FORECASTING COVID-19 CASES: ARTIFICIAL NEURAL NETWORKS SUGGEST THAT THE PANDEMIC WILL SOON DISAPPEAR IN NEPAL

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ABSTRACT

The global spread of COVID-19 has triggered a range of public health responses, including the need for modeling and forecasting the transmission dynamics of the pandemic. The ANN approach was applied to analyze COVID-19 cases in Nepal. The employed data covers the period January 25, 2020 to October 31, 2020 and the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model suggest that the model is stable in forecasting daily COVID-19 cases in Nepal. The study predicts that the pandemic will start disappearing in Nepal around November 28, 2020 onwards. People in Nepal should not be complacent but rather continue to behave responsibly in order to avoid a second wave of infections. To ensure total public health safety, the government of Nepal should continue to ensure strict adherence to WHO sanitary rules and guidelines.

Keywords: - *ANN, COVID-19, Forecasting*

INTRODUCTION

COVID-19 originated from China, specifically from the city of Wuhan, in late 2019 (WHO, 2020). The increasing number of new infections and death toll the virus has been a major threat and challenge for each and every country (Pathak *et al*., 2020). On March 11, 2020; the World Health Organization (WHO) declared it as a pandemic (WHO, 2020). Nepal is a landlocked country sharing borders with India and China. In the North, Nepal shares the border with China which is the epicenter of the pandemic and other three sides; the country shares the borders with India which is experiencing a surge in COVID-19 cases. The first case of COVID-19 in Nepal was officially recorded on January 25, 2020. It was a 32-year old male student, studying in Wuhan, China, who had returned in Nepal on January 9, 2020. At first, the escalation of cases was very slow, with the first case of local transmission being recorded on April 4, 2020. Approximately 2 months later, on March 24, 2020; the government of Nepal imposed a nationwide lockdown, which lasted for 58 days; after which the government made a five-phase re-opening plan. June 2020, is the month during which the number of cases in Nepal significantly increased, precisely due to the influx of migrant workers from India (Thakur *et al*.,

2020). Very few studies have predicted COVID-19 dynamics in the country, for example; Thapa (2020), who employed SIR models and forecasted that the peak of the epidemic will be reached around August to October 2020. Given the magnitude of destruction caused by the pandemic in the country, there is need for more studies in order to improve policy formulation in Nepal. In an attempt to predict how COVID-19 will spread in Nepal and to influence public health interventions in the country to achieve the greatest impact, the current study will model and forecast daily COVID-19 case volumes in Nepal.

METHODOLOGY

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in Nepal. This study particularly applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. The study is based on daily new covid-19 cases (referred to as NC series in this study) for all age groups in Nepal. The data covers the period 25 January 2020 to 31 0ctober 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this research paper was gathered from John Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
607.63	156.00	0.00000	5743.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
1009.1	1.6607	2.4083	6.0341
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	3077.9	780.50	0

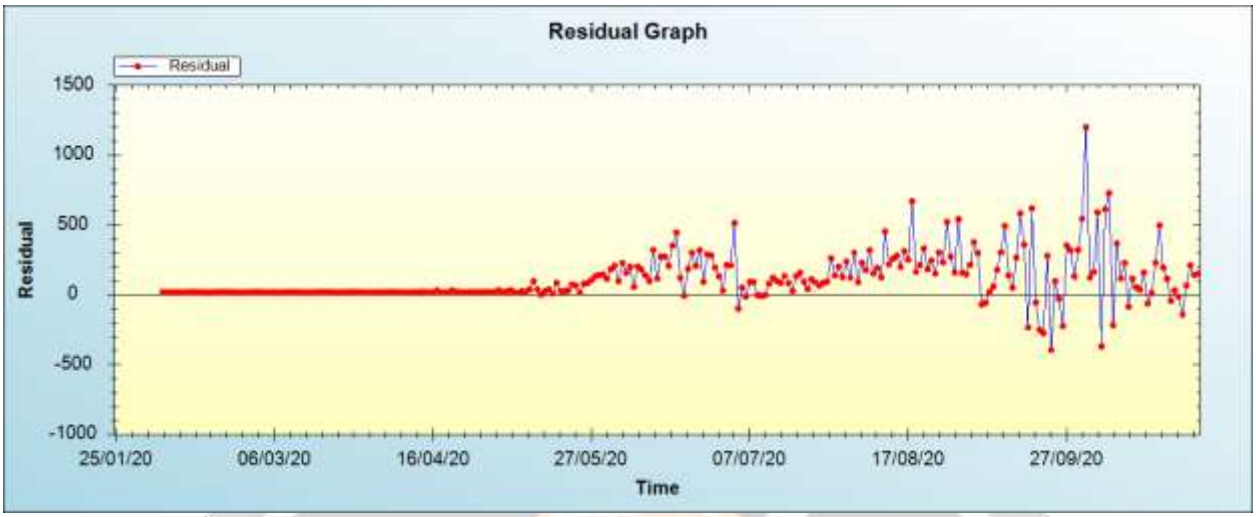
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN NEPAL

Table 2: ANN model summary

Variable	NC
Observations	269 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.064393
MSE	42209.437530
MAE	132.584792

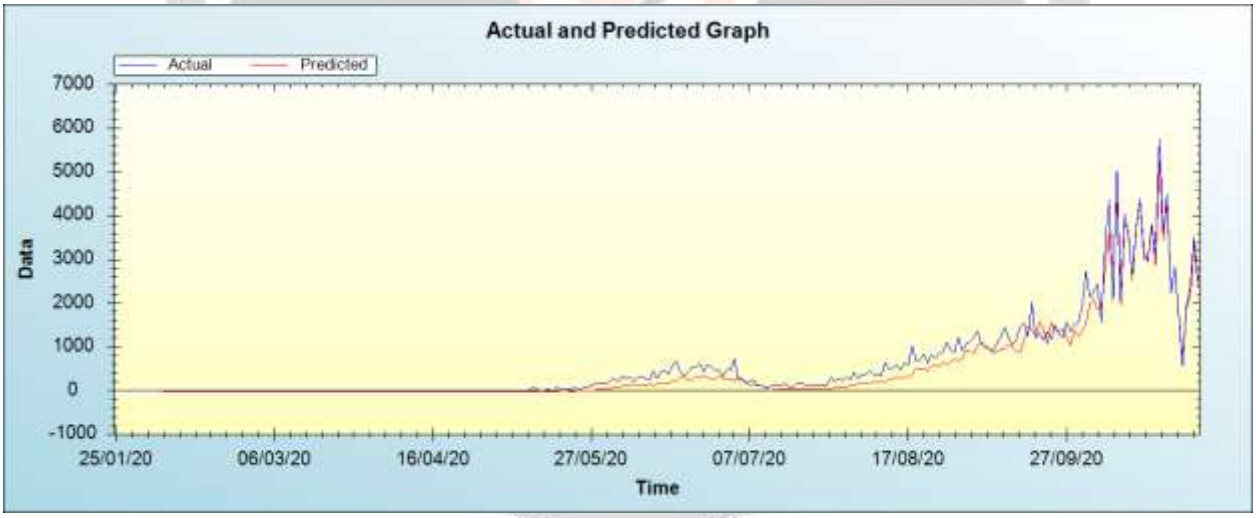
Residual Analysis for the ANN model

Figure 1: Residual analysis



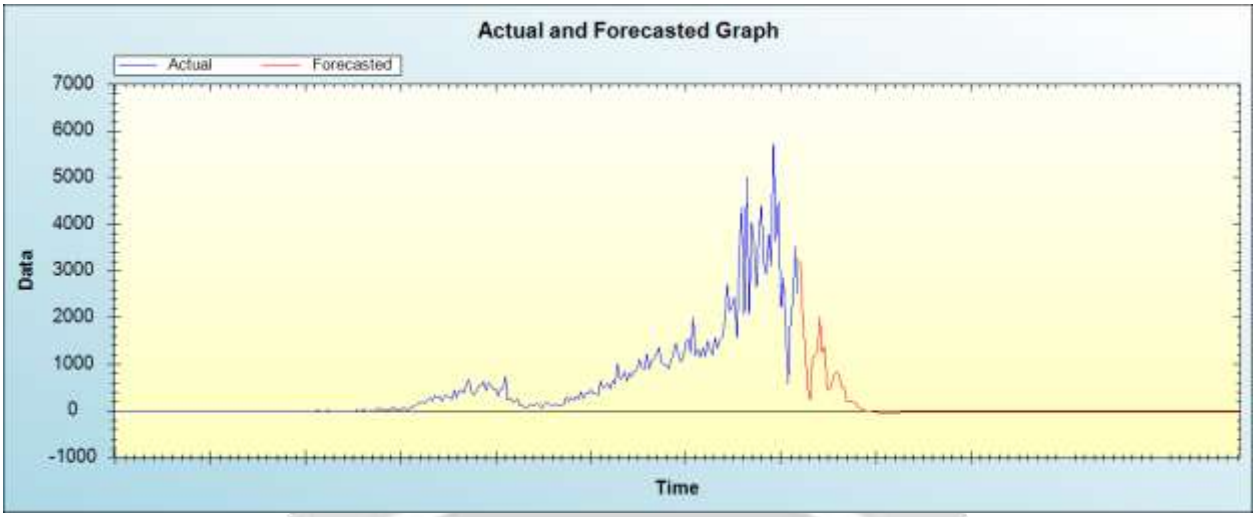
In-sample Forecast for NC

Figure 2: In-sample forecast for the NC series



Out-of-Sample Forecast for NC: Actual and Forecasted Graph

Figure 3: Out-of-sample forecast for NC: actual and forecasted graph



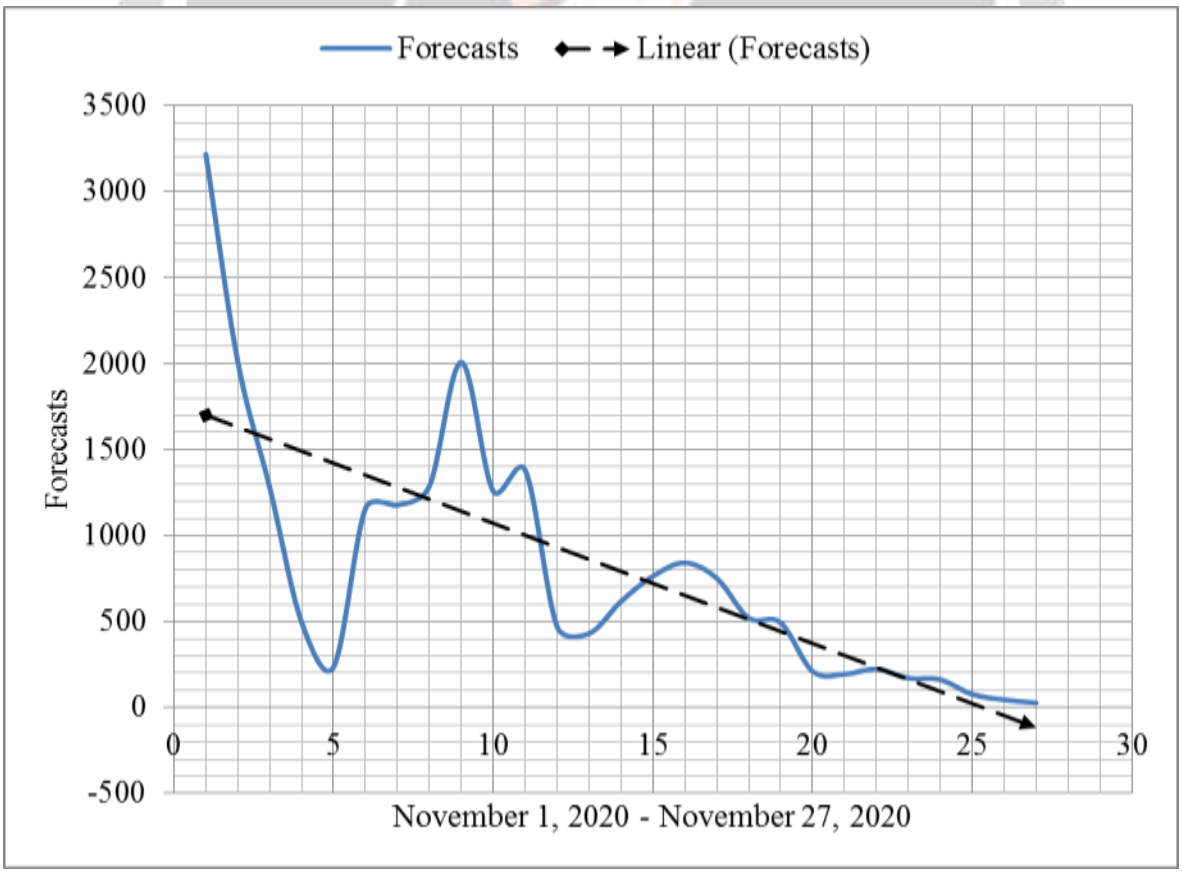
Out-of-Sample Forecast for NC: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	3217.0438
02/11/20	2012.0738
03/11/20	1280.8069
04/11/20	495.1600
05/11/20	235.9442
06/11/20	1158.6022
07/11/20	1176.1552
08/11/20	1285.9711
09/11/20	2007.9466
10/11/20	1257.6746
11/11/20	1380.5266
12/11/20	469.7489
13/11/20	430.1907
14/11/20	617.2055
15/11/20	764.1833

16/11/20	841.6350
17/11/20	751.9942
18/11/20	520.9258
19/11/20	493.3309
20/11/20	210.3742
21/11/20	194.2950
22/11/20	223.9381
23/11/20	170.6946
24/11/20	162.1621
25/11/20	77.1182
26/11/20	45.1038
27/11/20	26.9475

Figure 4: Graphical presentation of out-of-sample forecasts



The average number of daily cases over the study period is 608 cases per day while the maximum has been shown to be 5743 cases. With a population of approximately 30 million, these are very large number for Nepal. Table 2 is the summary of the ANN model employed while figure 1 shows the residual diagnostics of the model. The model is indeed stable. Figure presents the in-sample forecasts while figure 3 and table show out-of-sample predictions. The study establishes the idea that COVID-19 daily cases will continue to fall over the out-of-sample period. Specifically, the study shows that cases will continue to decline from the estimated 3217 cases on November 1, 2020 down to approximately 27 cases by November 27, 2020. This clearly suggests that by the tail end of November 2020, the pandemic is most likely to start varnishing or disappearing in Nepal. By early December 2020, onwards we project that the pandemic will no longer be a big threat in Nepal. By then, the country could possibly start on engaging on a genuine post-COVID-19 recovery trajectory. The results of this study are consistent with Thapa (2020) who predicted that the pandemic would peak around August to October 2020 in the country and thereafter, decline gradually.

CONCLUSION & RECOMMENDATIONS

The COVID-19 pandemic continues to rapidly spread across the globe with high mortality, severely straining health systems and causing devastating social disruptions and economic damage. Just like any other developing country with a fragile healthcare system, Nepal has already suffered significantly to the pandemic; and also due to the fact that Nepal is a remittance-based economy (Chaudhary, 2020), the country has been greatly affected. The study is based on 281 daily COVID-19 observations and projections that the pandemic will soon disappear in Nepal by the tail end of November 2020. The rest of the out-of-sample period, beginning from December 2020 up to April 2020, will be largely characterized by zero new cases on almost on a daily basis. To ensure total public health safety, the government of Nepal should continue to ensure strict adherence to WHO sanitary rules and guidelines.

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