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INTELLIGENT SMART FARMING AND CROP VISUALIZATION

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ABSTRACT

Agriculture is a backbone of the economy for any country. Being a part of primary sector, all the other major sectors and industries depend on it for their raw materials. It satisfies the basic needs of human like food, clothing and shelter. However, due to climate change and other related problems, it is becoming increasingly difficult for farmers to keep pace with rising demands. As per estimate by Food and Agricultural Organization of United Nations, around 55 percent of India's total land area is used for agricultural produce. India is also a leading producer and exporter of some of the major crops. Still there are concerns regarding food security in India by United Nations. For overcoming the natural hurdles, involvement of technology is required for better analysis and decision-making. Through this paper, we plan to propose a visualization technique, which can help farmers to make better decision regarding crop selection.

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The study proposes a novel framework where farmers can get detailed information about the crops grown in any particular district and also area, production and productivity of any particular crop. This web-based agri solution will help farmers to take smart farming decision by resource optimization and smart planning.

Keywords: Data Visualization; Crop search; Decision Making

1. INTRODUCTION

Farming is an activity that falls into agriculture. A large section of population worldwide depends on the agriculture as their basic source of income. All the other people depend on agricultural produce for satisfying their basic needs. Farming is a combination of activities that involves, selecting the right crop, preparing the field or farm, sowing, irrigation, harvesting and storage. Selecting the right crop is one of the most crucial step. Being initial step, all the other tasks will depend on it. Therefore, it is very important to select the proper crop before starting any farming activity.

A number of factors influence the crop that can be grown in a particular region. For instance, some crops are irrigation intensive like rice and suitable for coastal region, whereas some fruits like apple are more suitable to hilly regions like Kashmir. Availability of water, average temperature, weather pattern, soil type, rainfall pattern, location, terrain and topography are some of the factors that influence the crop selection. Any mistake in crop selection can largely affect the income of the farmer and disrupt the farming cycle.

Geological location of a place is the combination of the latitude and longitude that uniquely marks the location of the place on the map of entire world. This geological location can be a very important cue when it comes to crop selection. Two regions closer to each other are likely to have many factors, which influence the crop selection, in common as compared to others that are far apart. For instance, two regions closer to each other are likely to follow common rainfall pattern, topography, terrain, weather pattern, etc.

Therefore, closeness of two regions on map serves as an important input to farmer while selecting proper crop. Apart from the geological closeness of two regions, visualizing the locations on map add helps farmer with other inputs as well. Suppose a farmer is from coastal region and wishes to know the crop he / she can grow. Plotting districts on map will help him / her to locate other coastal districts and then find the crops grown there for better decision - making. There are two farming seasons in India namely, kharif(autumn) and rabi(spring).

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Kharif season spans from July to October during the south-west monsoon winds. Rabi season spans from October to March, i.e. during winters. Crops grown during March to June are called as summer crops. So me crops are suitable for sowing in either kharif or rabi. Some can be grown entire year.

In this paper, we propose a novel visualization technique to help farmers select crop that is suitable to their region. There are two parts to this technique, search by district and search by crop. In former, a farmer can select any district on map and get a list of all the crops grown in that area. Selecting the crop, farmer gets graph visualization of area, production and production per unit area of given crop in selected district. This can help farmer to explore district wise crop pattern. Search by crop, provides the farmer with a list of all crops. Farmer can click on any crop and visualize the districts where the selected crop is grown. Upon selecting the district, the farmer can view graph-based visualizations as before.

Following sections talk about literature survey, followed by description about dataset, methodology and conclusion.

2. LITERATURE REVIEW

Odisha is primarily dependent on agriculture. Although there has been a shift in the state's GDP ratio, with service sector accounting for 54.4%, around 60% of the population of the state is still dependent on agriculture. This paper is a study of cropping pattern in Odisha over a period of around 25-30 years, since 1980. During this period, the area under cereals such as wheat, bajra, rabi pulses, oil seeds and cash crops declined, whereas certain cereals such as maize and rice, increased drastically (DUKU; ZWART; HEIN, 2018).

Salem, located between 11.14º and 12.53º North and 77.44º and 78.50º East is a land locked area of 5245sq. Km. There are a variety of crops grown in this region, including, paddy, cholam, maize, cotton, etc. Coffee is alone grown in around the area of Yercaud. All other crops are more or less uniformly distributed around the district (LAKSHMINARAYANA; RAJAGOPALAN, 1977).

Climate change is having its own effect in affecting cropping patterns around the world. Currently about 41% of the cultivated area in Upper Oueme can grow rainfed sequential cropping. However, by 2050, it will decrease to 2-16%. Farmers thus will need to shift to single cropping systems, short cycle cultivars or adopt improved agronomic practices. Conversion of forested areas to crop lands will have negative impacts on water availability for irrigation. Even if there is no change in woodlands, 50% of irrigation potential will be lost due to climate change

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(LEFF; RAMANKUTTY; FOLEY, 2004). Cropping pattern is further affected by the involvement of pesticides and high yielding varieties of the crops. It has been found that the area under the crops such as maize, cotton and other vegetables has increased. The uses of HYVs are further subject to the availability of fertile soils. These are also used to suppress the pesticides and improve higher growth. The over exploitation of water going on in Indo Gangetic plain, particularly in Punjab and Haryana, may lead to adverse environmental issues (MAJHI; KUMAR, 2018).

It is not so that the interest of Indian farmers is dying from agriculture. Rather, they now increasingly cultivate more cash crops such as spices, oilseeds, fibres, etc when compared to cereals. This may differ in different states as per the demand and land quality (MANDAL; BEZBARUAH, 2013).

On observing closely, it has been found that 18 major crops (barley, maize, millet, rice, rye, sorghum, wheat, cassava, potatoes, sugar beets, sugar cane, pulses, soybeans, groundnuts/peanuts, rapeseed/canola, sunflower, oil palm fruit, and cotton) are the representative of the agriculture of most regions of the world. Rice dominates the production in Asia. Approximately 24% of the cropland in Asia is used for the production of the rice. Pulses are grown largely in western India. In Asia as a whole, they constitute 6% of the cropland, but in India 12%, which is the third maximum after rice and wheat (MANJUNATH; PANIGRAHY, 2009).

Kerala is a unique state in itself because of its agro-climatic variations and cropping patterns. The trend of mono-cropping is at a rise in the state, as there has been a decline in both the area and production for food crops and in favor of crops such as coffee, banana and rubber (NAYAK, 2016).

In states such as Assam, where natural affects such as flood play a major role, farmers adopta system of Crop Diversification. Crop diversification has an important role in enhancing the farm income (RAJAGOPAL et al., 2015).

Not only are weather and climate influencers of the cropping pattern, factors such as availability of water, water levels, etc. also play a decisive role in the crop selection. Both the surface and ground water are used for determine an optimal pattern and release for maximizing the net benefits (REJULA; SINGH, 2015).

Among all the crops grown in India, Rice is most produced. India stands first in total area for rice production, where as it is second in terms of production. It is generally grown in two

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major seasons, dry and wet. Among all the states producing rice, it is most produced in the states of West Bengal, Andhra Pradesh, Tamil Nadu and Orissa (SHETTY et al., 2007).

The purpose of the article. The past study suggest that agriculture is highly dependent on climatic condition and landscape of a place therefore, in this research we have tried to suppose data visualization technique which could help farmers to make agriculture related online searches by district and by crop. If online searches made on the basis of district then farmers will get detailed list of the crop grown in that area.

On the other hand if farmer makes online search about a particular crop then he will get the detailed of production area and productivity which could help him to understand the cropping patten of that crop. Hence this research will help farmers in planning and implementation of smart farming activities by incorporating artificial intelligence and visualization techniques.

3. METHODOLOGY

3.1. Flow of work

The flow for building the web application is explained in the block diagram below (see Figure 1):

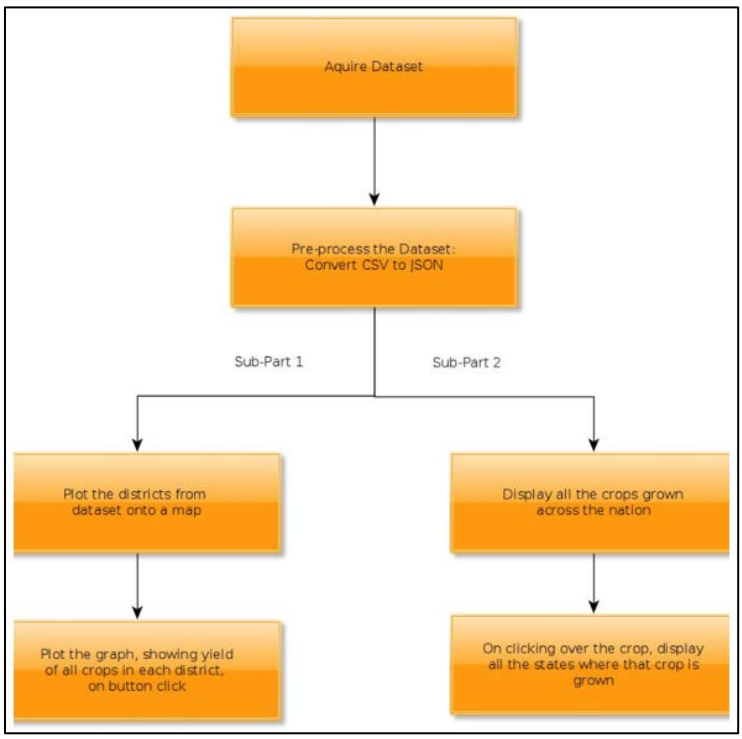

Figure 1: Flowchart of methodology for web application to predict the cropping pattern
Source: composed by authors

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3.2. Selection of datasets

In our visualization solution, we have used two datasets.

a. Crop Area and Production Dataset

This data set is available at Indian Government's website for sharing data - data.gov.in. Data being from government's website is expected to be correct. It has seven features or columns namely State, District, Crop year, Season, Area, Production. State denotes one of the 29 Indian states. District denotes one among several districts in the given state. Season has three possible values namely, "kharif", "rabi" and "whole year". Area and Production attributes respectively denotes the area of land cultivated and amount of production obtained for a given crop in a given year in a particular district (see Figure 2 for details). This is the main data set that contains all the information, which will be visualized for better decision making. Given below is a small clip of dataset for better understanding. It has 2,46,092 rows.

	A	B	C	D	E	F	G
1	State_Name	District_Name	Crop_Year	Season	Crop	Area	Production
2	Andaman and Nicobar Islands	NICOBARS	2000	Kharif	Arecanut	1254	2000
3	Andaman and Nicobar Islands	NICOBARS	2000	Kharif	Other Kharif pulses	2	1
4	Andaman and Nicobar Islands	NICOBARS	2000	Kharif	Rice	102	321
5	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Banana	176	641
6	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Cashewnut	720	165
7	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Coconut	18168	65100000
8	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Dry ginger	36	100
9	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Sugarcane	1	2
10	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Sweet potato	5	15
11	Andaman and Nicobar Islands	NICOBARS	2000	Whole Year	Tapioca	40	169
12	Andaman and Nicobar Islands	NICOBARS	2001	Kharif	Arecanut	1254	2061
13	Andaman and Nicobar Islands	NICOBARS	2001	Kharif	Other Kharif pulses	2	1
14	Andaman and Nicobar Islands	NICOBARS	2001	Kharif	Rice	83	300
15	Andaman and Nicobar Islands	NICOBARS	2001	Whole Year	Cashewnut	719	192

Figure 2: Prototype of Crop Area and Production Dataset
Source: composed by authors

b. Latitude and Longitude Dataset

This dataset contains latitude and longitude information of all the state & district combination in our previous dataset. It is used to plot the districts on the map. It has four columns namely, State, District, Latitude, Longitude. Since, we required the latitude and longitude information for our custom list of districts, the dataset was not available andhad to be prepared. Python scripts were used to create the dataset. It has 653 rows.

Firstly, the previous dataset was read and parsed and list of state, along with districts in that state was created. Then for each state and district combination, Open Cage Geo coder

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fetched the latitude and longitude values using the API call.

Once, all the data was fetched, it was stored in excel file and dataset was created. Some on the python packages used were, open pyxl, for reading and writing to excel files and requests for calling the API and fetching the results (see Figure 3). Given below is a snippet of the dataset.

	A	B	C	D
1	**State**	**District**	**Latitude**	**Longitude**
2	Andaman and Nicobar Islands	Nicobars	8	93.5
3	Andaman and Nicobar Islands	North And Middle Andaman	12.6112387	92.8316541
4	Andaman and Nicobar Islands	South Andamans	12.50029	92.75004
5	Andhra Pradesh	Anantapur	14.6546235	77.5562598
6	Andhra Pradesh	Chittoor	13.1601048	79.1555506
7	Andhra Pradesh	East Godavari	17.233496	81.7225986
8	Andhra Pradesh	Guntur	16.2915189	80.4541588
9	Andhra Pradesh	Kadapa	14.4752936	78.8216861
10	Andhra Pradesh	Krishna	16.6691525	80.7190024
11	Andhra Pradesh	Kurnool	15.8309251	78.0425373
12	Andhra Pradesh	Prakasam	15.5	79.5
13	Andhra Pradesh	Spsr Nellore	14.2939818	79.7794384
14	Andhra Pradesh	Srikakulam	18.320022	83.9160772
15	Andhra Pradesh	Visakhapatanam	15.83333	79.75

Figure 3: Prototype of Latitude and Longitude Dataset
Source: composed by authors

3.3. Processing of Datasets

Initially both the datasets were in csv format. Our representation needed the data in form that could be easily used to view it on the mapona web inter face. While working with web inters face and plotting maps and graphs on web, Java Script, HTML, CSS are the commonly used languages. However, loading data from csv format in JavaScript and web interface for visualization is not a very efficient option. Therefore, the data need to be converted to form that would be easy to work with in web interface. So, the data was converted to Java Script Object Notation or popularly known as JSON format. Python scripts were used to convert the data to required JSON files. Four JSON files were created for fast and better visualizations.

a. Latitude and Longitude JSON file

The JSON file consists of list of objects with each object have four attribute value pairs. The attributes were State, District (dis), latitude (lat) and longitude (long). It is used to model the latitude and longitude data of all states analyst format. When plotting the districts on map, the entire list is traversed to plot on the districts on the map. In addition, the list can be searched for a given state and district and the location data for that district could be found out. ‘xlrd’ and

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'json' are the Python packages used for creating the file. Latitude and Longitude dataset is used to create this JSON file. Schema of the file is as follows:

[{

"state": "Andaman and Nicobar Islands", "dis": "Nicobars",

"lat":8,

"long":93.5

},

{

"state": "Andaman and Nicobar Islands", "dis": "North And Middle Andaman", "lat":12.6112387,

"long":92.8316541

},...]

b. Crop list JSON file

This file consists of a list of all the crops. This file has unique, non-repetitive names of all the crops, about which data is present in the dataset. It is used in the part of visualization where search by crop name is used. This list is traversed to make buttons for all the crops. "pandas" and "json" are the python packages used to make Python script for creating the given file. Crop area and production dataset is used to make this JSON file. Schema of the file is as follows:

[

"Arecanut",

"Other Kharif pulses", "Rice",

"Banana",

…]

c. Crop Data JSON file

This file contains all the data about the crops produced in different major districts of India. The data is organised in the form of array of objects, where each state is an object, having further districts as their object. Each district contains the year wise data in the form of arrays. For each element of the array, first element is the year, second is the type of crop, quantity of production of the crop and area in which the production was carried out. This JSON is the heart and soul of the project, which forms the basis of thisproject.

Schema of the file is as follows:

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[
{
“Andaman and Nicobar Islands”:{ “NICOBARS”: {
“Arecanut”: [[
2000,
“Kharif”, 1254,
2000
], [
2001,
“Kharif”, 1254,
2061
],

d. Crop-wise State list JSON file

This file has a JSON object in which the attributes are names of all the crops that are present in the crop list. The value of each crop name is list consisting of names of all the states followed by underscore and name of district where the given crop is grown. This data is useful for faster marking on map, when using search by crop name option. “pandas” and “JSON” are the python packages used to make Python script for creating the given file. Crop area and production dataset is used to make this JSON file.

Schema of the file is as follows:

{
“Arecanut”: [
“Andaman and Nicobar Islands_Nicobars”,
“Andaman and Nicobar Islands_NorthAnd Middle Andaman”, “Andaman and Nicobar Islands_SouthAndamans”,
“Andhra Pradesh_Anantapur”,
…],
…
}

4. RESULTS AND DISCUSSIONS

The aim of the visualization technique is to make crop selection easier and better for farmers. So, to visualize the information there are two available options. One is Search by District and other is Search by Crop. Let us understand one by one.

a) Search by District

In this part, the flow goes as follows: All the districts are marked on the Indian mapby a red marker. When the marker for a given district is selected, a list of crops grown in that

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district is loaded below the map. The user can click on any given crop. When user selects a given crop, three plots are loaded – Production, Area and Production per unit area. Plots denote the pattern of production, area and production per unit area overyear.

To start with, we first need to include a map. Out of all available options here, Leaflet is used to include the map. Leaflet is a popular open – source Java Script based library which is used to include maps in web applications. We initialize the map and add the layer to display the names and routes, which is a basic layer. We also, set the view of the map, showing Indianregion.

After including the map, we need to represent all the districts with a marker. Districts are represented by a red circle. Here the Latitude and Longitude JSON file comes into use. Java Script's looping functions are used to loop through the list of objects representing state and district along with geolocation data. The markers for all the districts in the list are created. In the marker object of each district, the state and district name is added as separate fields. In addition, an "on click" event listener is added to each marker to call the function when the marker is clicked. When the district marker is clicked, the function in on click event listener is called. The state and district information stored in marker object helps identity the district and state in the called function.

Once the unique information about the district and state is received, it is further used to get the data out of crop data, where these are used as nested keys to get the nested array of crop information. From here, we can get all the crops produced in that region, which are then displayed in the form ofbuttons.

After we choose any of these crops for the selected district, an on click listener calls the function, which then plots the graph. For plotting the graph, we are using a Java Script library called Plotly.js, which requires us to pass the values to it in the form of production, year and the season, or type of crop.

We are plotting 3 graphs for proper visualization of the data. The first graph represents the production of a particular crop in the selected district over the years. Similarly, second graph shows the area used for production in the particular district, dedicated to the crop over years. And in addition to these, third graph provides production per unit area, which helps farmers to understand about the climate change or other issues which may be causing growth or decline in the production of the crop and take suitable decision for the future (see Figure 4).

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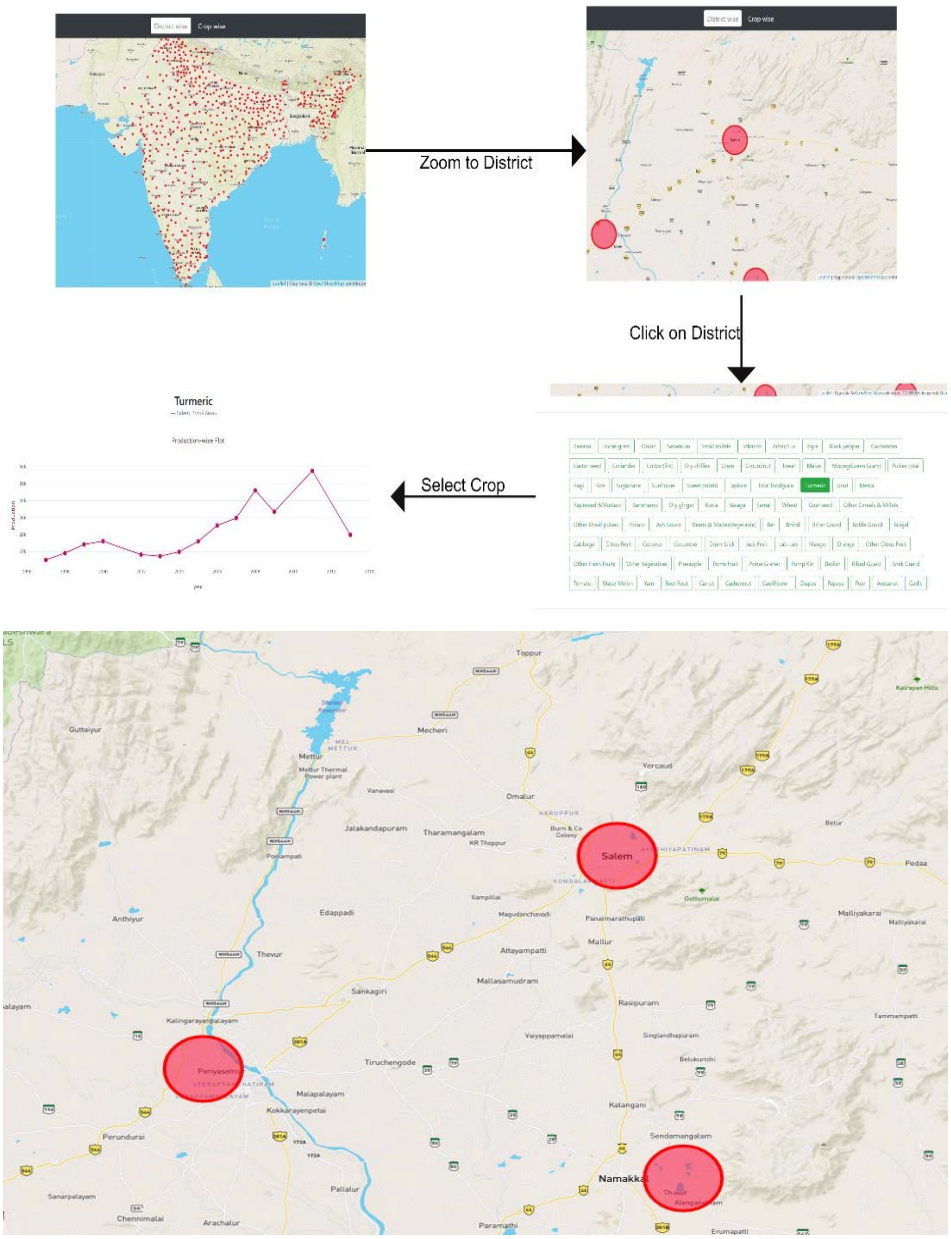

Figure 4: District wise Search
Source: composed by authors

b) Search by Crop

In this part, the flow is follows: Initially there is series of buttons for all the crops

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cultivated in India. When a crop is clicked, the maps gets loaded with markers for all the districts in which the selected crop is cultivated. When the marker of a district is clicked, three plots are loaded showing the area, production and production per unit area of the crop in the selected district.

Firstly, we need to add the buttons for all the crops cultivated in India. Crop list JSON file is used to get a list of all the crops. Using Java Script looping function, loops through the entire crop list and create button for each crop. In button, we add an on click event listener along with function to be called. Function takes name of the crop as the parameter to identify which crop isselected.

Once user selects the crop, function with crop name as parameter is called. Using the Crop-wise State list JSON file, a list of the state, district combination cultivating the selected crop is obtained. Using Leaflet we include the map along with layers as explained before. Loop through all the districts; find the geolocation data of each using Latitude and Longitude JSON file and then mark the district with a red circle marker on the map. Here, state, district and crop name added as separate fields. On click event listener is added to marker as before. As the user clicks on district marker, the call-back function of event listener is opened.

Similar as before, once we have received the district and crop information from the user, we can easily plot the data in the form of graphs (see Figure 5).

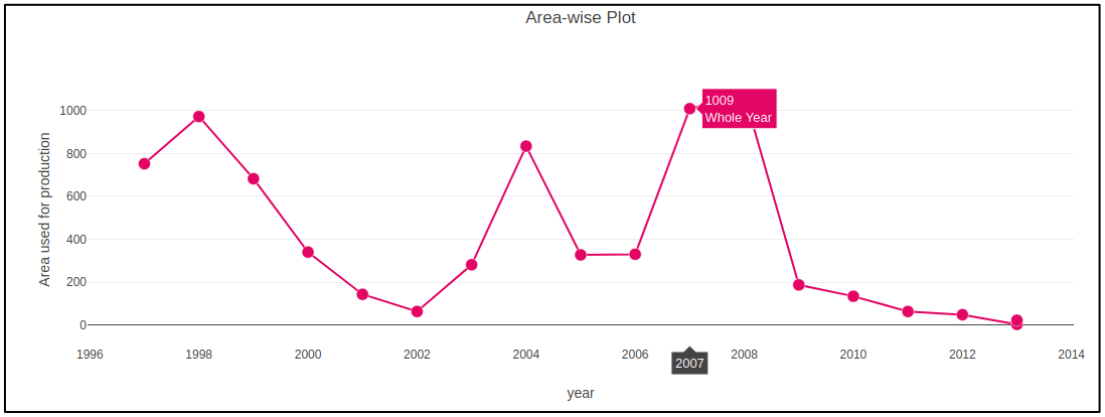

Figure 5: Crop Area Wise Search
Source: composed by authors

5. CONCLUSION AND DISCUSSION

India is an agronomic nation. Providing employment to 50% of the country's workforce, agriculture sector accounts for 18% of the country's Gross Domestic Product (GDP). Thus, it is very important, not only from a farmer perspective, but for nation as a whole. Visualizing the crop production, crop area and production per unit area for several years, does

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help farmer to make better decisions with regard to crop selection.

Also, farmers get flexibility to either search by district or search by crop. With these options, one can easily visualize how the topology and geography of a place affects the crop produced in an area. Various insights can be drawn from these visualizations like, Coffee is only grown in considerate amounts in the hilly districts of Kerala, namely, Wayanad, Idukki and Palakkad.

Although the production of Coffee is on a decline in all the districts, Idukki shows a remarkable increase in production per unit area for coffee. Tea on the other hand is also produced in the north-eastern states of Nagaland and regions near Assam.

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