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Forecasting of GHG (greenhouse gas) Emission using (ARIMA) Data Driven Intelligent Time Series Predicting Approach

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Abstract: Climate change is emerging as one of the major challenges to the existence of life on the Earth. Most scientists believe that if the GHG (greenhouse gas) concentration doubles, temperature would increase by 3^0C by the end of the century and this would result in economic loss. Countries across the world are showing their concern to reduce GHG emissions in the form of the Paris agreement. Indian participation in the Paris Agreement demonstrated its commitment to reduce GHG emissions by half the amount of GHG produced for every dollar of economic activity by increasing the proportion of non-fossil fuels in power generation capacity up to 40 percent of total capacity, thereby reducing the emissions intensity of the economy by 33 percent to 35 percent. The aim of the present study is to investigate the past and current trends of GHG emissions in India and to forecast the emissions of GHG for future Years. Forecasting GHG emissions over the coming decade will help to know the level of GHG emissions in the forecasted period of the next 10 years. Data-driven intelligent time-series predicting approach, ARIMA (Auto-Regressive Integrated Moving Average) is applied for forecasting GHG emissions. ARIMA (0, 2, 1,) model is used for forecasting, which showed an increasing trend of emissions of GHG. This Projection will help the policymakers to take actions to reduce GHG emissions and achieve the target set in the Paris agreement and minimize the economic loss due to climate change. The forecasted value of GHG emissions over the decade can help the government to plan its future course of action.

***Keywords:** ARIMA; Forecasting; Paris agreement on climate change; ADF; ACF; PACF; GHG.*

I. Introduction

Climate change states to the continuing variations in the environment that emerge over years or extended. Climate change is instigated by fast-growing GHG (greenhouse gas) emissions in the Earth's atmosphere. GHG emissions in the Earth's atmosphere have risen dramatically since the beginning of the industrial revolution due to pollution from fossil fuels, deforestation, and other human activities. As a result, the earth's atmosphere's heat-trapping capacity has considerably multiplied, and the globe is warming at a higher speed than in the previous 10,000 years. The Intergovernmental Panel on Climate Change (IPCC) and the National Academy of Science have both concluded that the increase in earth temperature, human activity, and the warming trend are all likely to intensify in the upocoming years and becoming major cause for GHG emissions [1].

In the past couple of years, temperatures have increased in the World's climate. Over the previous 100 years, the temperature of the earth increased by $.6^0$ C, and if the earth's atmospheric GHG concentration doubles, most scientists believe that the temperature would increase by 3^0C by the expiration of the 21^{st} century [2], [3]. Emissions of GHG at the current emission rate or above would cause a further increase in global heat and mid 2.6^0 C to 4.8^0 C [4]. This transformation is impacting native weather all around the world.

India is the third-largest emitter of GHG and emitted 2307.78 Metric tons (Mt) Carbon Dioxide (CO2e), an increase of 335.33% from 1990 [5]. India releases about 3 gigatonnes (Gt) CO_{2eq} of GHG every year which is 7% of the global emissions and about 2 tons per individual, which is nearly half of the world average.

Climate change and global warming are posing threats to economic development and in the case of India; the social cost of carbon is the highest. India may miss somewhere around 3% to 10% of its Gross domestic product per annum by the end of this century and its poverty rate may rise by 3.5% in the year 2040 owing to climate change (Report of overseas development institute). As per the report "The Costs of Climate Change in India," if the Earth's temperature is enclosed to 2^0C, India can lose 2.6% of its Gross domestic product annually, and if the Earth's temperature will increase to 3^0C degrees Celsius, this damage will magnify to 13.4%per annum. Increased levels of GHG emissions and an adverse climate change will adversely affect and intensify human fitness, arrangement, forestry and farming, sources of fresh water supplies, shorelines, and maritime systems. These changes would lead to economic challenges in the form of a decrease in Gross domestic product (GDP) growth rate and an increase in the level of poverty.

The problem of climate change and its repercussions are taken seriously by the government of India which has shown its sincere commitment to the reduction of GHG emissions. India has set a target of reduction of 45% of its emissions of GHG by 2030 in comparison to 33%-35% earlier. The Intergovernmental Panel on Climate Change (IPCC) set a goal of global net-zero, in which no country will add any new level of emissions to the overall amount of GHG in the atmosphere to retain the temperature upsurge to 1.5 C by 2050.

To meet the target, precise estimation of GHG emissions is critical to improving policies and plans to reduce emissions. There are numerous methods for doing so. These methods are classified into two types: data-driven predicting methods and deterministic predicting methods [6]. Time-series methods that use past data to predict future data are examples of data-driven predicting approaches. Each method has advantages and disadvantages; however, in the absence of deterministic evidence, data-driven methods produce more precise forecasts. Auto-Regressive Integrated Moving Average (ARIMA) forecasting model is a data-driven intelligent time-series predicting approach that shows reasonable performance even from small samples [7]. For policymakers and government, it is critical to understand the factors that drive the fast emissions of GHG, hence forecasting GHG emissions over a decade will help to frame the policy accordingly. This research has important implications over the existing literature (1) forecasting of GHG emissions will help to estimate the accurate value of GHG emissions in the case of India and (2) to check the effectiveness of policies by comparing the actual level of GHG emissions from the forecasted value and possibilities of achieving the target set in Paris agreement.

II. Literature Review

The study of relationship between the Country's GHG emissions and its exposure to adverse effects of climate change revealed that the highest GHG emissions countries were least exposed to the negative effect of climate change while the lowest GHG emissions countries were acutely vulnerable to the negative impact of future climate changes [8]. Huang et al. noticed a rise in the earth's temperature because of the warming of the lower layers of the atmosphere and the accumulation and emissions of GHG. Due to the increased temperature of lower layers of the atmosphere, the air temperature is greater than the prescribed limit and this is leading to adverse climate change and global warming [9]. To forecast the energy intake and GHG emissions of Indian pig iron business organizations using the ARIMA model, (1,0,0) and (0,1,1) were found as the best-fit models to forecast energy consumption and (0,1,4) and (0,1,1) were the best-fit models to forecast GHG emissions. Selection of the accurate forecasting model will help in accurate forecasting and drafting more impactful environmental policies [7]. Rahman & Hasan used Time-series data of 44 years ranging from 1972-to 2015 using the ARIMA (0,2,1) model to forecast carbon dioxide in Bangladesh and the results seemed nearer to reality [10]. CO2 emissions using Box Jenkins ARIMA methodology in Bangladesh from 1972 to 2013 study found ARIMA (12, 2, 12), (8, 1, 3), and (5, 1, 5) as the best models to predict the CO2 emissions from GFC, LFC, and SFC rather than other techniques of projecting – HWNS and ANN models [11].

CO_2 is one of the key GHG which pollute the environment and assessment and projection of CO_2 are very important for energy planning and environmental strategy decisions. A multiple linear regression model and PSO algorithms based on a nonlinear model were used for forecasting CO_2 and the result showed an increasing and alarming trend in CO_2 emissions in India. It also reveals the PSO model could find an extremely precise approximation linked to the MLR model [12]. Time-series data to forecast the carbon emissions in India using ARIMA (2,2,0) suggested that an increasing trend can occur in carbon emissions in the case of India and that can lead to more climate-related challenges [13]. Hosseini et al. in their study tried to forecast the CO_2 emissions in the light of the 6th development plan using multiple linear regressions (MLR) and multiple polynomial regressions (MPR) analysis. The results of the study proposed that Iran would not be able to fulfill its promise to the Paris agreement on CO_2 emissions [14]. Yusuf et al. concluded that economic growth in South African OPEC (Organization of the Petroleum Exporting Countries) countries contributed to an increase in the level of GHG emissions. It explain economic growth contributes to the increased emissions rate of all the components of GHG [15]. The growth of emissions of GHG emerged as a source of transferable and non-infectious sicknesses. The average global temperature is increasing significantly and the carbon absorption has surpassed 400 ppm owing to an increase in GHG emissions. Sensitivity analysis of the sources of GHG indicates that emissions of anthropogenic CO2 from people would reduce, while emissions from industry would increase emissions and would increase the level of GHG emissions [16]. GHG emissions were a major area of concern in case of economic and health conditions of the countries. Research discovered that the transportation sector was a major source of GHG emissions. Using coefficients of determination modified R2 and R2 values of 89.46 percent and 91.8 percent, respectively, research discovered that the Vehicle Kilometer by Mode (VKM) and Number of Transportation Vehicle (NTV) ratio for the various modes of transportation have a substantial impact on GHG emissions. These coefficients of determination values showed a positive relationship between VKM and NTV and it was a major source of growth in GHG emissions [17]. Lamb *et al.* in their study related to movements and drivers of GHG emissions found that progress towards reducing the level of GHG is limited. Modest decarbonization of energy systems was noticed in the boundaries of North America and Europe, inspired by fuel switching and the growing use of renewables while in speedily industrializing areas, fossil-based energy systems have uninterruptedly extended to GHG emissions. Very recently a decelerating trend in emissions of GHG was noticed [18]. Pradyot, Shunsuke & Babita developed a multilayer artificial neural network model to estimate carbon emissions by providing optimal weights for the forecasters with a high level of estimation accuracy [19]. Andi, Hari Krishnan proposed research is more concerned with leveraging the precise forecast of bitcoin prices through the normalization of a specific dataset. That dataset has been trained using LSTM machine learning to provide a more accurate forecast of the bitcoin price. [20]. Apache Storm is one of the most extensively used platforms for data stream processing.[21] The results of a stock market price prediction experiment reveal that the ARIMA model outperforms the DL models. [22]. In another study for the semiconductor manufacturing process, Karthigaikumar, P. suggests an industrial quality prediction system based on a mix of several Program Component Analysis (PCA) and Decision Stump (DS) algorithms for MMP quality prediction [23]. Li et al. forecasted the emissions of GHG using a new information priority generalized accumulative grey model. The maximum value of the novel model was found by the intelligent optimization algorithm [24].

According to most of the studies mentioned above, a GHG emission is a considerable factor in climate change. The rate of GHG emissions can impact the Earth's temperature and can lead to economic loss and expansion of the economy. Few common research issues observed from previous research are (1) most of the research are related to factors contributing to emission of GHG (2) traditional method of forecasting like regression are used commonly used in forecasting the value of GHG emission. To overcome the problem related to traditional method of forecasting more advanced data driven intelligent time series methods (ARIMA) is used for forecasting in the study. The Prediction of GHG emissions using time series data analysis methods facilitated in projecting the rate of GHG emissions. Utmost of the research discussed above finds ARIMA an ideal and best precise technique for projecting. Projection of GHG emissions in India can give policymakers and the government a precise image

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of upcoming GHG emissions which will support realizing the policies and actions to meet the target set in the Paris climate agreement to reduce the GHG emissions and Earth's temperature.

III. Research Methodology

The objective of this research is to investigate the past and current trends of GHG emissions in India and to forecast the emissions of GHG for future Years. To accomplish the intent of the research, the objectives of the research are split into two (1) To find the most suitable and best-fit ARIMA model to predict the GHG emissions (2) To forecast the GHG emissions in the upcoming decade in India. The purpose of this study is to predict future GHG emissions in India by using ARIMA for a period of 10 years, ranging from 2021-to 2030.

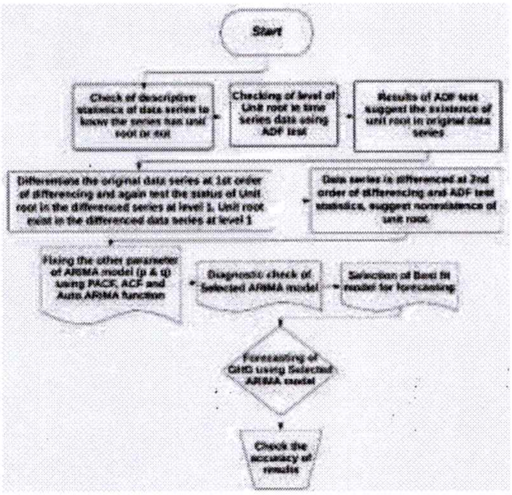

Figure 1 Research Flow Chart

This research advocates the use of the secondary source of data to study the level of GHG emissions for present and upcoming periods in India and to forecast the future emissions of GHG. A secondary data source, related to GHG emissions is the database of the World Bank. Evidence related to the current level of GHG emissions in India are collected from reports in the World Bank database. The time series technique ARIMA (Autoregressive Integrated Moving Average) is applied to anticipate GHG emissions in India. An Augmented Dickey-Fuller (ADF) test is used to determine the stability of the data series under consideration. In order to complete the selection of an appropriate ARIMA model, Autocorrelation function (ACF), and Partial autocorrelation function (PACF) plots is used. In this study, partial autocorrelation correlograms and correlograms are used to establish ARIMA model parameters (p, d, and q), and the validity of the ARIMA model is assessed using the Auto.Arima function in R software. Statistical tools such as R, E-Views, and Microsoft Excel are used for data analysis and forecasting.

IV. Forecasting of GHG Emissions (KT OF C02 EQUIVALENT) in India

4.1 Analysis and Discussion

In Figure 2, the plot of total GHG emissions showed moving trends with minimal variations in recent years. According to the graphic analysis of GHG emissions, mean, variance, and covariance, measures of descriptive statistics such do not follow a continuous trend and change over the period, indicating that the GHG emissions series for India do not follow stationary patterns. A visual examination of the time series of total GHG emissions in figure 2 reveals a growing trend, indicating that it is non-stationary.

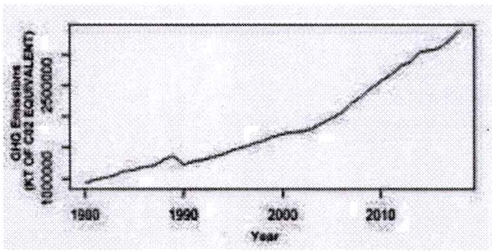

Figure 2 Greenhouse gas emissions (KT of Co2 equivalent)

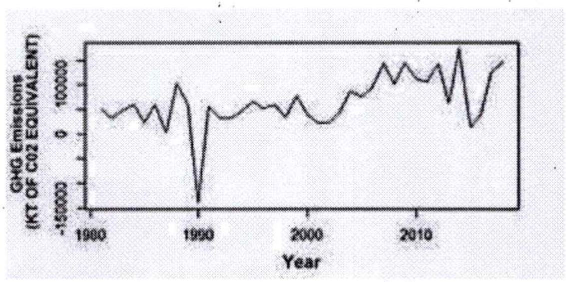

Figure 3 Greenhouse gas emissions (KT of Co2 equivalent) at the first order of differencing

The initial step in time series analysis is to test for stationarity before applying any of the time series models for forecasting. The ADF test is a fairly reliable statistical test for determining the stationarity of data series or the presence of a unit root in the series. The Augmented Dickey-Fuller (ADF) test is applied to India's total GHG emissions data set.

Table 1: Test statistics of ADF Test

Level of Differencing	At Level	At first order	At second-order
Augmented Dickey-Fuller test	3.45	-2.69	-10.31
P- Value	1.00	.083	.01
1% significance level	-3.61	-3.62	-3.62
5% significance level	-2.94	-2.94	-2.94
10% significance level	-2.60	-2.61	-2.61

The ADF test findings shown in table 1 represent the value of value of ADF at original data series and differenced data series at order 1, the value of the test is more than the t-statistic at the 1%, 5%, and 10% levels of significance, and the Probability (p) score is larger to ideal value of .05, at level and 1st order of differencing, indicating that the GHG emissions data series does not appear to track a pattern of stationarity at level and 1st order. The original data series relating to GHG emissions are differenced at the second-order level to convert the non-stationary.

4.2 Second-Order Difference

Time series data related to total GHG emissions in India are differenced at a second-order level to transform the original data series into a data series which follows the stationary pattern.

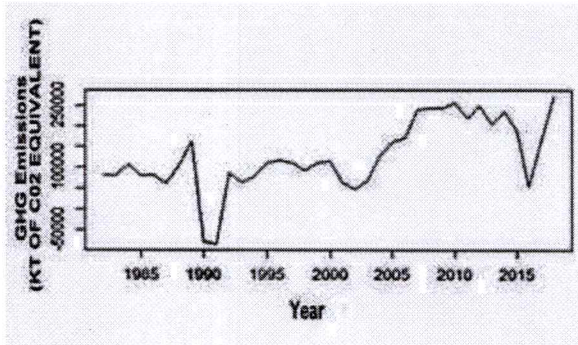

Figure 4 Greenhouse gas emissions (KT of Co2 equivalent) at second order of differencing

As shown in Figure 4, a time series plot created by employing second-order differencing appears persistent on the measures of descriptive statistics like (mean, variance, and covariance), implying that the data of GHG emissions in India follows a stationary pattern. The ADF test is used to examine the nature of data series (unit root) at level and at first order differenced time series, and the test results in table 1 support the null hypothesis of a non-stationary time series.

ADF test statistics in table 1 at the second level of differencing, shows that the value of the ADF test is less than the value of the t-test value at the 1% and 5% levels of significance, and the Probability value is smaller than .05, indicating that the original data series diverged at the 2nd order follows a stationary pattern. The results of ADF test approve the rejection of the null hypothesis of non-stationary data series and confirm the acceptance of the alternative hypothesis of stationary time series and confirm the stationarity pattern in time series. As a result, the parameter d is 2 in the ARIMA model (p,d,q).

4.3 Partial Auto Correlogram and Correlogram

PACF and ACF plots can be used to find out the parameters of the best fit ARIMA model. To find the best suitable AR and MA (p & q) parameter value in the ARIM

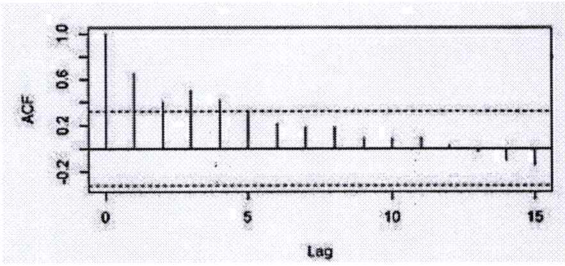

Figure 5 ACF Plot at second order of differencing

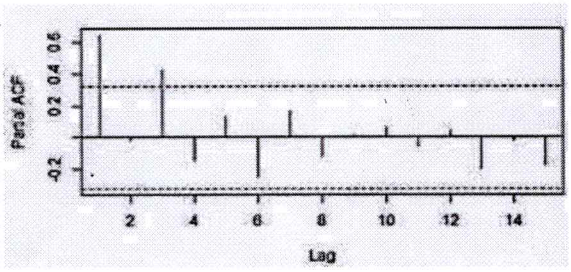

Figure 6 PACF Plot at second order of differencingA model, the PACF and ACF plots are examined

A visual view of PA Correlogram or PACF plot showed that Auto regression (AR =p) equal to 0 as it dies down quickly and cut off before lag 1 and all its bar are within the boundary. A visual inspection of ACF plot suggest the Moving average (MA =q) equals to 1 as it is decreasing gradually with the lag length thus the value of AR and MA (p & q) in ARIMA (p,d,q) is 0 and 1 correspondingly. Thus, the ARIMA model's projected parameters are AR =0, integrated =2, and moving average =1. Henceforth results of PACF and ACF plots suggest ARIMA (0,2,1) as the best fit model according to the properties of the data series to forecast the value of GHG emissions in India.

4.4 AUTO.ARIMA Function

Auto.Arima is an inbuilt function in R software which suggest the best fit ARIMA model on the basis of nature of data series using the criteria of selection of best fit ARIMA model (p.d.q). Acceptability of selected ARIMA (0,2,1,) model is tested using the "auto. arima" inbuilt function in software R which advises the most suitable and appropriate model according to the pattern of data. We found a best-fit model using the "Auto. Arima()" function to be ARIMA (0,2,1), which is same as we found earlier using partial auto correlograms and correlograms.

Table 2- Best-fit ARIMA Model

Series: greenhouse
ARIMA(0,2,1)
Coefficient:
ma1
-0.7956
s.e. 0.0937
Sigma^2 estimated as 2.59e+09: log likelihood =-453.48
AIC=910.96 AICc= 911.31 BIC=914.18

The results of "auto.Arima()" are shown in table 2 as the ARIMA (0,2,1) satisfies all investigative checks so we applied it to the forecasting of GHG emissions in India.

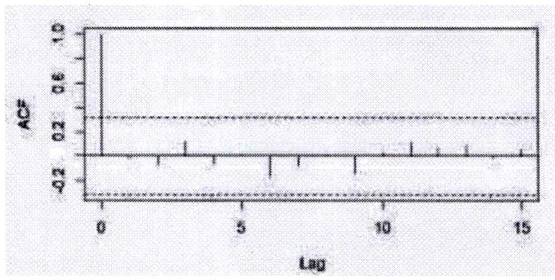

Figure 7 ACF Plot residuals at second order of differencing

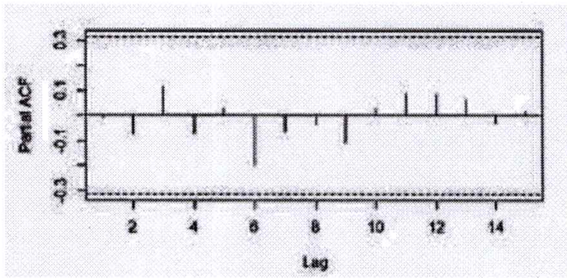

Figure 8 PACF Plot residuals at second order of differencing

Figures 7 and 8 illustrate the residuals created by ARIMA (0,2,1). Figure 7 shows an ACF plot of residuals that is acceptable within the parameters that recommend no autocorrelation. The PACF figure in Figure 8 shows that the residual series' variance does not change considerably over time. Finding of PACF plot advises any change in the residual can be viewed as lasting endless and the suggested ARIMA (0,2,1) fits the data correctly and accurately. The ARIMA (0,2,1) meets all of the diagnostic checks related to residual and approves all the properties checks of ARIMA (0,2,1)

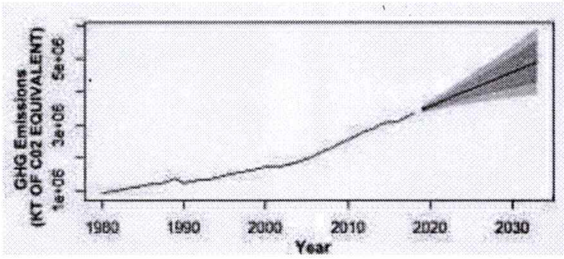

Figure 9 The forecasted value of GHG emissions

ARIMA (0,2,1) model selected using PACF and ACF plot and confirmed by AUTO.ARIMA function, after all the diagnostic and property checks are used to forecast the GHG emission for the next 10 years.

Table: 3 - Forecasted Value of greenhouse gases emission in (Kt of Co2 equivalent)

Year	Forecast	Lo 80	Hi 80	Lo 95	Hi 95
2021	3675880	3546134	3805625	3477450	3874309
2022	3778438	3615037	3941839	3528538	4028338
2023	3880996	3682313	4079680	3577136	4184857
2024	3983555	3747895	4219214	3623144	4343965
2025	4086113	3811784	4360442	3666564	4505663
2026	4188672	3874008	4503335	3707436	4669907
2027	4291230	3934606	4647854	3745820	4836640
2028	4393788	3993619	4793958	3781782	5005795
2029	4496347	4051091	4941602	3815387	5177307
2030	4598905	4107065	5090746	3846700	5351111

The ARIMA (0,2,1) model forecasted value of GHG emissions in India shows an increasing trend over the next ten years. Table 3 and Figure 9 show the expected values and GHG emissions. Figure 9 shows an increasing trend in GHG emissions over ten years from 2021 to 2030. Figure 9's shaded area depicts the predicted amount of GHG emissions at the level of eighty percent and ninety five percent assurance levels. The probable amount of GHG emissions correspond to the past pattern of the GHG emissions. The projected value of GHG emissions in India follows the same rising patterns as in the past. Based on the findings above, it can be predicted that GHG emissions in India will continue to rise over the next ten years.

V. CONCLUSION

Climate change is a big threat to environmental degradation and it has contributed to changing patterns of the weather cycle, increase in earth's temperature, global warming, and many more. 196 Countries across the world have come forward in the form of the Paris agreement to bound global heating below 2 preferably to 1.5 degrees Celsius. To achieve the longstanding temperature goal, member countries are taking responsibility and aspiring efforts to fight against climate change and adapt to its effects by economic and social changes, based on the best available science. In the 2020 summit on climate change, countries have submitted their plans in the form of nationally determined contributions to reduce their emissions of GHG emissions to reach the targets of the Paris agreement. India as a member of the Paris agreement has set its target to reduce greenhouse gas emissions by half the amount of GHG produced for every dollar of economic activity by the end of the decade. Projection of GHG emission using the projective technique will project (annual emission) value of GHG emission and this will guide the government and policy makers to plan accordingly. It is anticipated that the projection of GHG emissions in India will assist the government in developing strategies and actions to reduce GHG emissions and meet the Paris Agreement target by increasing the share of non-fossil fuels in total power generation capacity up to 40 percent, decreasing the economy's emissions intensity by 33 to 35 percent relative to 2005 levels and generating an additional 2.5 billion to 3 billion metric tonnes of carbon dioxide equivalent in carbon sinks.

References

[1] E. Claussen, "Technology and Climate Change: Sparking a New Industrial Revolution," *Am. Inst. Chem. Eng. New Orleans, LA*, vol. 10, 2002.

[2] R. A. Kerr, "Three degrees of consensus." American Association for the Advancement of Science, 2004.

[3] V. S. Negi, R. K. Maikhuri, D. Pharswan, S. Thakur, and P. P. Dhyani, "Climate change impact in the Western Himalaya: people's perception and adaptive strategies," *J. Mt. Sci.*, vol. 14, no. 2, pp. 403–416, 2017.

[4] IPCC, "IPCC 2014 Impacts - Technical Summary," Cambridge University Press, Cambridge, UK and New York, USA, pp. 169-1131., 2014. [Online]. Available: https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf.

[5] IEA, "International energy law: Rules governing future exploration, exploitation and use of renewable resources," 2017. doi: 10.4324/9781315252056.

[6] C. Deb, F. Zhang, J. Yang, S. E. Lee, and K. W. Shah, "A review on time series forecasting techniques for building energy consumption," *Renew. Sustain. Energy Rev.*, vol. 74, pp. 902–924, 2017.

[7] P. Sen, M. Roy, and P. Pal, "Application of ARIMA for forecasting energy consumption and GHG emission: A case

study of an Indian pig iron manufacturing organization," *Energy*, vol. 116, pp. 1031–1038, 2016.

[8] G. Althor, J. E. M. Watson, and R. A. Fuller, "Global mismatch between greenhouse gas emissions and the burden of climate change," *Sci. Rep.*, vol. 6, no. 1, pp. 1–6, 2016.

[9] S. K. Huang, L. Kuo, and K.-L. Chou, "The applicability of marginal abatement cost approach: A comprehensive review," *J. Clean. Prod.*, vol. 127, pp. 59–71, 2016.

[10] A. Rahman and M. M. Hasan, "Modeling and forecasting of carbon dioxide emissions in Bangladesh using Autoregressive Integrated Moving Average (ARIMA) models," *Open J. Stat.*, vol. 7, no. 4, pp. 560–566, 2017.

[11] S. M. Hosseini, A. Saifoddin, R. Shirmohammadi, and A. Aslani, "Forecasting of CO2 emissions in Iran based on time series and regression analysis," *Energy Reports*, vol. 5, pp. 619–631, 2019.

[12] A. Sangeetha and T. Amudha, "A novel bio-inspired framework for CO2 emission forecast in India," *Procedia Comput. Sci.*, vol. 125, pp. 367–375, 2018.

[13] T. Nyoni and W. G. Bonga, "Prediction of co2 emissions in india using arima models," *DRJ-Journal Econ. Financ.*, vol. 4, no. 2, pp. 1–10, 2019.

[14] S. M. Hosseini, A. Saifoddin, R. Shirmohammadi, and A. Aslani, "Energy Reports," 2019.

[15] A. M. Yusuf, A. B. Abubakar, and S. O. Mamman, "Relationship between greenhouse gas emission, energy consumption, and economic growth: evidence from some selected oil-producing African countries," *Environ. Sci. Pollut. Res.*, vol. 27, no. 13, pp. 15815–15823, 2020.

[16] A. Mikhaylov, N. Moiseev, K. Aleshin, and T. Burkhardt, "Global climate change and greenhouse effect," *Entrep. Sustain. Issues*, vol. 7, no. 4, p. 2897, 2020.

[17] R. Alhindawi, Y. Abu Nahleh, A. Kumar, and N. Shiwakoti, "Projection of greenhouse gas emissions for the road transport sector based on multivariate regression and the double exponential smoothing model," *Sustainability*, vol. 12, no. 21, p. 9152, 2020.

[18] W. F. Lamb *et al.*, "A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018," *Environ. Res. Lett.*, 2021.

[19] P. R. Jena, S. Managi, and B. Majhi, "Forecasting the CO2 Emissions at the Global Level: A Multilayer Artificial Neural Network Modelling," *Energies*, vol. 14, no. 19, p. 6336, 2021.

[20] H. K. Andi, "An Accurate Bitcoin Price Prediction using logistic regression with LSTM Machine Learning model," *J. Soft Comput. Paradig.*, vol. 3, no. 3, pp. 205–217, 2021.

[21] J. Geetha, D. S. Jayalakshmi, R. R. Ganiga, S. Z. Kottur, and T. Surabhi, "Improvised Distributed Data Streaming Scheduler in Storm," in *International Conference on Communication, Computing and Electronics Systems*, 2021, pp. 557–568.

[22] C. Anand, "Comparison of Stock Price Prediction Models using Pre-trained Neural Networks," *J. Ubiquitous Comput. Commun. Technol.*, vol. 3, no. 02, pp. 122–134, 2021.

[23] P. Karthigaikumar, "Industrial Quality Prediction System through Data Mining Algorithm," *J. Electron. Informatics*, vol. 3, no. 2, pp. 126–137, 2021.

[24] K. Li, P. Xiong, Y. Wu, and Y. Dong, "Forecasting greenhouse gas emissions with the new information priority generalized accumulative grey model," *Sci. Total Environ.*, vol. 807, p. 150859, 2022.

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Dr. Ashish Kumar Saxena

has successfully presented the paper entitled

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