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AI Enabled Water Well Predictor

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Abstract: Groundwater models in India are vital for managing water resources, understanding water flow, and assessing environmental impacts. These models address tasks such as managing water balance, simulating water flow, and establishing protection zones. However, current models rely on outdated lumped approaches that treat groundwater as a single entity, neglecting its complex interactions with streams and aquifers. This limitation affects their accuracy in predicting water availability and safe withdrawals. Our proposed system improves on these models by incorporating advanced techniques like Random Forest and Deep Convolutional Neural Networks (DCNN). With proposed algorithms implemented clustering algorithm to group similar points for aqua dataset and K-means clustering will group all states with less water in one cluster and states with high water in other cluster. These methods better capture groundwater system complexities, including recharge rates, interactions with streams, and sea-water intrusion. While traditional models may offer limited accuracy, our approach provides significantly improved predictions. This results in more reliable data for groundwater management. In practice, our system enhances decision-making for sustainable water use, effectively addressing current groundwater management challenges. Web application using Django framework is implemented to get easy interface to the user.
Keywords: Next-Gen Groundwater, RF, DCNN, Data Visualization, Django Web Framework.

1. INTRODUCTION

Groundwater resources in India play a critical role in meeting the country's agricultural, industrial, and domestic water demands. However, managing these resources effectively requires accurate predictions of water availability, recharge rates, and interactions with other water bodies like streams and aquifers. Traditional groundwater models in India often rely on outdated lumped parameter approaches, which oversimplify the dynamics of groundwater systems. These models treat the entire groundwater body as a single, homogeneous entity, neglecting the complex spatial variations and interactions with surface water. As a result, they are less effective in providing accurate predictions for water availability and safe extraction levels.

To overcome these limitations, our proposed system incorporates advanced machine learning techniques, including Random Forest (RF) and Deep Convolutional Neural Networks (DCNN). By using RF and DCNN, the system can capture non-linear relationships and provide more accurate predictions for groundwater levels and flow patterns. This is especially critical in a country like India, where over-extraction of groundwater is a pressing concern and contributes to issues such as declining water tables and increased vulnerability to droughts.

Fig. Next Generation Groundwater Water using machine learning

In addition to improving prediction accuracy, our system leverages clustering algorithms like K-means to group regions based on their groundwater characteristics. This approach enables the identification of states or regions that are more vulnerable to water scarcity, as well as areas with abundant water resources. The clustering analysis helps decision-makers prioritize water conservation efforts and allocate resources more effectively. For instance, regions with lower water levels can be grouped into one cluster, allowing for targeted interventions such as regulated water extraction or improved recharge efforts, while regions with higher water levels can be managed differently.

Furthermore, the proposed system includes a user-friendly web application developed using the Django framework. This web interface allows users to easily access groundwater data and prediction results, facilitating better decision-making for policymakers, water management authorities, and local communities. By providing real-time data and insights, the system empowers stakeholders to make informed decisions that promote sustainable water use, ensuring the long-term availability of groundwater resources. In essence, this next-generation groundwater modeling system not only addresses the limitations of traditional approaches but also provides a comprehensive and practical solution for groundwater management in India.

2. Objective

To develop an advanced groundwater modeling system that integrates Random Forest (RF) and Deep Convolutional Neural Networks (DCNN) to enhance the accuracy of groundwater predictions in India. This system will address the limitations of traditional lumped approaches by effectively capturing the complex interactions within groundwater systems, including recharge rates, stream interactions, and seawater intrusion. By implementing K-means clustering to categorize states based on water availability, the model aims to facilitate targeted interventions and sustainable water management practices. Additionally, a user-friendly web application developed using the Django framework will be provided to empower stakeholders with real-time data and insights, ultimately supporting informed decision-making for the sustainable management of groundwater resources.

3. Scope:

This project focuses on developing a groundwater modeling system that utilizes Random Forest and Deep Convolutional Neural Networks to improve predictions of groundwater levels and flow patterns in India. It encompasses the analysis of complex groundwater interactions, the application of K-means clustering for regional categorization based on water availability, and the creation of a web application for user access to real-time data. The scope aims to enhance decision-making processes for sustainable water management and address current challenges in groundwater resource management.

4. Methodology

As a result, for the Next-Gen Groundwater Models project involves the utilization of two datasets to predict groundwater details. Initially, K-means clustering is applied to the aqua dataset to categorize regions into clusters based on water availability, identifying areas with low and high groundwater levels. Subsequently, two classification models are employed: Random Forest, which leverages an ensemble approach to predict water-bearing zones, and Deep Convolutional Neural Networks (DCNN), which capture complex data patterns for enhanced prediction accuracy. To support decision-making, various visualizations, including graphs and charts, are generated to illustrate groundwater usage for domestic and industrial purposes. The model's predictions are then evaluated against actual groundwater data to assess their accuracy and effectiveness.

The proposed method for Next-Gen Groundwater Models involves uploading and preprocessing the dataset, followed by data visualization, training using Random Forest and DCNN, testing the models, performing performance analysis with MAE and RMSE, and finally testing on new data.

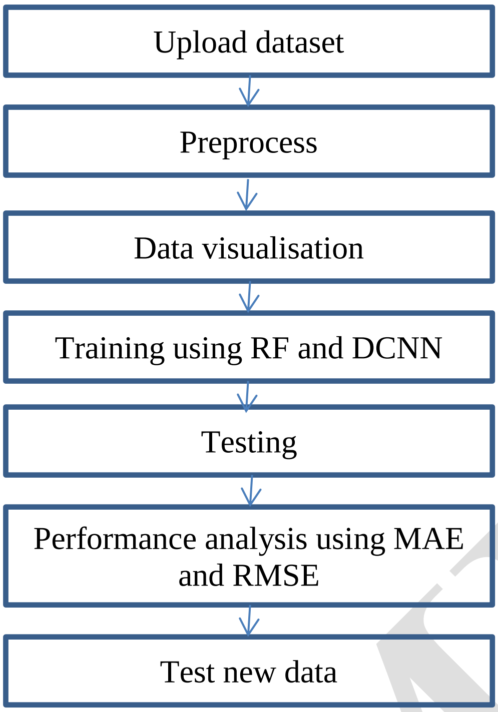

Fig. Block Daigram Of Proposed Method

Proposed method has following steps as ,

1. **Upload Dataset**: Collect and upload the relevant groundwater dataset for analysis.
2. **Preprocess**: Clean and preprocess the data to ensure quality and consistency for modeling.
3. **Data Visualization**: Create visual representations of the data to identify trends and patterns in groundwater usage.
4. **Training using RF and DCNN**: Train the Random Forest and Deep Convolutional Neural Network models on the prepared dataset to predict groundwater levels.
5. **Testing**: Evaluate the trained models on a separate test dataset to assess their predictive accuracy.
6. **Performance Analysis using MAE and RMSE**: Analyze model performance using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) metrics.
7. **Test New Data**: Apply the trained models to new groundwater data to generate predictions and insights.

5. System Architecture

The system architecture for the Next-Gen Groundwater Models involves uploading a groundwater dataset, which is split into training data (70%) and testing data (30%). The training data is further divided into a training set (70% of the training data) and a validation set (30% of the training data) for model training and evaluation. This structured approach ensures accurate predictions using Random Forest and Deep Convolutional Neural Networks (DCNN).

5.1 Algorithms used in the Application

In proposed method we used two datasets for predicting groundwater details,

1) **K-means clustering Algorithm:**

   In our project aqua dataset is used from that dataset clusters are formed with less water and more water.

2) **Classification models:** In this module predicted water bearing level zone using one machine learning classifier Random Forest and one deep learning classifier DCNN (Deep CNN)
3) **Visualization:** Different graphs are plotted to understand the water uses for domestic purpose and industry purpose

5.2 Dataset

5.3 Data pre processing

In the data preprocessing stage for the Next-Gen Groundwater Models, the raw groundwater dataset is first imported using the read_csv() function to read CSV files. The iloc[] method from the pandas package is then utilized to extract independent variables (features) and dependent variables (targets) from the dataset. This step transforms unprocessed data into a structured format suitable for machine learning models, ensuring that the data is clean and consistent. Key tasks include handling missing values, normalizing or scaling numerical features, and encoding categorical variables. After preprocessing, the dataset is split into training (70%) and testing (30%) sets, with the training data further divided into training (70%) and validation (30%) sets, preparing the data for effective model training and evaluation using Random Forest and DCNN.

5.4 Results

Proposed model is designed for easy access of user to check groundwater details.Below is the webpage for proposed model

Fig. webpage for proposed model

Fig. User Signup

Fig. User Login

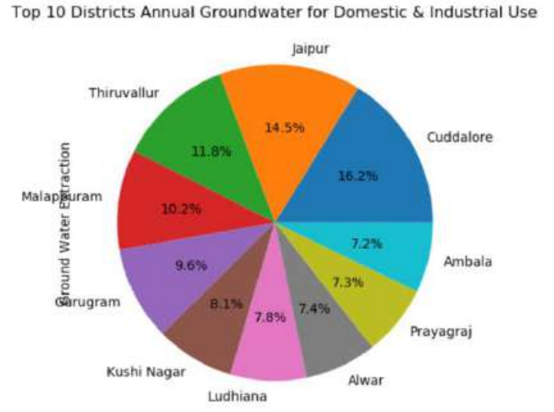

Fig. Top 10 Districts Annual Groundwater for Domestic and Industrial Use

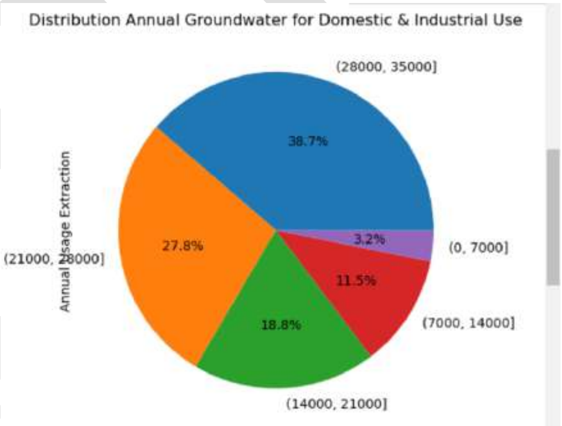

Fig. Distribution Annual Groundwater for Domestic and Industrial Use

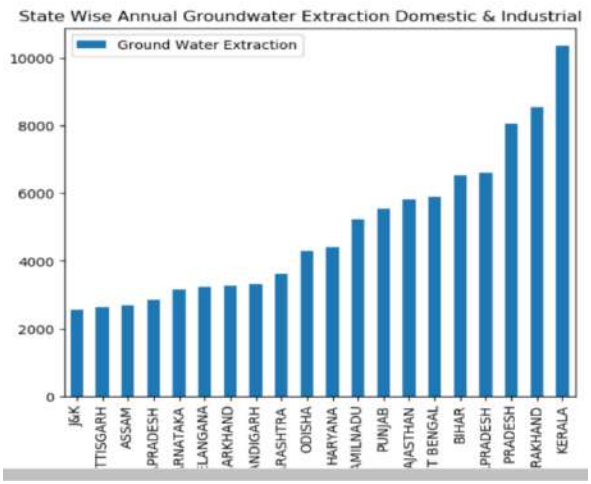

Fig. State wise Annual Groundwater Extraction Domestic and Industrial

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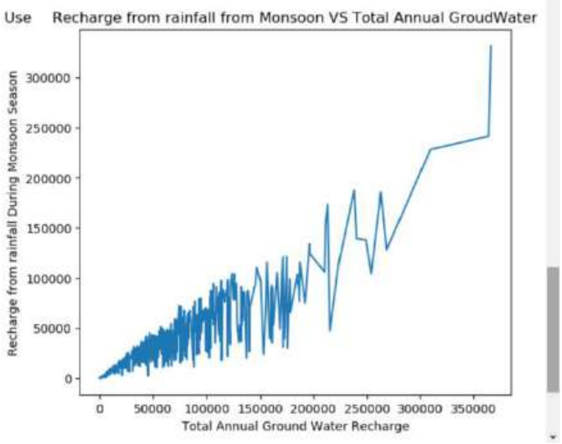

Fig. Total Annual Groundwater Recharge Vs. Recharge from rainfall

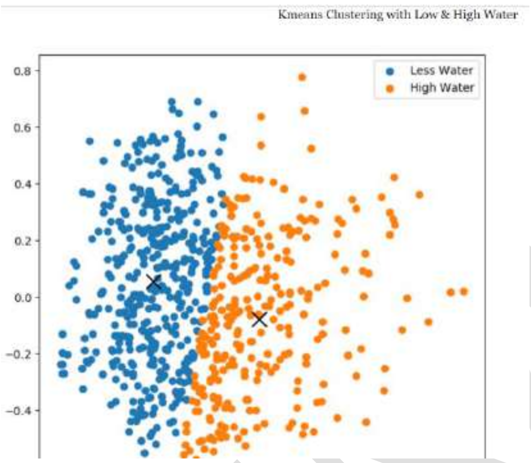

Fig. K-means clustering for Less and High water clustering

Algorithm Name	RMSE	MAE
Random Forest	0.07735203193430742	45.84210671833187
Deep CNN	0.06930024335280552	14.43254043032747б

Fig. RMSE and MAE performance comparison table for both existing (RF model) and Proposed (Deep CNN) model

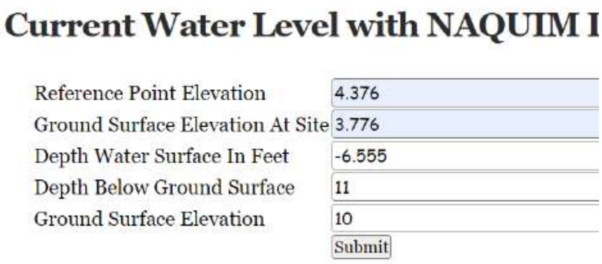

Fig. Input to the proposed model from user for water level prediction

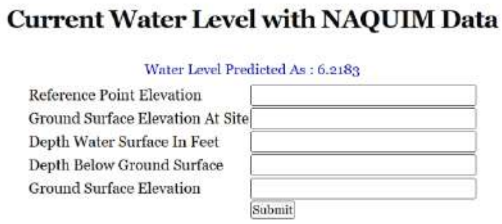

Fig. Current water level is predicted as 6.2183

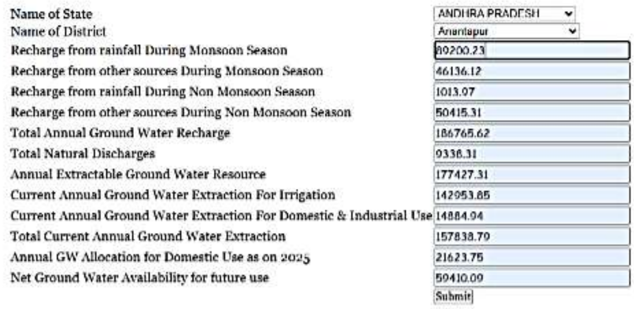

Fig. Input predicted by proposed method

Fig. water level predicted by proposed method

6. CONCLUSION

In conclusion, our proposed Next-Gen Groundwater Modeling system represents a significant advancement in groundwater management in India. By utilizing Random Forest and Deep Convolutional Neural Networks, the model effectively overcomes the limitations of traditional lumped approaches, offering more accurate predictions of water availability and safe withdrawals. The integration of K-means clustering facilitates a nuanced understanding of regional water resources, allowing for targeted interventions in areas facing scarcity. Furthermore, the web application developed using the Django framework ensures that stakeholders can easily access real-time data and insights. This comprehensive approach not only improves decision-making for sustainable water use but also addresses the pressing challenges of groundwater management,

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promoting long-term conservation and resource efficiency. The performance evaluation shows that the Deep CNN significantly outperforms the Random Forest model in terms of both RMSE and MAE. The lower error rates in the Deep CNN model suggest higher accuracy and more reliable predictions, making it the better choice for this task. This indicates that deep learning models like CNNs can capture complex patterns more effectively than traditional machine learning methods such as Random Forest.

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