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Authors Name/s per 2nd Affiliation (*Author*)

line 1 (of *Affiliation*): dept. name of organization
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line 3-City, Country
line 4-e-mail address if desired

Abstract—The world population is increasing everyday and in order to keep up with the increasing population an extensive food production system has to be designed. Farming is one of the most important occupations in this modern time. Traditional farming is used by most of the farmers these days, however it has its own disadvantages. like less yield leading to less income. It also makes use of various pesticides which degrades the quality of the soil as well the crops. To overcome these disadvantages farmers are nowadays shifting to digital farming which yields more crops thus increasing their income. This research work intends to delineate the details of the newly built platform “DigiFarm” which aids the farmers in making informed decisions based on their soil pattern and weather condition. The central aim of DigiFarm is to help the farmers in predicting the crop which is most suited for their land to gain maximum yield. The crop prediction system is designed in such a way that it is user friendly and it gives accurate results. To get accurate crop prediction, in this research work two Machine Learning (ML) algorithms have been compared. They are Random Forest (RF) and Gradient Boosting (GB) algorithms. The RF algorithm outperformed with better accuracy compared to the GB algorithm. Hence, RF algorithm has been used in the platform for crop prediction which helps the farmers in predicting the best crop for their land based on various factors like soil composition, weather, etc.,. The platform also provides an Artificial Intelligence (AI) based chatbot named ‘AgriBot’ which helps the farmers in guiding them through the platform and also helps them in predicting the crops as well as answering their other queries. The platform also has a news section which provides the users with the latest agriculture related news.

Keywords — DigiFarm, Random Forest Algorithm, Gradient Boosting Algorithm, Crop Prediction Model, AgriBot.

I. INTRODUCTION

Farmers, the soul of the Indian economy, are the ones who feed the huge population of India. Without them, no one would be getting food on their plate today. With a continuous increase in the population, there is a need to increase the yield of the soil in order to support the growing demands of the

twenty-first century world. Authors [1] argue that there is a massive need to upgrade the production to meet the increasing population which is anticipated to reach 9.5 billion by the year 2050. In the literature [2], the authors note that 80% of the cultivable land grows single crops like rice, corn, wheat and soybean that deteriorate the quality of production across the world. Thus, there is a need to find alternatives where agriculture does not suffer because of the depletion and under-utilization of resources. While these literatures summarize the current issues which the agricultural sector is encountering, it does not give innovative details to resolve the same. In other words, the arena of digital farming remains untouched in the traditional purview.

The question arises - How far would digitalization be accepted by the indigenous farmers? According to the author P K Sofia [3] 70% of the population in India depends on traditional farming methods for their livelihood because it is economical and environment friendly to a certain extent. Almost 90% of the tribal population in India is dependent on and acts as guardians of conservative methods of farming [4] [5]. There are several reasons behind the continuation of these methods. For example, according to Lincoln NK [6], traditional farming requires local resources that replenishes the soil constituents and keeps them intact. Scholars like Timothy Johns [7] stated that traditional farming provides financial support to the farmers that secures the diet and nutrition of the global population. The author [8] mentioned that various traditional methods of agriculture have successfully met the overseas demands as well as the domestic demands of crops like rice.

Despite its advantages, traditional farming is not the best method of farming and there are numerous drawbacks for the same. The foremost problem is soil erosion caused due to water, wind, ice or gravity. The authors [3-7] do not take into consideration that to increase the total yield on a tract of land, traditional farming resorts to the use of excessive pesticides. While approximately a couple of decades ago, the pesticides and fertilizers were hundred percent organic, the farmers increasingly shifted to using synthetic products which depleted the soil quality and was harmful for the crops.

Climatic changes leading to water depletion, air and soil pollution, eutrophication has also created hurdles in the traditional farming methods. Climate change has become one of the most pressing concerns in modern times. The world has indeed experienced some drastic changes in the recent past, from glaciers melting to erratic rainfall. These challenges will continue to grow with the ever-increasing population. In addition to affecting crop growth rate, climate change also affects rainfall variability. They all play a role in raising global temperatures. Fig 1 shows the yearly increase in global temperature from 1880-2020. Global warming has led to a drastic increase in global temperature and it continues to increase every year.

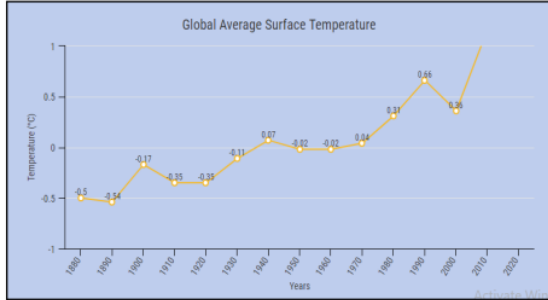


Fig 1: Yearly increase in Global temperature

The changing climate, erratic rainfall, pollution, drawbacks of traditional farming are the central cause behind the magnifying farmer suicide rates all the world every year [9]. Between 1995 and 2006, 1,66,304 farmers committed suicide [10] in India and the number has only increased since then. The author [11] says that farmer suicides increased between 2002 to 2007 and the main reason for this was indebtedness. In order to earn more in a shorter span of time, the farmers start growing cash crops like sugarcane, cotton on the soil that deteriorates its quality. Moreover, the farmers are able to retain a very small percentage of earnings. The cash crops are labour intensive and require more care. Inflation has further added to the troubles of the farmers [12]. Fig 2 shows the farmer suicide rate of India reported as per the National Crime Records Bureau (NCRB), India [13]. This shows the poor conditions of farmers in India and how they have to suffer for revenue and to pay off their debts.

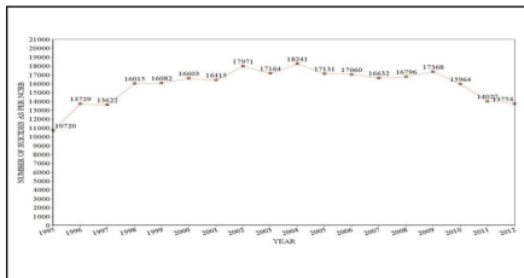


Fig 2: Farmer suicide rate as per NCRB [13]

The need of the hour is to transform the way in which farming is viewed. Every sector has not only introduced digitalization but is turning entirely virtual. This is the new world and the future. In order to keep up with the developments, our primary sector also needs a major revamp which shall be attained with digitalization.

This is where Digital Farming (DigiFarm platform) steps in. It is introduced with the sole purpose of helping farmers. The aim of DigiFarm platform is to aid the farmers in selecting the crop that can give them best yield and helping farmers in other aspects. The changes that are caused on their land and soil due to the climatic changes requires an innovative approach. The authors who have previously talked about the latest advancements in agriculture and digital farming such as field scouting and harvesting. They even mentioned various concepts such as sensors and robots that can be used extensively in digital farming [14]. Their research is very beneficial for bringing a major change to the current farming trends that can be insightful for the farmers. However, they fail to predict the crops which the farmers could grow for better yield. DigiFarm is primarily aimed at farmers that can assist with their needs. The motive is to make the farmers aware of digital farming and its benefits. By tracking the latest climatic changes, soil patterns and weather conditions, using DigiFarm farmers can predict which crops can be sown on their land for maximum yield.

The prediction is based on the machine learning model which is trained with adequate amounts of statistical data so that the prediction is accurate and is ultimately helpful for the farmers to increase their income. In the literature [15] it is mentioned that the authors used the algorithm that makes use of the arrangement calculation of Help Vector Machine to improve the crop prediction module. The algorithm detects the dirt and gives information about which crop would be best suited and it also tells which nutrients are not present abundantly for that specific crop. Authors Dhivya Elavarasan and P.M. Durairaj Vincent [16] have created a Deep learning based crop yield prediction model and authors [17] have created a ML model for crop yield prediction. In both the cases [16] and [17] they have emphasised on crop yield prediction. Authors [18] have prepared a soil classification and crop prediction model by using Support Vector Machines and k-Nearest neighbour algorithms. Researchers [19] have used time series analysis for predicting the production rate of crops. They have used SVM and Naive Bayes for classification ML models. Researchers [20] have created a crop prediction model by making use of Artificial Neural Network approach where one can predict the crop using parameters such as rainfall, humidity, copper, calcium, magnesium etc.,

The main aim of DigiFarm platform is to help the farmers in growing their business by growing the right crop at the right time and making them aware about Digital Farming. Due to the global accessibility of DigiFarm, even a farmer in some remote village can access it and make profit thereby. All their queries will be answered by the Artificial Intelligence

The research paper is organised in the following manner: Section 2 presents the Methodology used to develop the DigiFarm platform, collect the data and use different algorithms. Section 3 presents the result and description of the DigiFarm. Section 4 summarizes the conclusion to our study derived from the DigiFarm.

Statistical Parameters	Nitrogen	Phosphorous	Potassium	Temperature	Humidity	pH value	Rainfall
Count	220.0	2200.0	2200.0	2200.0	2200.0	22.00.0	220.0

Mean	50.5 5	53.36	48.14	25.61	71.4 8	6.4 8	103. 46
Standard Deviation	36.9 1	32.98	50.64	5.063	22.2 6	0.7 7	54.9 5
Minimum Value	0.0	5.0	5.0	8.82	14.2 5	3.5 0	20.2 1
25%	21.0	28.0	20.0	22.76	60.2 6	5.9 7	64.5 5
50%	37.0	51.0	32.0	25.59	80.4 7	6.4 2	94.8 6
75%	84.2 5	68.00	49.0	28.56	89.9 4	6.9 2	124. 26
Maximum Value	140. 0	145.0	205.0	43.67	99.9 8	9.9 3	298. 56

ii) The correlation between different attributes which is summarized in the following Fig 4

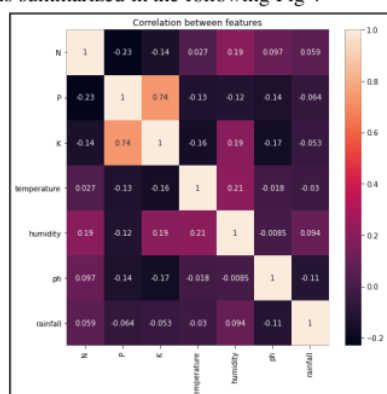


Fig 4: Correlation between different features

iii) Since there were no missing cells or null values, the approach proceeded to the next step, i.e., choosing the algorithm and training the crop prediction model..

3) Choosing the algorithm for training the crop prediction model

In this research work, from the dataset [21] the “crop name” attribute has been considered as a target label and “Multiclass Classification” model has been used (i.e. 22 classes). Gradient Boosting algorithm and Random Forest algorithms have been used for training the ML model.

Gradient Boosting (GB) Algorithm

The Gradient Boosting method for Machine Learning is widely used to perform classification and regression tasks. This algorithm was invented by Jerome Friedman [23]. In this research work, the GB algorithm has been used for classification tasks (i.e. to classify the crops). It is a boosted ensemble of trees as opposed to a bagged ensemble; they are less interpretable as the second tree in the model may or may not predict the same value as the previous model. Using the residuals from the preceding trees, successive trees try to predict how far the original predictions were from the truth. As a result, each successive tree in the GB model slowly reduces the errors of the preceding trees. As a result, GB models have high predictive power but low interpretability. In addition, GB models are quite prone to overfitting the training data, to combat there are several extra hyper parameters which can be used.

Random Forest (RF) Algorithm

The Random decision forests or Random forests are an ensemble method (it groups multiple Decision tree predictors) which is used for regression and classification. This was invented by Leo Breiman [24]. In this research study, the RF algorithm has been used for classification task (i.e. to classify the crops). In this each tree makes their own prediction and they are accumulated into a final prediction as votes for classification models. In RF there are two aspects of randomness involved. The first aspect of randomness is, which features in each decision tree, a random subset of features is chosen. The second aspect of randomness is using only a sample of the training data each time a tree is fit. The central aim behind this is to utilise each row and feature them in at least one of the decision trees, however not to use all the features in any one single decision tree. This allows us to build trees that are not correlated while adding variation to our collection of models and reduce the risk of overfitting. Even with this approach overfitting is still a concern that can be solved by setting the max depth. Max depth is the number of questions asked before reaching the prediction. Limiting the depth to reduce the risk of overfitting.

4) Training and Testing ML model

On training the RF and GB ML models with 90% samples data and subsequently testing it with 10% samples of the data the accuracy that was achieved is summarized in the Table 2. As it is evident that the RF model outperformed GB model by having higher training and testing accuracy than GB model.

Table 2.: Accuracy of RF and GB ML models

Accuracy	Random Forest Model	Gradient Boosting Model
Training Accuracy	0.998	0.996
Testing Accuracy	0.989	0.982

5) Deploying the ML model

Since the accuracy of RF was high in both training and testing phases which can be seen in table 2, the RF model was chosen for deploying and using it in our platform for predicting the crop. For deploying this RF model, IBM cloud services have been used.

III. RESULT AND DISCUSSION

DigiFarm is designed to equip the farmers with digitized farming so that they can make the most out of their crops. In this section, the outcomes of the platform “DigiFarm” are discussed. With the aid of this platform, they can receive precise information about which crops would be the most suitable for their land.

Software Compatibility

The platform DigiFarm is compatible with latest versions of browsers such as Google Chrome, Microsoft Edge, Mozilla Firefox etc. The Front-end of DigiFarm is designed using HTML 5, CSS 3 and JavaScript whereas for the Back-end Django 3.2.5 has been used (i.e., a Python back-end framework).

3.2 Home Page

DigiFarm platform along with its name is shown in Fig 5. The logo displayed on the top left corner has two central elements: a hand and the water. The water is representative of rivers and oceans that forms the backbone of the irrigation system in Indian agriculture. The hand that is holding a plant represents the farmers who grow the crops. Since India is an agrarian economy, not only is the population dependent on the farmers for food, but the national economy is also dependent on the yield from the primary sector.



Fig 5: Home Page of the DigiFarm

This page connects the user to all the different pages on the platform. The Navigation bar on the homepage as shown in Fig 5 has different buttons for various purposes such as ChatBot, Prediction and News. Additionally, there are two buttons at the center of the homepage:

1. To get the detailed tutorial on how to use the DigiFarm platform and make the best use out of it for the farmers
2. To predict the most suited crop(s).

According to the authors [25] User Interface (UI) should be simple to grasp for the user to understand it. Hence, DigiFarm platform has a very simple UI because of which farmers can access and navigate through our platform to get the best out of it without facing any hurdles.

The following sections of the platform have been discussed in detail:

3. Prediction Section

The prediction section is the main part of DigiFarm. The “Prediction” section can be used to predict the most suitable crops that can be sown on the farmer’s land.

As shown in Fig 6 farmers can predict the crop by entering details such as rainfall, humidity, temperature, and pH value along with the composition of the soil content (i.e. nitrogen, phosphorus, and potassium). The ML model will predict the crop which is most suitable for the given geographical conditions.

Instructions

In order to predict the best crop, Enter the values for the following fields. You have to get Nitrogen, Potassium, Phosphorous and pH values of the soil by contacting your nearest Government Soil Testing Laboratory. In case if you are facing any difficulties please feel free to open our ChatBot by clicking the button at the top navigation bar and get your problem solved.

NOTE: Fields marked with (*) are compulsory

Nitrogen Content*

N

Location*

Enter or place name Example bangalore

Phosphorous Content*

P

Temperature in °C

Example 25

Potassium Content*

K

Humidity

Example 50

pH of the soil*

Example 7

Submit

Rainfall in mm*

Example 50

Fig 6: Crop Prediction form

In this research work, two ML algorithm have been used. They are Random Forest (RF) algorithm and Gradient

Boosting (GB) algorithm. Let us discuss in detail how these two algorithms are used in predicting the crop.

Discussion on crop prediction ML models

RF and GB algorithms have been used for predicting the crop. The dataset which was used for training these ML models is explained in Methodology Section. The confusion matrix that was generated on running the test data with RF and GB model is as shown in the Fig 7 and 8 respectively where the numberings 0-21 refers to the “crop name” as shown in the lookup Table 3.

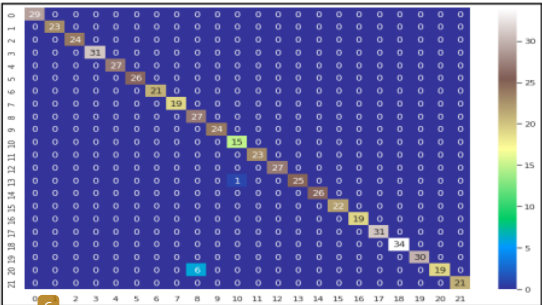


Fig 7: Confusion Matrix for RF Model

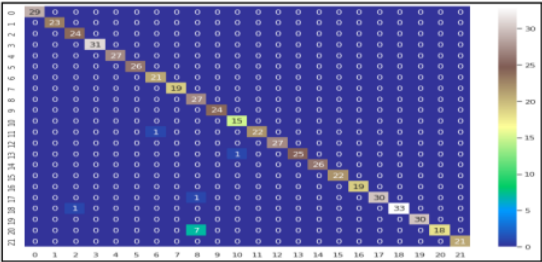


Fig 8: Confusion Matrix for GB Model

Table 3: Crop lookup table

Ind ex	Correspon ding Crop	Ind ex	Correspon ding Crop	Ind ex	Correspon ding Crop
0	Apple	8	Kidneybea ns	16	Papaya
1	Banana	9	Lentil	17	Pigeonpea
2	Blackgram	10	Maize	18	Pomegranat

					e
3	Chickpea	11	Mange	19	Watermelo n
4	Coffee	12	Mothbeans	20	Ric
5	Cotton	13	Mingbean	21	Coconut
6	Grapes	14	Muskmelon		
7	Jute	15	Orange		

Table 4 summarizes the Confusion matrix parameters (i.e., True positive rate, True negative rate, False positive rate and False negative rate) for RF model and GB model.

Table 4: Confusion matrix parameters of GB and RF model

Confusion Matrix Parameters	Random Forest Model	Gradient Boosting Model
True positive rate	0.990	0.981
True negative rate	0.990	0.999
False positive rate	0.0004	0.0008
False negative rate	0.009	0.018

The crop prediction models have been measured with respect to few performance metrics (i.e. accuracy, precision, recall and F1 score). The below are the formulae for the performance metrics.

Table 5: Performance measures (i.e. Accuracy, Recall, Precision, F1 Score) of RF and GB predictive models

Performance Measures	Random Forest Model	Gradient Boosting Model
Accuracy	0.989	0.982
Recall	0.990	0.981

Precision	0.990	0.981
F1 Score	0.990	0.981

Even though the RF model accuracy and GB model is close to one, the accuracy (testing accuracy) of RF model is higher than GB model by 0.007 as shown in Table 5. Similarly, other performance measures such as Recall, Precision and F1 Score of GB model are higher than RF model by a value 0.009.

Authors Disha Chiplonker et al., [24] have created a crop prediction model using machine learning methods such as linear regression and Random Forest regressor. But they have an accuracy of 94.63%, whereas the model used in DigiFarm can predict the crop with an accuracy of 98.9%.

For crop prediction model using RF algorithm, Training and Cross-validation curve of accuracy is as shown in Fig. 9. . As it can be seen in the Fig 9 there is a steep increase in the cross validation score till 500 training instances later on the curve tends to saturate. And the training score curve is approximately a straight line indicating that the accuracy is almost equal to one with very less losses and our model is neither a under fit nor a overfit model.



Fig 9: Training and cross-validation accuracy for RF model

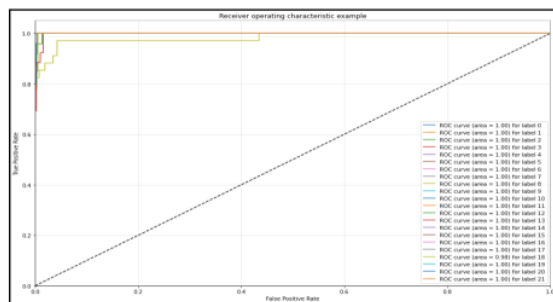


Fig 10: ROC Curve for RF model

The ROC curve for RF model is as shown in Fig 10. From Fig 10 we can see that the area of the curve is equal to one for all the classes.

For crop prediction model using GB algorithm, Training and Cross-validation curve of accuracy is as shown in Fig. 11. . As it can be seen in the Fig 11 there is a steep increase in the cross validation score till 500 training instances later on the curve tends to saturate. And the training score curve is approximately a straight line indicating that the accuracy is almost equal to one with very less losses and our model is neither a under fit nor a overfit model.

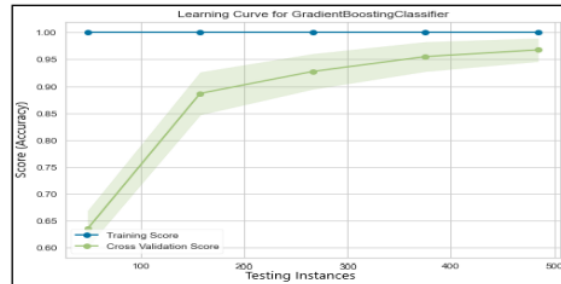


Fig 11: Training and cross-validation accuracy for GB model

The ROC curve for RF model is as shown in Fig 12.

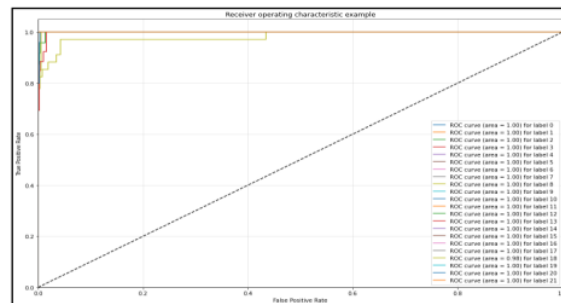


Fig 12: ROC Curve for GB model

In the fig 12, we can see that area of the curves is equal to 1 for all the classes except for the class 18 (i.e. for the crop Pomegranate) it is 0.98.

As it can be seen that the RF Model outperformed GB Model in all the aspects (i.e. Accuracy, Precision, Recall, F1 Score, ROC curve) hence RF model was chosen to deploy and use it for predicting the crop. This proposed system of crop prediction results in accuracy and efficiency which is unprecedented.

Sample output after deploying RF crop prediction model

Consider an instance, when the farmer fills the given form with nitrogen content as 20, phosphorus content as 89,

potassium content as 40, pH value as 6, rainfall as 700, location as Bengaluru - the ML model will predict the crop based on the values entered and the result is displayed as Coconut which is as shown in the Fig 13.

Similarly, for if the input values were 86 for nitrogen, 76 for phosphorous, 54 for potassium, 29°C for temperature, 80% humidity, 5.9 for ph and rainfall is 90mm then our model accurately predicted Rice as the best crop that can be sown based on the conditions mentioned (as shown in the Fig 14).

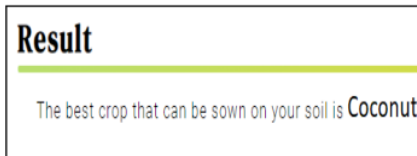


Fig 13: Sample Output 1 of the crop prediction model

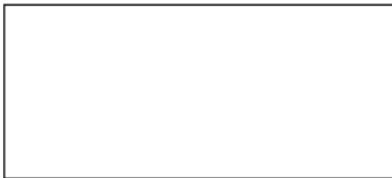


Fig 14: Sample Output 2 of the crop prediction model

3.4 AgriBot

As digitization is increasing day-by-day, chatbots made with the help of Artificial Intelligence(AI) methods play a major role by illustrating the concept of a virtual assistant that converses with the means of speech or text methods [26]. Using voice or textual queries, it provides answers, actions, and suggestions tailored to the user's needs. Artificial intelligence has allowed virtual assistants to penetrate every corner of the world [27]. Conversational bots with voice and/or chat interfaces can play a crucial role in solving the user queries by giving instant service. For this platform, the ChatBot which is created as shown in Fig 15 is an AI based bot called the "AgriBot". It is created using the IBM Watson Chatbot services (i.e. a part of IBM Cloud services). Text methods have been used while making this chatbot. With the use of textual methods the waiting time drastically reduces for the farmers to get their queries solved. The result of the AgriBot is the easy accessibility of DigiFarm platform for the farmers. The AgriBot provides three options (i.e. as shown in the Fig 15) which can be availed one at a time.

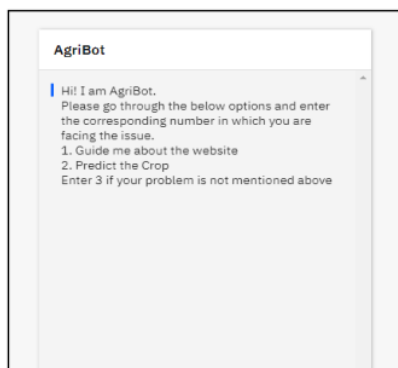


Fig 15: AgriBot

The different options available for farmers are:

- 1) To guide the farmers about the platform and how to make use of it.
- 2) To guide the farmers in predicting the crop
- 3) Directs users to a Google Form which they can fill for any further queries

For instance, when farmers open AgriBot and want to get the solution for any one of options which is mentioned above, the AgriBot will respond to their query as illustrated in the Fig 16.

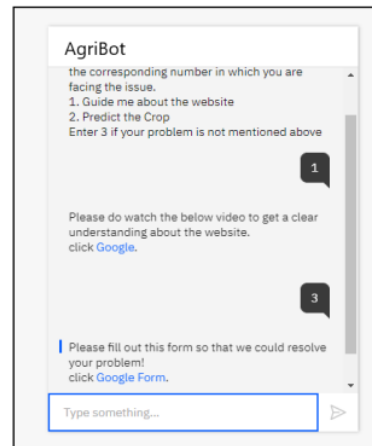


Fig 16: Sample output of AgriBot

The presence of an AgriBot on this platform simplifies the user experience which is the broader aim of the Digifarm.

3.6 News Section

The news section results in bringing together the latest information about agriculture [28] from across the globe [29]. The idea behind this is to inform the farmers about the technological developments happening in the agricultural field from different parts of the world. This enables them to learn from these techniques and apply the suitable ones on their land. The result of this would be increased productivity, developing a nature of taking risks and also equipping them with the most updated advancements which they may find suitable for their farm. In the news section of DigiFarm, a Really Simple Syndication (RSS) news feed from "The Hindu Agri-Business" section as shown in Fig 17 has been used.

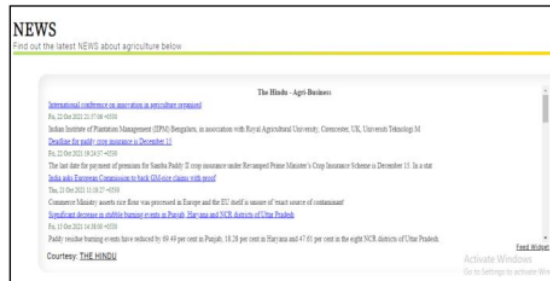


Fig 17: News section

The idea of this research work is to build a platform which solves all the queries of the farmers holistically and comprehensively. The main aim of DigiFarm is to help the farmers in increasing their production and yield per square by choosing the right crop for their field at the right time. Also, it enables them to sell their crop for maximum revenue. DigiFarm would result in digitization of agriculture on a global scale. However, it would prove extremely beneficial to farmers in India who find it difficult to access the information as their outreach is confined which results in using obsolete methods despite the advancements. DigiFarm, with the aid of technology will help them with the best possible information for their farm using a single platform.

IV. CONCLUSION

Today, farming is considered one of the most important occupations. Traditional farming is considered to be one of the best methods for farming but it has its own drawbacks like less yield of crops leading to less revenue. The traditional farming process is also quite laborious. Hence in order to avoid these drawbacks digital farming is promoted and it yields more crops thus increasing the revenue of farmers. This paper intends to introduce the new arenas of digital farming. Innovative techniques of farming are required to increase the yield of the tract of land and DigiFarm aims to aid the farmers in this endeavour. By helping the farmers through crop prediction, DigiFarm keeps up with the latest technological advancements. The platform DigiFarm which aids the farmers in making informed decisions based on their soil pattern and weather condition. DigiFarm helps the farmers in predicting

the crops which are most suited for their farm for maximum yield. The crop prediction system is designed in such a way that it is user friendly and it gives accurate results. The prediction model which is used for the platform is the result of testing the dataset with several algorithms and methodologies to determine which is best and has the highest accuracy rate. The prediction is based on the machine learning model which is trained with adequate amounts of statistical data so that the prediction is accurate and is ultimately helpful for the farmers to increase their income. DigiFarm is designed in such a manner so that farmers could access the platform from any corner of the world. The platform is designed to equip the farmers with digitized farming so that with the aid of this, they can receive precise information about which crops would be most suitable for their land. The platform answers all their queries by the chatbot present. DigiFarm is designed carefully and accurately to predict the most suitable crop that the farmer can produce in his/her land. DigiFarm also helps by providing the latest news related to agriculture in the news section. Thus DigiFarm helps in revolutionizing farming and helps farmers in their day-to-day lives.

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