

After applying the algorithm found, five optimum number of cluster are there as per the dataset. Normalized the different features of the dataset, applied the K-means cluster with 7

$$\text{Accuracy} = \frac{\text{Total Corrected Identified Samples}}{\text{Total Samples}} * 100 \dots\dots\dots(2)$$

473 samples are correctly grouped in their respective sample, So Here the accuracy is

$$\text{ACC(Fruit)} = \frac{473}{500} = 0.946 * 100 = 94.6 \dots\dots\dots(3)$$



Further, found the best suitable conditions for these fruits to grow computed the centroid points for these fruits shown in table 4.

Table 4 Optimum values of Soil and External Parameters for Fruit Production

Fruit Name	N	P	K	Ph	Temperature	Humidity	Rainfall	Identified Cluster
Apple	20.8	134.22	199.89	5.92966293	22.63094241	92.3333829	112.6547793	1
Orange	19.58	16.55	10.01	7.01695745	22.7657255	92.1702088	110.4749687	2
Grapes	23.18	132.53	200.11	6.02593668	23.84957512	81.8752275	69.61182889	3
Mango	20.07	27.18	29.92	5.7663728	31.20877015	50.1565727	94.70451504	4
Banana	100.23	82.01	50.05	5.98389318	27.37679831	80.3581226	104.6269804	5

Conclusion

The soil fertility is of prime importance to farmers as the continuous supply of organic material feeds a huge number of soil organisms and presents an ideal environment in realm of developing organic farming for growing high quality nutritious fruits. In this paper an in-depth analysis of the effect of soil nutrients on different types of fruits (in particular Mango, Apple, Banana, Orange and Grapes) has been done. It is done by critically examining the different types of soils present on the Indian Terrain in terms of their different characteristics, pH range, minerals present and fruits grown on it in different parts of India. K-means clustering is implemented 5 different samples of fruits (in particular Mango, Apple, Banana, Orange and Grapes) An accuracy of 94.6% has been achieved by using K-means clustering so as to identify the best suitable condition to grow a certain kind of fruit.

Apart from soil, there are several other factors such as natural, historical, social, economic factors and government policies that define the crop production and cropping pattern. Cropping pattern for a production cluster is defined as proportion of area covered under different crops at given point of time as well as change in this area coverage proportion over period. From the perspective of agricultural science, the primary drivers of cropping pattern in an area are rainfall, climate, temperature and soil type. However, as the agriculture is getting commercialized, other factors such as market demand, market prices, production costs, adoption of technologies, yield levels and incomes have also gained significant role in deciding cropping patterns. In the future

more parameters will be studied to get up-growth in Indian crop production.

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