International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Impact of Deep Learning in Analytics of Climate Change: A Survey

Rohith R, Geetha G

Department of Information Science and Technology, College of Engineering, Anna University, Guindy, India

Abstract: ***The paper Impact of Deep Learning in the Analytics of Climate Change surveys the recent advances and applications of deep learning methods for various climate change related tasks, such as detection, prediction, estimation, and attribution. The paper reviews the literature on how deep learning can help with super-resolution, pattern recognition, forecasting, and data fusion in global warming, air pollution, drought, wildfire, and other environmental issues. The flow of our survey starts with reviewing the articles on causes then to consequences and finally the remedies of climate change. The paper also discusses the challenges and limitations of deep learning for climate change analytics, such as data quality and availability, model interpretability and robustness, and computational resources and efficiency. The paper concludes that deep learning is a promising branch of machine learning that could provide valuable insights and solutions for climate change mitigation and adaptation***

Keywords: Deep Learning, Climate Change, Analytics, Global Warming, Environmental Issues, Mitigation and Adaptation

1. Introduction

Climate change is one of the most pressing challenges facing humanity and the planet. It poses serious threats to the environment, society, and economy, and requires urgent and coordinated actions from various stakeholders. However, understanding and addressing climate change is not an easy task, as it involves complex and dynamic interactions among natural and human systems, as well as large-scale and high-dimensional data from multiple sources and domains. Therefore, there is a need for advanced methods and tools that can help with the analysis, prediction, estimation, and attribution of climate change and its impacts.

Deep learning is a branch of machine learning that uses artificial neural networks to learn from data and perform various tasks, such as classification, segmentation, detection, generation, etc. Deep learning has shown remarkable success in many fields, such as computer vision, natural language processing, speech recognition, etc., by exploiting the availability of large-scale data and computational resources. Recently, deep learning has also been applied to various climate change related tasks, such as detection and prediction of extreme weather events , estimation and attribution of greenhouse gas emissions , mapping and monitoring of land use and land cover changes , etc. These applications demonstrate the potential of deep learning to provide valuable insights and solutions for climate change mitigation and adaptation.

In this survey paper, we review the recent advances and applications of deep learning methods for different climate change related tasks. We first introduce the basic concepts and principles of deep learning, as well as some common architectures and techniques. Then we discuss how deep learning can help with super-resolution, pattern recognition, forecasting, and data fusion in global warming, air pollution, drought, wildfire, and other environmental issues. We also highlight the challenges and limitations of deep learning for climate change analytics, such as data quality and availability, model interpretability and robustness, and computational resources and efficiency. We conclude by providing some future directions and recommendations for further research in this field. We hope that this survey paper will serve as a useful reference for researchers, practitioners, policymakers, and students who are interested in applying deep learning to climate change analytics. We also hope that this paper will inspire more research and innovation in this important and timely domain.

Deep Learning in Climate Change Causes of Climate Change

The first article, "Comparative Analysis of Deep Learning and Statistical Models for Air Pollutants Prediction in Urban Areas" by Fareena Naz et al., focuses on comparing deep learning and statistical models for predicting air pollutants in urban areas. While this study provides valuable insights into the performance of different models, it primarily addresses short-term predictions and doesn't directly analyze the causes of climate change. The second article, "Deep Learning Model Based CO2 Emissions Prediction Using Vehicle Telematics Sensors Data" by Mukul Singh and Rahul Kumar Dubey, introduces a scalable and efficient system for monitoring CO2 emissions at the vehicular level using real-time sensor data. This research contributes to understanding the impact of vehicular emissions on climate change, but it has limitations related to dataset size and quality and the need for validation on various types of vehicles and conditions. "NeSNet: A Deep Network for Estimating Near-Surface Pollutant Concentrations" by Prasanjit Dey and colleagues focuses on estimating near-surface pollutant concentrations, including NO2, SO2, and O3, using satellite data. While NeSNet provides accurate and robust estimations, it's constrained by the availability and quality of training data and needs validation on other regions and datasets. The article "Physics-Guided Multitask Learning for Estimating Power Generation and CO2 Emissions From Satellite Imagery" by Joëlle Hanna and co-authors introduces a novel method to estimate power generation and CO2 emissions from fossil fuel power plants using satellite images and weather data. This research contributes to understanding the causes of CO2 emissions, but it also relies on the quality of training data and requires validation on other regions and datasets. "Solar Radiation Forecasting Based on the Hybrid CNN-CatBoost Model" by Hyojeoung Kim and colleagues presents a model for accurate and stable solar radiation prediction using weather variables."Toward Global Estimation of Ground-Level NO2 Pollution with Deep Learning and Remote Sensing" by Linus Scheibenreif and others proposes a model to estimate ground-level NO2 pollution, offering high accuracy and global coverage. "Spatio-Temporal Deep Learning Approach to Map Deforestation in Amazon Rainforest" by Raian V. Maretto and team introduces an automatic approach for deforestation mapping in the Amazon. "Deep Remote Sensing Methods for Methane Detection in Overhead Hyperspectral Imagery" by Satish Kumar and colleagues discusses deep learning methods for methane detection in hyperspectral imagery, contributing to the understanding of methane emissions, a potent greenhouse gas."Deep Learning Algorithm Applied to Daily Solar Irradiation Estimations" by Emre Yüce and Bulent G. Akinoglu demonstrates that deep learning can estimate daily solar irradiation with accuracy comparable to classical approaches."EuroSAT: A Novel Dataset and Deep Learning Benchmark for Land Use and Land Cover Classification" by Patrick Helber and colleagues presents an open dataset for land use and land cover classification using CNNs. "Prediction of CO2 emissions using deep learning hybrid approach: A Case Study in Indian Context" by Lakshay Amarpuri and others introduces a model for accurate prediction of CO2 emissions in India using deep learning and sensor data.

S.No.	Title	Authors	Publisher	Year	Methodologies Used
1	Comparative Analysis of Deep Learning and Statistical Models for Air Pollutants Prediction in Urban Areas	FAREENA NAZ , CONOR MCCANN, MUHAMMAD FAHIM	IEEE	2023	ARIMA LSTMGRU
2	Deep Learning Model Based CO2 Emissions Prediction Using Vehicle Telematics Sensors Data	Mukul Singh and Rahul Kumar Dubey	IEEE Transactions on Intelligent Vehicles	2023	LSTM, OBD- II, PCA, feature selection
3	NeSNet: A Deep Network for Estimating Near-Surface Pollutant Concentrations	Prasanjit Dey, Bibhash Pran Das, Yee HuiLee, and Soumyabrata Dev	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	2023	CNN, TROPOMI, VCD, univariate estimation
4	Physics-Guided Multitask Learning for Estimating Power Generation and CO2 Emissions From Satellite Imagery	Joëlle Hanna, Damian Borth, and Michael Mommert	IEEE Transactions on Geoscience and Remote Sensing	2023	CNN, Sentinel-2, PPM, ENTSOE, ERA-5, multitask learning, physical constraints
5	Solar Radiation Forecasting Based on the Hybrid CNN- CatBoost Model	Hyojeoung Kim, Sujin Park, Hee- Jun Park, Heung- GuSon, and Sahm Kim	IEEE Access	2023	CNN, CatBoost, hybrid model (CNN- CatBoost)
6	Toward Global Estimation of Ground-Level NO2 Pollution With Deep Learning and Remote Sensing	Linus Scheibenreif, Michael Mommert, and Damian Borth	IEEE Transactions on Geoscience and Remote Sensing	2022	Gradient boosting, deep neural network, Monte Carlo dropout, Sentinel-2and Sentinel-5P data fusion
7	Spatio-Temporal Deep Learning Approach to Map Deforestation in Amazon Rainforest	Raian V. Maretto et al.	IEEE Geoscience and Remote Sensing Letters	2021	U-Net, spatio- temporal variations of U-Net, weighted cross-entropy, average soft dice score
8	Deep Remote Sensing Methods for Methane Detection in Overhead Hyperspectral Imagery	Satish Kumar, Carlos Torres Oytun Ulutan, Alana Ayasse Dar Roberts B.S. Manjunath†	IEEE	2020	Hyperspectral Mask-RCNN (H-mrcnn)
9	Deep Learning Algorithm Applied to Daily Solar Irradiation Estimations	Emre Yüce and Bulent G. Akinoglu	IEEE	2020	Multi Layer Perceptron MLP
10	EuroSAT: A Novel Dataset and Deep Learning Benchmark for Land Use and Land Cover Classification	Patrick Helber, Benjamin Bischke, Andreas Dengel, and Damian Borth	IEEE Journal of Selected Topics in AppliedEarth Observations and Remote Sensing	2019	CNNs, Sentinel-2 satellite images, 13 spectral bands, 10 classes, 27000 images
11	Prediction of CO2emissions using deep learning hybrid approach: A Case Study in Indian Context	Lakshay Amarpuri, Navdeep Yadav, Girish Kumar, Saurabh Agrawal	IEEE Access	2019	CNN-LSTM, time series data, exponential smoothing, RMSE, MAPE

Consequences of Climate Change

"Burned Area Mapping Using Unitemporal Planet Scope Imagery" by AhYoung Cho and colleagues presents a deep learning approach for mapping burned areas using Planet Scope imagery. While it contributes to assessing the consequences of wildfires, it mainly addresses the effects of these fires on the environment and ecosystems."Location-Aware Adaptive Normalization" by Mohamad Hakam Shams Eddin and co-authors introduces a deep learning approach for wildfire danger forecasting. This study aims to predict and mitigate the consequences of wildfires, considering static and dynamic variables."Probabilistic Evaluation of Drought Propagation Using Satellite Data" by Jae Young Seo and Sang-IILee explores the probabilistic evaluation of drought propagation using satellite data and deep learning. It offers insights into drought consequences and management, focusing on monitoring and mitigating the impact of droughts. "Forest-Fire Response System Using Deep-Learning-Based Approaches" by DaiQuocTran and colleagues presents a deep learning-based system for forest fire detection and damage estimation using CCTV images and weather data. "Satellite Remote Sensing of Daily Surface Ozone in a Mountainous Area" by Songyan Zhu and co-authors uses deep learning to estimate daily surface ozone levels. "Unsupervised Deep Slow Feature Analysis for Change Detection in Multi-Temporal Remote Sensing Images" by Bo Du and colleagues presents a model for change detection in remote sensing images. "Wildland Fire Detection and Monitoring Using a Drone-Collected RGB/IR Image Dataset"by Xiwen Chenand others offers a dataset and deep learning-based models for fire detection and monitoring. "Consensus Forecast of Rainfall Using Hybrid Climate Learning Model" by Neethu Madhu kumar focuses on rainfall forecasting. "Deep Learning for Regular Change Detection in Ukrainian Forest Ecosystem" by Kostiantyn Isaienkov and colleagues presents a deep learning model for monitoring changes in the Ukrainian forest ecosystem. "Prediction of Dominant Ocean Parameters for Sustainable Marine Environment" by D. Menaka and S. Gauni utilizes deep learning to predict ocean parameters. "Research on the Lake Surface Water Temperature Downscaling Based on Deep Learning" by Zhenyu Yu and co-authors focuses on downscaling lake surface water temperature. It provides insights into environmental conditions. "Study of Spatial–Spectral Feature Extraction Frameworks With 3-D Convolutional Neural Network" by Bishwas Praveen and Vineetha Menon introduces a framework for hyperspectral imagery classification. While it addresses remote sensing applications, it primarily deals with classification and monitoring. "Using Long Short-Term Memory (LSTM) and Internet of Things (IoT) for Localized Surface Temperature Forecasting" by Manzhu Yu and colleagues focuses on localized temperature forecasting. It contributes to understanding local climate conditions. "GlacierNet: A Deep-Learning Approach for Debris-Covered Glacier Mapping" by Zhiyuan Xie and others presents a model for debris- covered glacier mapping. It contributes to understanding glacier changes. "An Attention Enhanced Bidirectional LSTM for Early Forest Fire Smoke Recognition" by Y. Cao and colleagues addresses early forest fire smoke recognition. This research helps mitigate the impact of forest fires.

S. No.	Title	Authors	Publisher	Year	Methodologies Used
1	Burned Area Mapping Using Unitemporal Planet Scope Imagery With a Deep Learning Based Approach	Ah Young Cho, Si-eun Park, Duk-jin Kim	IEEE	2023	U-NET
2	Location-Aware Adaptive Normalization: A Deep Learning Approach for Wildfire Danger Forecasting	Mohamad Hakam Shams Eddin, Ribana Roscher, and Juergen Gall	IEEE Transactions on Geoscience and Remote Sensing	2023	2-D/3-D CNN, LOAN, TE, FireCube dataset, 90 variables, binary classification
3	Probabilistic Evaluation of Drought Propagation Using Satellite Data and Deep Learning Model: From Precipitation to Soil Moisture and Groundwater	JaeYoungSeo and Sang-II Lee	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, Vol. 16, 2023	2023	Satellite-based deep learning model, drought index calculation, drought identification and propagation, conditional probability based on copula function
4	Forest-Fire Response System Using Deep- Learning-Based Approaches With CCTV Images and Weather Data	Dai Quoc Tran, Jinyeong Bak, Minsoo Park, Yuntae Jeon, and Seunghee Park	IEEE Access	2022	DetNAS, Faster R-CNN, BNN, weather API, UAV
5	Satellite Remote Sensing of Daily Surface Ozone in a Mountainous Area	Songyan Zhu, Hao Zhu, Jian Xu, Qiaolin Zeng, Dejun Zhang, and Xiaoran Liu	IEEE Geoscience and Remote Sensing Letters	2022	Deep forest machine learning model to link O3 columns from TROPOMI and surface monitoring data from CNEMC.
6	Unsupervised Deep Slow Feature Analysis for Change Detection in Multi- Temporal Remote Sensing Images	Bo Du, Lixiang Ru, Chen Wu, and Liangpei Zhang	IEEE Transactions on Geoscience and Remote Sensing	2022	Deep network, slow feature analysis, change vector analysis, chi-square distance
7	Wild land Fire Detection and Monitoring Using a Drone-Collected RGB/IR Image Dataset	Xiwen Chen, Hao Wang, Bryce Hopkins, Leo O'Neill, Fatemeh Afghah, Abolfazl Razi, Peter Fulé, Janice Coen,	IEEE Access	2022	DJI Mavic 2 Enterprise Advanced system, dual RGB/IR imagery, deep learning- based classification and detection models,
		Eric Rowell, and Adam Watts			image processing-based flame detection and localization
8	Consensus Forecast of Rainfall Using Hybrid Climate Learning Model	Neethu Madhukumar	IEEE	2021	hybrid climate learning model (HCLM)CM and a probabilistic multilayer perceptron (PMLP) and hybrid deep long short-term memory (HD- LSTM)
9	Deep Learning for Regular Change Detection in Ukrainian Forest EcosystemWithSentinel-2	Kostiantyn Isaienkov, Mykhailo Yushchuk, Vladyslav Khramtsov, and Oleg Seliverstov	IEEE Journal of Selected Topics in Applied Earth Observations and	2021	U-Net, FPN, ResNet, LSTM, Siamese CNN, image difference, NDVI, NDMI

			Remote Sensing		
10	Prediction of Dominant Ocean Parameters for Sustainable Marine Environment	D. Menaka and S. Gauni	IEEE Access	2021	HM-LSTM, a deep learning model that combines multi- layer convolutional LSTM and high- speed LSTM for predicting temperature, pressure, salinity and density at three different oceans.
11	Research on the Lake Surface Water Temperature Downscaling Based on Deep Learning	Zhenyu Yu, Kun Yang, Yi Luo, Pei Wang, and Ze Yang	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	2021	DisTrad–SRCNN downscaling model, which combines statistical-based and learning- based algorithms to improve the spatial resolution of LSWT from 1km to 50 m.
12	Study of Spatial–Spectral Feature Extraction Frameworks With 3-D Convolutional Neural Network for Robust Hyperspectral Imagery Classification	Bishwas Praveen and Vineetha Menon	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	2021	Gabor filtering, sparse random projection, 3-D convolutional neural network, support vector machine with composite kernel, Gaussian filtering, principal component analysis
13	Using Long Short-Term Memory (LSTM) and Internet of Things (IoT) for Localized Surface Temperature Forecasting in an Urban Environment	Manzhu Yu, Fangcao Xu, Weiming Hu, Jian Sun, and Guido Cervone	IEEE Access	2021	LSTM network, IoT data, WU data, GeoTab data platform
14	GlacierNet: A Deep- Learning Approach for Debris-Covered Glacier Mapping	Zhiyuan Xie, Umesh K. Haritashya, Vijayan K. Asari, Brennan W. Young, Michael P. Bishop, and Jeffrey S. Kargel	IEEE Access	2020	CNN, Landsat8, ALOS DEM, geomorphometric parameters
15	An Attention Enhanced Bidirectional LSTM for Early Forest Fire Smoke Recognition	Y. Cao, F. Yang, Q.Tang, and X. Lu	IEEE Access	2019	Inception V3, Bidirectional LSTM, Attention Mechanism

Remedies for Climate Change

"An Improved Deep Learning Model for High-Impact Weather Nowcasting" introduces an accurate now casting model that can be used to predict severe weather events. This type of forecasting can help authorities and communities prepare for extreme weather conditions, potentially mitigating the impact of climate-related disasters. "Data-Driven Dynamical Control for Bottom-up Energy Internet System" discusses the use of deep reinforcement learning (DRL) for managing energy systems. Implementing data-driven control methods can enhance the efficiency and sustainability of energy systems, which is crucial for reducing greenhouse gas emissions and promoting renewable energy sources. "Deep Learning-Based Automated Forest Health Diagnosis from Aerial Images" offers a framework for automated dead tree detection. Monitoring and diagnosing the health of forests are essential for climate change mitigation, as healthy forests act as carbon sinks and contribute to carbon sequestration. "Deep Learning for Image Processing: A Review" provides a comprehensive survey of deep learning techniques for various image processing tasks. While not directly related to climate change, the advancements in image analysis through deep learning can be applied to environmental monitoring, such as land cover analysis, deforestation detection, and pollution tracking.

S. No.	Title	Authors	Publisher	Year	Methodologies Used
1	An Improved Deep Learning Model for High-Impact Weather Nowcasting	Shun Yao , Haonan Chen	IEEE	2022	self-attention- based gate recurrent unit (SaGRU)
2	Data-Driven Dynamical Control for Bottom-up Energy Internet System	HaochenHua	IEEE	2022	Deep reinforcement learning (DRL) with curriculum learning (CL)
3	Deep Learning-Based Automated Forest Health Diagnosis From Aerial Images	CHIA-YEN CHIANG, CHLOE BARNES, PLAMEN ANGELOV	IEEE	2020	re-trained Mask RCNN
4	Deep Learning for Image Processing: A Review	Shikha Singh, Anand Singh Jalal, and Gaurav Tiwari	IEEE Access	2020	CNN, RNN, GAN, AE, DBN, SVM, PCA, LDA, etc.

2. Conclusion

In this survey, we have delved into the profound impact, far-reaching consequences, and innovative remedies of climate change using deep learning techniques. Through an extensive exploration of various applications, we have witnessed the transformative potential of deep learning in climate analytics. From accurate air pollutant predictions and CO_2 emissions estimations to early wildfire danger forecasting and drought propagation evaluations, deep learning has emerged as a formidable tool in addressing climate-related challenges. However, this survey also underscores the critical need for ongoing research and innovation. The challenges of climate change are dynamic and multifaceted, requiring adaptive solutions and cutting-edge technologies. While deep learning has proven its mettle in many aspects, it is essential to address limitations, extend research into uncharted territories, and further validate models on diverse datasets and in varied environmental conditions. By harnessing the power of deep learning, we are better equipped to confront climate change and work toward a sustainable and resilient future. This survey serves as a vital resource for researchers, policymakers, and stakeholders committed to addressing the global challenge of climate change using state-of-the-art technologies.

References

[1] Naz, F., McCann, C., & Fahim, M. (2023). Comparative Analysis of Deep Learning and Statistical Models for Air Pollutants Prediction in Urban Areas. IEEE.

[2] Singh, M., & Dubey, R. K. (2023). Deep Learning Model Based CO2 Emissions Prediction Using Vehicle Telematics Sensors Data. IEEE Transactions on Intelligent Vehicles.

[3] Dey, P., Das, B. P., Lee, Y. H., & Dev, S. (2023). NeSNet: A Deep Network for Estimating Near-Surface Pollutant Concentrations. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

[4] Hanna, J., Borth, D., & Mommert, M. (2023). Physics-Guided Multitask Learning for Estimating Power Generation and CO2 Emissions From Satellite Imagery. IEEE Transactions on Geoscience and Remote Sensing.

[5] Kim, H., Park, S., Park, H.-J., Son, H.-G., & Kim, S. (2023). Solar Radiation Forecasting Based on the Hybrid CNN-CatBoost Model. IEEE Access.

[6] Scheibenreif, L., Mommert, M., & Borth, D. (2022). Toward Global Estimation of Ground- Level NO2 Pollution with Deep Learning and Remote Sensing. IEEE Transactions on Geoscience and Remote Sensing.

[7] Maretto, R. V., et al. (2021). Spatio-Temporal Deep Learning Approach to Map Deforestation in Amazon Rainforest. IEEE Geoscience and Remote Sensing Letters.

[8] Kumar, S., Torres, C., Ulutan, O., Ayasse, A., & Roberts, D. (2020). Deep Remote Sensing Methods for Methane Detection in Overhead Hyperspectral Imagery. IEEE.

[9] Yüce, E., & Akinoglu, B. G. (2020). Deep Learning Algorithm Applied to Daily Solar Irradiation Estimations. IEEE.

[10] Helber, P., Bischke, B., Dengel, A., & Borth, D. (2019). EuroSAT: A Novel Dataset and Deep Learning Benchmark for Land Use and Land Cover Classification. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

[11] Amarpuri, L., Yadav, N., Kumar, G., & Agrawal, S. (2019). Prediction of CO2 emissions using deep learning hybrid approach: A Case Study in Indian Context. IEEE Access.

[12] Cho, A. Y., Park, S.-e., & Kim, D.-j. (2023). Burned Area Mapping Using Unitemporal Planet Scope Imagery With a Deep Learning Based Approach. IEEE.

[13] Shams Eddin, M. H., Roscher, R., & Gall, J. (2023). Location-Aware Adaptive Normalization: A Deep Learning Approach for Wildfire Danger Forecasting. IEEE Transactions on Geoscience and Remote Sensing.

[14] Seo, J. Y., & Lee, S.-I. (2023). Probabilistic Evaluation of Drought Propagation Using Satellite Data and Deep Learning Model: From Precipitation to Soil Moisture and Groundwater. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 16.

[15] Tran, D. Q., Bak, J., Park, M., Jeon, Y., & Park, S. (2022). Forest-Fire Response System Using Deep-Learning-Based Approaches With CCTV Images and Weather Data. IEEE Access.

[16] Zhu, S., Zhu, H., Xu, J., Zeng, Q., Zhang, D., & Liu, X. (2022). Satellite Remote Sensing of Daily Surface Ozoneina Mountainous Area. IEEE Geoscience and Remote Sensing Letters.

[17] Du, B., Ru, L., Wu, C., & Zhang, L. (2022). Unsupervised Deep Slow Feature Analysis for Change Detection in Multi-Temporal Remote Sensing Images. IEEE Transactions on Geoscience and Remote Sensing.

[18] Chen, X., Wang, H., Hopkins, B., O'Neill, L., Afghah, F., Razi, A., Fulé, P., Coen, J., Rowell E., & Watts A. (2022). Wildland Fire Detection and Monitoring Using a Drone- Collected RGB/IR Image Dataset. IEEE Access.

[19] Madhukumar N. (2021). Consensus Forecast of Rainfall Using Hybrid Climate Learning Model. IEEE.

[20] Isaienkov K., Yushchuk M., Khramtsov V., &Seliver O. (n.d.). Deep Learning for Regular Change Detection in Ukrainian Forest Ecosystem with Sentinel-2.

[21] Yu, M., Xu, F., Hu, W., Sun, J., & Cervone, G. (2021). Using Long Short-Term Memory (LSTM) and Internet of Things (IoT) for Localized Surface Temperature Forecasting in an Urban Environment. IEEE Access.

[22] Xie, Z., Haritashya, U.K., Asari, V.K., Young, B.W., Bishop, M.P., & Kargel, J.S.(2020). GlacierNet: A Deep-Learning Approach for Debris-Covered Glacier Mapping. IEEE Access.

[23] Cao, Y., Yang, F., Tang, Q., & Lu, X. (2019). An Attention Enhanced Bidirectional LSTM for Early Forest Fire Smoke Recognition. IEEE Access.

[24] Yao, S., & Chen, H. (2022). An Improved Deep Learning Model for High-Impact Weather Nowcasting. IEEE.

[25] Hua, H.(2022).Data-Driven Dynamical Control for Bottom-up Energy Internet System. IEEE.

[26] Chiang, C.-Y., Barnes, C., & Angelov, P. (2020). Deep Learning-Based Automated Forest Health Diagnosis From Aerial Images. IEEE.

[27] Singh, S., Jalal, A.S., &Tiwari, G.(2020).Deep Learning for Image Processing: A Review. IEEE Access.

[28] Amarpuri, L., Yadav, N., Kumar, G., & Agrawal, S. (2019). Prediction of CO2 emissions using deep learning hybrid approach: A Case Study in Indian Context. IEEE Access.

[29] R. R. Rohith R, K. S. Kavipriya Sand J. D. M. Joshua Dayalan M, "Combining Feature Selection and Deep Learning for Precise COVID-19 Cases Forecasting: A Hybrid Approach", International Journal for Research Trends and Innovation, vol. 8, no. 11, pp. 419–434, Nov. 2023, doi: 10.5281/zenodo.10259171.