Early Warning System for Landslide Prediction and Mitigation

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***Abstract*—Every year, India experiences countless landslides with devastating consequences for the affected areas. Over 12% of the Indian landmass is prone to landslides. In India, the number of large-scale landslides and their damage seems to be increasing in recent years. Due to the lack of inaccurate prediction methods and effective early warning systems, the destruction caused by landslides is magnified. The existing system uses a lower number of factors and does not provide a method for ensuring the safety of the user. As a result, it is not effective in predicting and mitigating landslides. The proposed system allows for the mitigation of destruction to life caused by landslides, by providing them with routes to safe regions. The system receives the user's location and uses GPS to find the route to the safe zone. The model incorporates more landslide factors to ensure more accuracy in the prediction of landslides. As a result, the proposed model is more effective in the prediction and mitigation of landslides and the destruction it causes to human life.**

Keywords—Landslides,Logistic regression, Landslide prediction.

I. INTRODUCTION

Every year, landslides wreak havoc on various regions of India. In India, the number and damage of large-scale landslides seems to have increased in recent years. Landslides are a serious geological danger common to almost all states in India. Landslides occur around the world, causing billions in economic losses and thousands of casualties each year in all climates and terrains. Landslides occur when a slope undergoes several processes that change from stable to unstable. Changes in slope stability can be caused by several factors that work together or alone. They often cause long-term economicturmoiland adverse effects on the naturalenvironment.

According to a survey by the Geological Society of India, 43% of the total area of Kerala is in landslide-prone or landslide-prone areas. The survey describes that 74% of 51% of Wayanad are on the hillside where landslides are likely to occur. The effects of landslides can be widespread, including loss of life, destruction of infrastructure, damage to land, and loss of natural resources. Landslides can also block rivers and increase the risk of flooding.Landslides have a devastating impact on farmers' livelihoods, impeding access to land for years, disrupting seed and food supplies, and often resulting in livestock and crop losses. Factors such as precipitation can have a significant impact on the likelihood of a landslide. Therefore, it is essential to consider this factor when predicting landslides. There is no effective landslide prediction system. Moreover, mitigating landslide destruction is rarely discussed. Due to this, India experiences great devastation to its people and the economy. Therefore, landslide prediction and mitigation systems are essential in the current situation of the world.

Here we take into account various factors that cause landslides. Precipitation is one of the biggest causes of landslides. Taking this factor into account is essential for making accurate predictions. In addition to rainfall, we consider various other landslide factors such as slope, distance to a water source, etc. This data for a particular region is taken from the user and used to predict the occurrence of landslides. The system then sends the predicted outcome to users in the specified area. The system then uses the user's location and GPS to find the closest safe zone. This allows the user to safely reach the specified safe location. Thus, the proposed system allows for the proper prediction and mitigation of destruction caused by landslides.

II. RELATED WORK

With the improvement of prediction and detection technology, there are many ways to efficiently predict and reduce the damage caused by landslides.[1] This paper isbased on geographic data framework (GIS) technology, combined with the verifiable avalanche hazard data, we utilized back-propagation (BP) neural network, decision tree, irregular timberland, back vector machine (SVM) to ponder the avalanche defenselessness of Bazhou district. Using the Tropical Precipitation Measuring Mission (TRMM) precipitation item information, we set up a rainfall intensity-duration edge demonstrate and get parameters to predict the rainfall-induced avalanche time. At long last, we establish a probabilistic quantitative demonstrate for the disasters caused by topographical catastrophes in Bazhou district, conducting meteorological early caution.

Here, the system [2] looked at the specific strategies of a solid ReLWaM. It is critical to identify and give a specific warning level (WL). It can be summarized in five simple stages. Step 1: Observational rainfall thresholds are defined and approved. Step 2: determining rainfall thresholds for the implementation of expanding WLs within the ReLWaM. step 3: starting with precipitation estimates, cumulated precipitation across various time intervals is calculated. step 4: issue the fitting WL after comparing precipitation edges to pre-identified WLs. step 5: Execution evaluation of the warning model section in order to extend the show's unshakable quality through a regular overhaul of the WLs is required.

[3] This model manages the complex preparation of distinguishing and optimizing hydro-meteorological thresholds and propose a precise strategy that still permits the client a few adaptabilities to constrain the craved time-scale and extent of fizzled to untrue cautions. limits are optimized dispassionately with recipient working characteristics (ROC), distinctive threshold variables and aptitude measurements utilized for optimization can impact the utility of said limit for an avalanche alarm framework,depending on end-user targets, prerequisites and information accessibility.

This paper [4] involves the usage of meteorological information to forecast geohazards is that the basic limit of precipitation for triggering a geohazard is determined, and then the plausibility of a calamity event is computed based on the quantifiable inspection of precipitation data. The association between geohazard processes and past precipitation designs obtained from recorded factual data is used to develop a meteorological forecasting model. This uses two lists: potential precipitation and rainfall on that particular day. The viable precipitation sum reflects prior precipitation properties.

[5] The paper's main purpose is to map landslide risks and analyze risk in Ratnapura district in order to determine the true scale, timing, and severity of landslide processes. This knowledge will help government officials, consulting engineering firms, and the general public avoid landslide hazards and limit damages.Hybrid machine learning approaches could be used to build prediction models using existing data. An ensemble technique based on Support Vector Machine (SVM) and a Naive Bayes model were combined and deployed for the final prediction. This study has a strong ability to predict landslides based on causative elements such slope, land use, elevation, geology, soil materials, and triggering factors; rainfall was retrieved and fed into machine learning algorithms. This research presents a revolutionary architectural design.

[6] Using multiple hardware devices, this paper proposed a modern technique to detect and predict landslides. The sensor nodes used here are among the most modern on the market, with exceptional sensitivity and a large coverage area. It also enables accurate real-time processing and transmission of crucial data with high resolution. The sensor module detects natural catastrophe ground vibrations and delivers data to the monitoring station via the RFID module. Moisture, weight, and tilt meter sensors are also used to disguise a variety of geo-technical sensors with advantageous qualities. This is critical because it ensures that the system responds appropriately to changing geotechnical conditions.

III. METHODOLOGY

A. *Proposed System*

The proposed system is used to predict the occurrence of a landslide. The early warning system then sends a warning message to users in the corresponding region.Then the system uses the current location of the user to create a route to a safe zone. The safe zones are regions that are at very low risk of landslides.Thus, the user is given the opportunity to ensure his or her safety.

B. *System Design*

The user can send data to the administrator through an application. The administrator uses this data in the trained model to produce an output prediction. According to the prediction, the admin sends a safe route to the application. Admin receives the GPS location of the user and uses it to create a safe route.This allows the user to reach the safe zone. Figure 1 shows the components of the system.

The components of the proposed system are as follows:

1. User Application
2. Administrator
3. Database

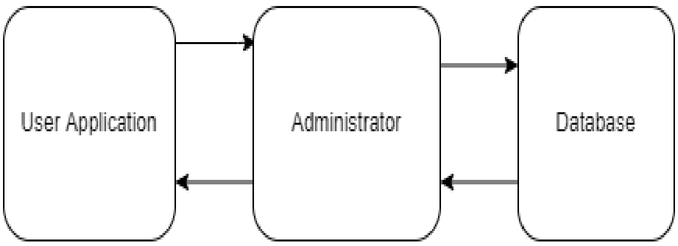

Fig.1.System Components

1. *User Application*

The application is used by the user to send the features [7] that are involved in the prediction of landslides. The live location of the user is obtained by the GPS. The application then sends this data to the administrator. The administrator sends the map that contains the route to the safe zone[8] to the application.

2.*Administration*

The data from the user application is received by the administrator. The administrator sends a warning message along with a safe route to the user.The administrator keeps a record of the safe zones near the user's region.

3.Database
All the predicted values are stored in a database. It holds all the data regarding the user.

C. System Architecture

1. Training and classification
The collection of datasets is essential in the process of training the model. The features used in the training of the model are rainfall[9], altitude [10], distance to river, slope etc.The algorithm used here is logistic regression [10].

2.Receiving data from user
The user sends the required data for the region through the app to the admin. The features that are sent by the user are used in the prediction of landslides.

3. Prediction and finding the nearest safe zone
The feature received from the user is used by the trained model and an output is produced. This output prediction is stored in a database.If the prediction for the landslide is true, then the users nearest safe region is found.

4.Finding the route to the nearest safe zone
A safe route to the safe zone is calculated by the system using the user's current location. The current location is retrieved using GPS.The safe route is then sent to the user's application.

D. Working

The user's data is received by theadministrator. This involves the current location and the features involved in the prediction model. This data is sent to the admin from the user application. Rainfall, altitude, latitude, longitude, distance to river, soil type [11], slope [12], humidity, and landslide type are the most important factors in landslide occurrence and are used in the model's training. The algorithm used in the model is logistic regression. Then the trained model is used by the administrator to produce a prediction [13]. The output is delivered to the user. The administrator then receives the current location of the user. The current location of the user is obtained by GPS [14] and the data is then sent by the application to the administrator. The system then generates a safe path based on the current location and the nearby safe zones. The database stores the safe zones. The safe route is then sent to the user application. the user application displays the route map to the user, thus allowing the user to reach safety.Figure 2 shows the overall functioning of the proposed system.

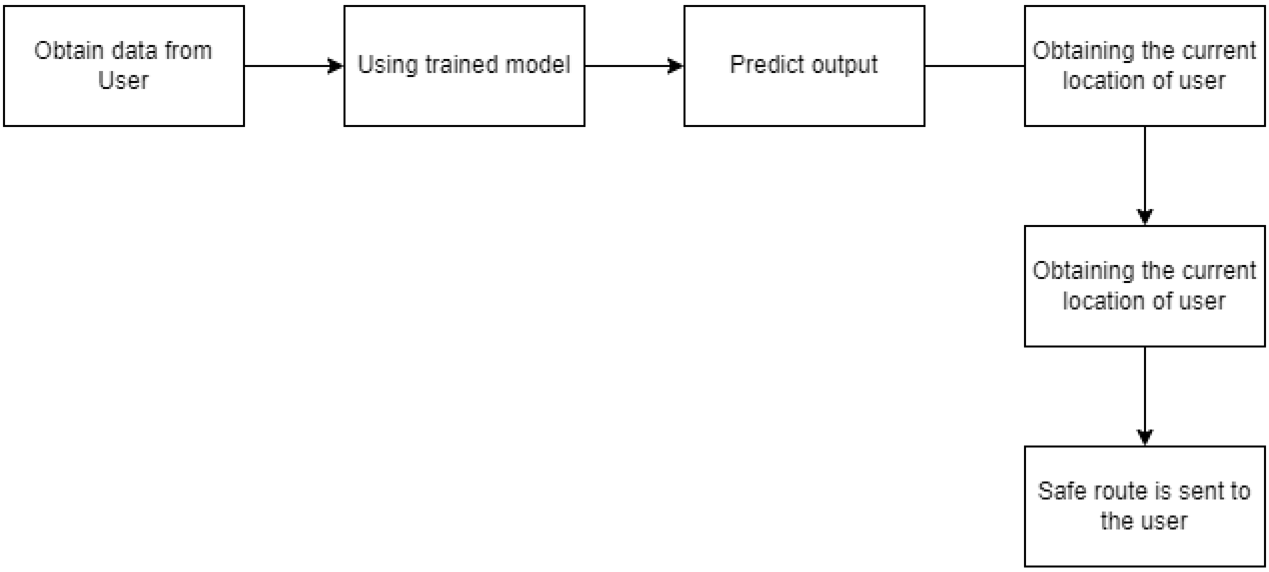

Fig.2.System Architecture

IV. RESULT

The prediction system of the administrator along with the user application successfully warned the user of an impending landslide. The trained model predicted the occurrence of landslides accurately. The user application was able to produce the safe route precisely. The system was successful in keeping the user safe and thus mitigating the destruction caused by landslides.

V. FUTURE SCOPE

Landslide forecast accuracy can be enhanced by considering a wider range of other landslide parameters. A few systems are in place without a thorough understanding of landslides, soils, and their behaviors in various weather conditions. To improve detection, the architecture can include hardware devices and numerous sensors.Different landslides may necessitate different system architectures, installation methodologies, and software adaptations. Systems would be deployed and tested on many sorts of landslides to ensure that they are suitable for all forms of landslides in India and even abroad.

VI. CONCLUSION

Most past work involving landslides concentrates mainly on prediction. Many systems built on detecting landslides are not effective at mitigation of the destruction caused by landslides. Here we were able to implement a system capable of reducing the damage caused by it.The system successfully predicts the occurrence of landslides using various factors. Then the systemsends the prediction to the users in the specified region and thenfinds the route to the nearest safe zone. By using the proposed system, we can reduce the damage caused by landslides.

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REFERENCES

[1] M. Li et al., "Warning of Rainfall-Induced Landslide in Bazhou District," IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, 2020, pp. 6879-6882, doi: 10.1109/IGARSS39084.2020.9324416.

[2] Piciullo, Luca &Gariano, Stefano Luigi & Melillo, Massimo & Brunetti, Maria &Peruccacci, Silvia & Guzzetti, Fausto &Calvello, Michele. (2017). Definition and performance of a threshold-based regional early warning model for rainfall-induced landslides. Landslides. 14. 995-1008. 10.1007/s10346-016-0750-2.

[3] Mirus, B.B.; Morphew, M.D.; Smith, J.B. Developing Hydro-Meteorological Thresholds for Shallow Landslide Initiation and Early Warning. Water 2018, 10, 1274.

[4] Cheng, Y., Huo, A., Zhang, J. et al. Early warning of meteorological geohazard in the Loess Plateau: a study in Huangling County of Shaanxi Province in China. Environ Earth Sci 73, 1057–1065 (2015).

[5] C. N. Madawala, B. T. G. S. Kumara and L. Indrathilaka, "Novel machine learning ensemble approach for landslide prediction," 2019 International Research Conference on Smart Computing and Systems Engineering (SCSE), 2019, pp. 78-84, doi: 10.23919/SCSE.2019.8842762.

[6] N. P. Bhatta and N. Thangadurai, "Detection and prediction of calamitous landslide in precipitous hills," 2016 International Conference on Advanced Communication Control and Computing Technologies (ICACCCT), 2016, pp. 238-240, doi: 10.1109/ICACCCT.2016.7831638.

[7] C. Wang et al., "Classification of Landslide Stability Based on Fine Topographic Features," 2020 17th International Computer Conference on Wavelet Active Media Technology and Information Processing (ICCWAMTIP), 2020, pp. 54-57, doi: 10.1109/ICCWAMTIP51612.2020.9317358.

[8] Z. Wen, B. He, D. Xu and Q. Feng, "A method for landslide susceptibility assessment integrating rough set and decision tree: A case study in Beichuan, China," 2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 2016, pp. 4952-4955, doi: 10.1109/IGARSS.2016.7730292.

[9] Y. Dash, S. K. Mishra and B. K. Panigrahi, "Rainfall prediction of a maritime state (Kerala), India using SLFN and ELM techniques," 2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), 2017, pp. 1714-1718, doi: 10.1109/ICICICT1.2017.8342829.

[10] B. Pradhan, E. A. Sezer, C. Gokceoglu and M. F. Buchroithner, "Landslide Susceptibility Mapping by Neuro-Fuzzy Approach in a Landslide-Prone Area (Cameron Highlands, Malaysia)," in IEEE Transactions on Geoscience and Remote Sensing, vol. 48, no. 12, pp. 4164-4177, Dec. 2010, doi: 10.1109/TGRS.2010.2050328.

[11] S. B. Bai, J. Wang, A. Pozdnoukhov and M. Kanevski, "Validation of Logistic Regression Models for Landslide Susceptibility Maps," 2009 WRI World Congress on Computer Science and Information Engineering, 2009, pp. 355-358, doi: 10.1109/CSIE.2009.1019.

[12] T. -H. Liao, S. -B. Kim, A. L. Handwerger, E. J. Fielding, M. H. Cosh and W. H. Schulz, "High-Resolution Soil-Moisture Maps Over Landslide Regions in Northern California Grassland Derived From SAR Backscattering Coefficients," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 14, pp. 4547-4560, 2021, doi: 10.1109/JSTARS.2021.3069010.

[13] T. Li, Y. Tian, C. Xiao and W. Zhao, "Slope location-based landslide vulnerability assessment," 2013 21st International Conference on Geoinformatics, 2013, pp. 1-4, doi: 10.1109/Geoinformatics.2013.6626073.

[14] S. Ansar.A and S. Sudha, "Prediction of Earthquake Induced Landslide Using Deep Learning Models," 2020 5th International Conference on Computing, Communication and Security (ICCCS), 2020, pp. 1-6, doi: 10.1109/ICCCS49678.2020.9277206.

[15] S. S. binti Tuan Sariff, T. Shintarou and S. Takayama, "GPS implementation in sensing node network system for landslide disaster," SICE Annual Conference 2011, 2011, pp. 2014-2018.