International Journal of Advance Research in Science and Engineering
Volume No. 13, Issue No. 04, April 2024
www.ijarse.com
IJARSE
ISSN 2319 - 8354

A thorough analysis of deep learning-based crop yield and price prediction system

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***Abstract* —** Agricultural farming is one of the most important and essential duties that must be accomplished in order to feed the expanding population. Many agricultural nations rely primarily on food production to maintain their people and support their economies. A country's reliance on agriculture has been essential to its development and progress since a population that is well-fed and healthier has a significantly higher life expectancy and profitability than a society with weaker output and nutrition supplies. India is primarily an agrarian country, accounting for a substantial portion of its trade. The intricacy of the agricultural process makes it impossible to forecast crop yield with precision. The farmer is unable to make wise plans due to inadequate output projections, which may result in unanticipated losses. As a result, an effective plan for using deep learning techniques to anticipate agricultural output and pricing is required. This paper mainly concentrates on the studying of the all the earlier works that are engaged in the research of crop yield prediction and price prediction, So that the formers can earn more income by putting all their efforts in the field. The suggested approach employs ANN and LSTM in addition to hybrid decision making to predict agricultural productivity and pricing which can be formulated in the next edition of this article.

Keywords: *Crop Yield prediction, Crop price Prediction, Artificial Neural network, long short term memory.*

I INTRODUCTION

Precision agriculture (PA) is a well-known and refined method of farm management among modern farmers. Precision agriculture uses agricultural and information technologies to monitor crop health and productivity. PA seeks to reduce the cost of agricultural inputs without sacrificing the quality of the finished product. It has long been standard practice to apply chemical pesticides and fertilizers in large quantities, treating the entire field as one unit.

In order to do this, the UN Council has recommended expanding the world's supply of food that is of a high standard. Therefore, in order to address the issue, new strategies are required. Projecting future agricultural output and human populations is one way to address the problem.

Accurately estimating crop yields during the growing season is beneficial for both farmers and policymakers because it helps them plan import and export activities, forecast market prices, and reduce the social cost of crop losses. Smallholders and major agricultural corporations alike benefit from these forecasts since they enable them to make informed decisions regarding the financing and management of their crops. Policymakers find it challenging to effectively forecast crop production due to the intricacies of the data. Agroeconomists and agricultural experts are constantly searching for novel mathematical techniques that could improve forecast accuracy while utilizing already-existing variables. The aim of this branch of study is to show how crop yields are related to agricultural location while accounting for environmental factors like irrigation systems and soil quality. Rule-based models with parameters serve as the basis for these models. The experts involved in the initiative have a thorough awareness of the numerous connections that could be made between farming practices and environmental conditions. Attempting to construct an empirical expert system using knowledge that is not classified in this way is problematic. Crop yield predictions are made using data from remote sensing and manual surveys. Studies in mathematics based on historical data and observations from prior years might be helpful in a particular area or nation, but they cannot be used globally. New improvements in crop simulation models have addressed these issues. Crop simulation uses models of soil properties, weather patterns, and crop management techniques to mimic crop growth over the course of the growing season. For these modeling techniques to effectively estimate agricultural output across wide areas, a substantial data set is required.

Researchers frequently employ satellites, aircraft, or simply a basic camera for remote sensing. Machine learning is an interdisciplinary field that draws on a variety of disciplines, including math, information theory, statistics, artificial intelligence, and more. The creation of quick and efficient algorithms that can predict data is the main objective of machine learning research. Machine learning is a method used in data analytics to create prediction models from the gathered data. The three primary types of machine learning tasks are reinforcement, unsupervised, and supervised learning.

Through reinforcement learning, it is feasible for robots to learn behavior depending on the input they receive from interactions with the outside environment. Unsupervised machine learning has a lot to offer data sets that haven't been labeled by conventional techniques like cluster analysis. Supervised machine learning requires labeled data in order to function. There is an input value and a target output value for every batch of labeled training data. Using supervised learning, you can transfer new values into the training data using this inferred function as a foundation. While both supervised and unsupervised learning are recommended for data processing analysis, reinforcement learning is the preferred method for handling decision-making difficulties.

Information science agriculture and various machine learning techniques. The application of various cutting-edge agricultural techniques advances environmental science technologies. All around the world, the agricultural sector has to be improved. To get a high crop yield, more sophisticated techniques are employed, however they are not applied correctly. However, today's agricultural output is lower because of environmental factors (rain, temperature), which have an impact on crop productivity and cause loss. Therefore, it is essential to ascertain the crop yield prior to planting. With the help of this study, we will be able to forecast crop yields ahead of time by taking into account soil and climate conditions. Before spending money, it would be more beneficial for businesses and farmers to make wise selections. One such cutting-edge method used in agriculture to forecast crop yield is machine learning. The goal of agriculture is to improve crop quality and productivity by employing nutritious

IJARSE
ISSN 2319 - 8354

fertilizers that promote health. The natural world is an integral aspect of all living things. Thus, it is our responsibility to preserve and safeguard the natural world. Farming, or agriculture, is also a part of nature. Back then, farming was the primary industry and the majority of jobs. Every nation's economy revolves around agriculture because without it, there would be no food and no need to spend money on goods, which would result in a weaker national economy. Agriculture is a profession that is regularly practiced in India since it forecasts the highest agricultural production at the lowest possible cost. Crop productivity and economic growth can be enhanced by the early identification and treatment of issues related to agricultural yield indicators. The most creative and innovative methods are applied in agribusiness to increase company earnings. As a result of these, the organization might turn unwanted circumstances into desired ones. Large-scale meteorological phenomena can significantly affect agriculture productivity by affecting regional weather patterns. Farmers are committing suicide at an alarming rate as a result of losses and a lack of assistance. Crop yields are generally unpredictable due to the great variability of temperature and rainfall. In addition to being unpredictable, the rainfall during the crap season is unequal, falling when the crop needs it least and falling heavily when it does. Thus, we have information about the crop's growers and yield as well as weather forecasts based on local climate factors. The layout of This method can boost agricultural output yield and aid in the early identification and management of crop yield-related issues. The error rate of this technology is lower than that of other methods.

It is a useful machine learning tool for yield prediction. to produce crops with an inventive arrangement in order to achieve a high harvest. These artificial circumstances will have an impact on crop yield economics. By predicting the crop first and subsequently the meteorological element, most of these climatic situations can be avoided in agriculture. Crop predictions, particularly for rice, wheat, and corn, are crucial for both domestic and global programming. In every industry, machine learning is a cutting-edge and rapidly developing technological method that may help solve even the most challenging problems by helping decision-makers make well-informed choices.

[1] Sandeep Gupta et al. discuss how carefully choosing the correct crops and putting in place enabling infrastructure can boost agribusiness crop yields. When developing agricultural forecasts, various elements such as weather, crop prices, water quality, availability, and soil fertility are taken into account. Because machine learning can estimate crop output based on variables like location, weather, and season, it is essential for predicting crop yield. By using this tool, farmers may make more educated choices about what crops to plant on their property. This paper states that one possible approach to agricultural yield prediction is to employ a machine learning framework. * The crop is included in the data set for an experiment. Subsequently, the features to be used are selected using the Relief algorithm. The characteristics are extracted using the PCA approach. Examples of machine learning predictors used for classification are random forest, KNN, and PSO-SVM. It is evident that machine learning algorithms now perform better thanks to feature extraction and selection. The most accurate classifier is PSO-SVM when compared to other ones. The K-nearest neighbor approach outperforms the other classifiers in terms of sensitivity and specificity.

[2] Martin Kuradusenge et al. investigated how climate change would affect the output of rainfed agriculture. The study promotes early information sharing, particularly regarding predicted yield, to enable appropriate

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ISSN 2319 - 8354

planning and potentially lessen food insecurity. Using data from Musanze, an active agricultural district in Rwanda, three MLMs—RF, SVR, and PR—were tested to see how well they could predict the yields of Irish potatoes and maize. The R2, MAE, and RMSE values for both crops demonstrate the RF model's better performance on the data. The data consisted of historical agricultural yields and meteorological conditions, with temperature and rainfall serving as predictors for the weather. Furthermore, an examination of the relationship between meteorological factors and crop yield has been done. As discussed in the discussion section, the ideal rainfall and temperature levels for each stage of crop development have been determined.

In section II of this literature survey study, prior research on the structure of literature surveys is evaluated, and in section III, conclusions are drawn and future research goals are outlined.

II RELATED WORKS

In [3], the supervised machine learning models (XgBoost, SVM, ANN, Light MLP, KNN, and RF) developed by Hazra, Simanta, et al. are compared to predict crop yield for various parameters such as pesticide use, crop type, and soil type. With the use of these forecasts, farmers will be better able to make decisions about the use of pesticides, crop kinds, soil types, and other elements that will contribute to more productive crop growth. Ultimately, the system concludes that, when used with the crop dataset, the XGBoost Classifier shows the best accuracy. However, in terms of accuracy, MLP and LightGBM rank second, while RF and KNN provide subpar prediction ability. Additionally, the system has used five CNN models (VGG-19, VGG-16, Inception v3, ResNet-50, and EfficientNet-B0) to handle the problem of crop picture recognition. Five crop images were studied, and the results show that VGG19 performs the best. To help farmers, it is necessary to look into crop disease prediction utilizing some cutting-edge approaches as a potential area for future research.

[4] M. A. Manivasagam et al. forecast crop and yield by analyzing crop details, or agricultural data collected. This study can conclude that, in order to obtain more accurate findings and help farmers in particular make decisions, systems based on machine learning approaches should be used and implemented. Making consistent decisions is particularly significant in agriculture because it is crucial to determining profits and losses. Crop predictions made with a random forest algorithm are reliable, effective, and free of errors. Climate-related characteristics, such as average temperature, average humidity, average rainfall, and route map for a certain crop with date specificity, are analysed to determine how they impact crop output. Using several machine learning approaches, such as K-Near Neighbour, Decision Tree, and Random Forest Classifier, this methodology for designing and developing crop prediction and crop yield prediction helps to boost yield and subsequently profit of agricultural production. Certain characteristics include crop analysis, yield guidance, crop forecast utilizing certain criteria, and algorithm verification and check. The project's goal is to make it simple to forecast yield utilizing a variety of environment parameters in an accurate and effective manner.

In light of the meteorological input factors described by Kalaiarasi Sonai Muthu Anbananthen et al. [5], the current experiment demonstrated how four regression-based algorithms may be used to estimate crop production. The algorithms include the layered generalization ensemble approach, LASSO regression, gradient boosted tree regression, and random forest regression. After comparing these methods, it can be concluded that, for the provided dataset, the stacked ensemble model performed the best. The other algorithms followed suit. The web-based nature of the suggested system makes it easy to modify modules and input variables when new features are added in response to changing requirements. The farmers receive prompt and precise feedback from the system as well.

[6] P. When layered regression was used by S. Nishant et al., the outcome was more improvised than when those models were used separately. The output depicted in the image is presently a web application; however, the author plans to develop an application that farmers may use and translate the entire system into their native tongue in the future.

[7] D. Elavarasan and associates. DRL encourages the proposal of a unique crop yield forecast system by enhancing the autonomy and intelligence of artificial intelligence systems. The outcomes of the efficiency and precision tests demonstrate the adaptability and efficacy of the suggested Deep Recurrent Q-Network for yield prediction. The suggested approach makes it possible for the agent to recognize and learn the crop yield prediction through experience replay and self-exploration by creating a yield prediction environment. It is clear from the dataset prediction results that the yield prediction agent is in charge of the process, indicating that the suggested approach may accurately specify the parameters for crop yield. The key to achieving favourable outcomes is the combination of DQN based self-experimental analysis and RNN based feature processing. The DRQN-based approach offers a comprehensive solution that independently mines the non-linear mapping between the crop yield and the climatic, soil, and groundwater factors, in contrast to the supervised learning-based crop yield prediction procedure. This benefit can reduce the reliance on experts and past knowledge when creating models to estimate crop productivity. As a result, the suggested method gives the impression of applying a more comprehensive model for yield prediction. However, if the time series is really long, the RNN based DRL may cause the gradients to expand or vanish. It is possible to use data prediction experiments using a variety of machine learning predictive algorithms as a foundation for decision-making, but it is crucial to understand the statistical uncertainty associated with these predictions. Therefore, it is necessary to create a framework that forecasts the uncertainty of the aim as well as the prediction itself. To address the uncertainty in statistical predictions that may be observed as a future extension of the current model, probabilistic predictive modeling strategies such as information theory, probabilistic bias-variance decomposition, composite prediction strategies, probabilistic boosting and bagging approaches, etc., can be taken into consideration. An LSTM based DRL is another other strategy that should be taken into account. In order to build a more reliable working model in the future, it may be possible to incorporate additional crop yield prediction parameters into the current framework in relation to insect and infestation problems as well as crop damage. It would be interesting to focus on increasing the training process's computational efficiency.

[8] G. Sentinel-2, Landsat, and MODIS time series are described by Ghazaryan et al. as offering potential applications in crop prediction and yield monitoring at the regional and field levels. Several months prior to harvest, it was possible to estimate yield with respectable accuracy (R 2>0.8) using the suggested models. It is possible to evaluate the models' performance using other crops, like barley or wheat.

[9] F. A stronger suggestion for utilizing artificial neural networks as the foundational technique for continuous multiple regression model prediction comes from F. Haque et al. The present observation leads to the

conclusion that unsupervised learning algorithms yield continuous prediction outcomes more favourably than supervised learning algorithms. The results obtained can also be applied to hardware implementation, as explained above, in which every sensor serves as a data point. Cloud implementation will improve the utilization of modular applications. Coordinated nodes can aid in attaining higher points by obtaining useful data from each node acting as a relay node. In order to help farmers and laborers overcome the drought scenario, additional research will involve using the same model with enhanced picture recognition to help with some proofing of the object state and also incorporating more diverse affecting parameters. Nowadays, most machine learning work focuses on feature analysis when an image is supplied for a machine vision system. Research on data mining in agriculture is ongoing and has the potential to solve intricate technical issues in the field.

[10] P. Malik et al. investigate agricultural yield prediction using a dataset they self-obtained. The suggested work demonstrates how relationships between crops and different physical elements can be established using KNN, Naive Bayes, and Decision Tree models. Each model's accuracy is extracted following the dataset's validation. Greater accuracy is a sign that the model performed better on the gathered dataset. When compared to Naïve Bayes, KNN and Decision Trees have superior accuracy rates of 14.453% and 18.935%, respectively. Unlike earlier research in this field, the Naïve Bayes algorithm produced predictions with the lowest accuracy. It is also possible to determine which crop, in what soil, and under what circumstances is best. For varying crops and seasons, the dataset can be expanded to increase the models' accuracy. It can also be utilized in apps and webpages to educate individuals across the nation. Farmers may find it easier to determine crop yields under various soil and atmospheric conditions with the aid of the suggested work. Additionally, it can offer guidance to those attempting to establish a kitchen garden at home.

[11] N. Data mining approaches were demonstrated to be useful in predicting agricultural output based on climate input parameters by Suresh et al. The website has been designed with ease of use in mind, and it is expected that the reliability of prediction for every other grain and region selected for analysis would be more than 75%, signifying improved predictive performance. The website is designed to forecast crop yield by supplying information from that region. Anyone can utilize their crop feature.

[12] J. According to Patel et al., agricultural studies can assist rural organizations in assisting ranchers in making critical and profitable decisions. In order to guarantee appropriate connections, models were kept and finished in Python from the best point of view and under close programming and gear situations in this examination. The degree of introduction during a model's execution is described by the misstep metric. The screw up measure is evaluated using the residuals, or the discrepancy between the authentic and predicted features, that were collected during the assessments. By the conclusion of the day, the precision and model viability are determined by looking at the size of the waiting spread. In terms of practicality, the suggested substantial assistance model appears to outperform the LSTM-RNN with q-learning significant learning models, exhibiting enhanced bungle measures and an exactness of 99.59% for datasets from Gujarat. The methodology can be used to different state datasets in the future.

[13] M. According to Rashid et al., in order to feed the growing global population, new technology in the agriculture sector must be adopted. Aside from this, farmers require appropriate guidelines ahead of time in order to predict crop yields and develop efficient plans to optimize crop yields. By evaluating the enormous amounts of data and deciphering the information gleaned, machine learning frameworks provide a clear understanding of the procedure. These technologies are used to build the models that describe the relationships between constituents and actions. Additionally, the ML models can also be used to anticipate future reactions in a given situation. The current evaluation highlights how the chosen articles use a variety of criteria, with a particular emphasis on the research scope and data accessibility. The majority of the linked publications investigate yield forecasting using machine learning techniques. But the main distinction is the incorporation of a large number of features. Furthermore, the research have also noted variations in crop, location, and intensity. The accessibility of the dataset and the goal of the study will determine which features are chosen. The types of literature that currently exist also demonstrate that a model's use of extensive features may not always provide the best result for the yield estimate. While it is challenging to identify the best approach given the current research, it is crucial to understand the broad use of certain machine learning algorithms and their promising results in order to gain a general understanding. LR, RF, and NN are the most promising traditional machine learning architectures. In addition to these techniques, DL models such as CNN, LSTM, and DNN are also used in agricultural yield estimation. Some feature selection algorithms and currently available outperforming models should be examined in order to draw a precise judgment on the best performing model. The current evaluation also demonstrates how little research has been done to anticipate the production of palm oil. Furthermore, only a small number of feature sets have been included in the current palm oil yield prediction research, which has resulted in a significant discrepancy between the anticipated and real palm oil yield. Speculating on the optimal feature set and prediction model to forecast the production of palm oil is premature. Therefore, it would be beneficial to look into more research that use a big number of features and a variety of prediction methods. This work will likely lay the foundation for a thorough investigation into the relationship between agricultural yield prediction and palm oil yield prediction.

[14] N. According to Soodtoetong et al., the development of artificial intelligence technology leads to a lot of new inventions. There is no denying that people are more aware of and dependent on artificial intelligence technologies. Artificial intelligence is developing to the point where it can process patterns more complicated than humans can. This research compares agricultural production forecasting models using artificial intelligence approaches in order to determine which model performs best. The results of the experiment showed that the Support Vector Regression model had the highest accuracy, with R2 = -0.032 and RMSE = 178.522. Despite this, the statistic is still inappropriate for using the Support Vector Regression model to anticipate the highest fruit production. As a result, future improvements to this model's efficiency are necessary. It can include additional independent variables that affect fruit tree growth or employ GA in conjunction with forecasting models to obtain the best forecasting model.

[15] F. A satellite imagery-based smart agriculture management system that makes farming profitable and manageable is described by Shahrin et al. Additionally, a method for analyzing, tracking, and predicting crop

IJARSE
ISSN 2319 - 8354

production is suggested in this research so that farmers and agronomists may make the appropriate decisions. Additionally, datasets are forecasted in order to provide predictions that are more accurate, and a comparison between different models is employed to choose the best model. In the future, researchers will have the chance to use a variety of enhanced algorithms, models, and datasets to further enhance the accuracy and functionality of smart agriculture systems.

[16] Yo. J. N. Kumar together with others. developed a technique to forecast agricultural yield using historical data collection. Crop yield is forecasted by the use of data mining tools. Here, the optimal crop yield is predicted as an output utilizing the Random Forest technique. Crop production predictions in the realm of agriculture are generally accurate. The agricultural yield yields greater profit the more accuracy increases. The suggested method aids in farmers' understanding of the needs and costs associated with various crops. It supports farmers in choosing which crops to plant in the field. The agricultural yield yields greater profit the more accuracy increases. The purpose of this activity is to find out more about the crop so that an effective and practical harvesting can be made. The greatest number of crop varieties will be covered by this approach. Indian farmers will benefit from the precise forecasting of several designated crops in various districts.

[17] J. In the Canadian Prairies, Liu et al. report calculating grain yields of barley, canola, and spring wheat using MODIS data, which was assessed at two geographic resolutions. There are distinct seasonal trends in the relationships between crop yields and MODIS vegetation indices, with the largest correlations occurring during the peak growth period in late July and early August. For estimating crop yield, EVI2 was found to be more accurate than NDVI, and model performance is enhanced by a running average using three 8-day composites. Crop yields and MODIS GPP or NPP have a less association than when peak growing stage, which is determined by vegetation indices, is used. For the purpose of estimating crop output, a multiple linear regression model can be built using MODIS data to show the spatiotemporal variability of crop productivity on an annual basis and to pinpoint long-term yield trends. For each of the three crops in each of the three agroclimate zones, the relative root mean square error of estimation using seasonal maximum EVI2 as a predictor ranges from 14% to 20%, with corresponding coefficients of determination between 0.53 and 0.70. Leave-one-out cross validation proved the model's stability and resilience across several years, despite inter-annual volatility. The model's usefulness to disaggregating crop yields from a coarser resolution to finer spatial resolutions was demonstrated by its evaluation utilizing crop yield data at a finer spatial resolution. This study offers a possible method for creating a database of historical agricultural yield data over a lengthy period of time in the Canadian prairies.

III CONCLUSION AND FUTURE SCOPE

Agriculture is arguably one of the most common professions in the country. The government reaps significant financial benefits from a variety of agricultural ventures. It is therefore thought to be among the most flexible investment strategies. India is mostly an agricultural nation. Agrarian nations derive much of their income from farming and other agricultural products. It takes a tremendous effort to try to maintain a community, and the only way to do it is through productive farming. India possesses the largest amount of arable land. The vast majority of people in the country depend on agriculture as their primary source of income because it is predominantly an agrarian nation. Therefore, a more potent method utilizing machine learning techniques to forecast agricultural production is required. The effective set of studies that led to our strategy which will be covered in depth in the upcoming research article on this topic was compiled and assessed in this literature survey investigation.

This research work can be enhanced to work as a real-time mobile application that is integrated into the cloud for performing deep learning prediction models to provide the service to the formers of different states of India in the regional language for crop yield and price prediction.

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