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Forecasting Daily New Covid-19 Cases in the Kingdom Of Eswatini Using Artificial Neural Networks

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***Abstract* - In this research article, the ANN approach was applied to analyze daily new COVID-19 cases in the Kingdom of Eswatini. The employed data covers the period 1 January 2020 to 31 December 2020 and the out-of-sample period ranges over the period 1 January 2021 to 31 May 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting daily COVID-19 cases in Eswatini. The results of the study indicate that daily COVID cases will generally be between 0-260 cases over the out of sample period. Therefore the health authorities in Eswatini should continue enforcing the implementation of WHO guidelines on prevention and control of COVID-19.**

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

The kingdom of Eswatini is a lower middle income country with a total population of 2.1 million (Nhapi & Dhemba, 2020) and ranked 138 out of 189 countries in the 2019 Human development Index (World Bank, 2020; World Bank, 2017). A large proportion of people are living in poverty with 58.9 % of the rural populace living below the poverty datum line. Eswatini Kingdom did not escape the CVID-19 pandemic just like other neighboring SADC countries. On the 17th of March 2020 the government declared a state of emergency to control and limit the spread of the virus. Several measures were implemented such as wearing of face masks, social distancing, regular hand washing and isolation and treatment of cases. The government set aside funds to fight the epidemic. Partners such as PEPFAR, UN agencies and the Global Fund to fight AIDS, TB and MALARIA also committed funds to prevent and control the epidemic (World Bank, 2020; UNICEF, 2018). Arms of government and stakeholders made a meaningful participation in the national response to the COVID-19 epidemic (Deputy Prime minister's office Eswatini, 2019). The aim of this paper is to model and forecast daily new corona virus infections in the Kingdom of Eswatini using the multilayer perceptron (MLP).The model is composed of 3 layers of neurons namely the input, hidden and output layer connected by connection weights (Nyoni et al, 2020; Zhao et al, 2020; Arora et al, 2020; Yan et al, 2018; Kolter & Koltun, 2018; Kaushik & Sahi, 2018; Ruder, 2017; Fojnica et al, 2016;Quazi et al, 2015; Raghupathi & Raghupathi, 2015; Schmidhuber, 2014; Yan et al, 2006; Zhang, 2003; Kishan, 1997; Patterson, 1995). The findings of this are expected to reveal the future trends of daily COVID-19 cases in Eswatini and facilitate planning and the national response to the epidemic.

II. LITERATURE REVIEW

Table 1: Review of Literature

Author (s)	Study period	Method	Findings
Abebe (2020)	March – June, 2020	Exponential Smoothing Model	Double Exponential Smoothing method was appropriate in forecasting the future number of COVID-19 cases in Ethiopia. COVID-19 cases in Ethiopia are growing exponentially

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Balcha (2020)	March – June, 2020	Curve Fitting and Least Squares	COVID-19 cases trending upwards, sharply
Khajanchi & Sarkar (2020)	January – June, 2020	Compartmental Mathematical Model	Short-time prediction shows the increasing trend of daily and cumulative cases of COVID-19 for the 4 (studied) states of India
Nyoni et al (2020)	30 January 2020 to 30 October 2020	ANN model	COVID-19 daily new infections are likely to, generally, remain quite very high; over the next 6 months in India

III. METHODOLOGY

The Artificial Neural Network (ANN) will be applied in this study. It has the capability of learning from any data-set to describe the nonlinear and interaction effects with great accuracy. Arguably, explicit guidelines exist for the determination of the ANN structure hence the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function.

Data Issues

This study is based on daily new cases of COVID-19 in the Kingdom of Eswatini for the period 1 January – 31 December 2020. The out-of-sample forecast covers the period January 2021 – May 2021. All the data employed in this paper was gathered from the World Bank.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 2: ANN model summary

Variable	P
Observations	354 (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	0.546023
MSE	186.684522
MAE	10.344581

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Residual Analysis for the Applied Model

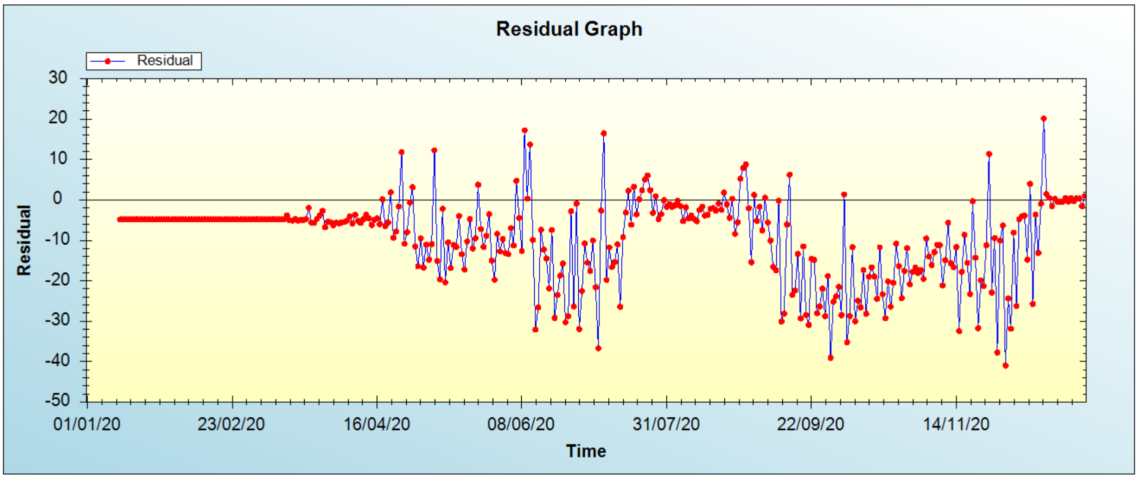

Figure 1: Residual analysis

In-sample Forecast for P

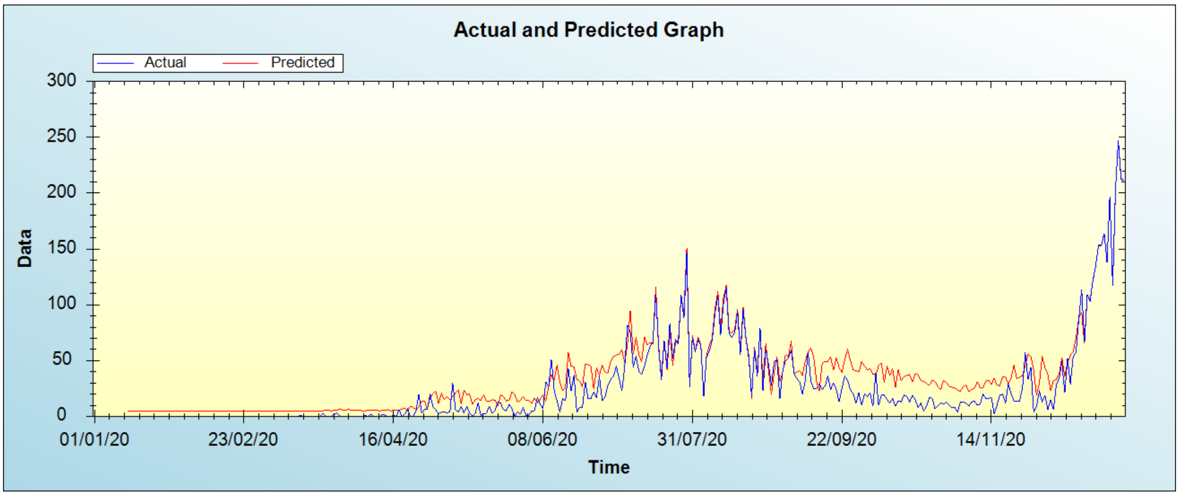

Figure 2: In-sample forecast for the P series

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

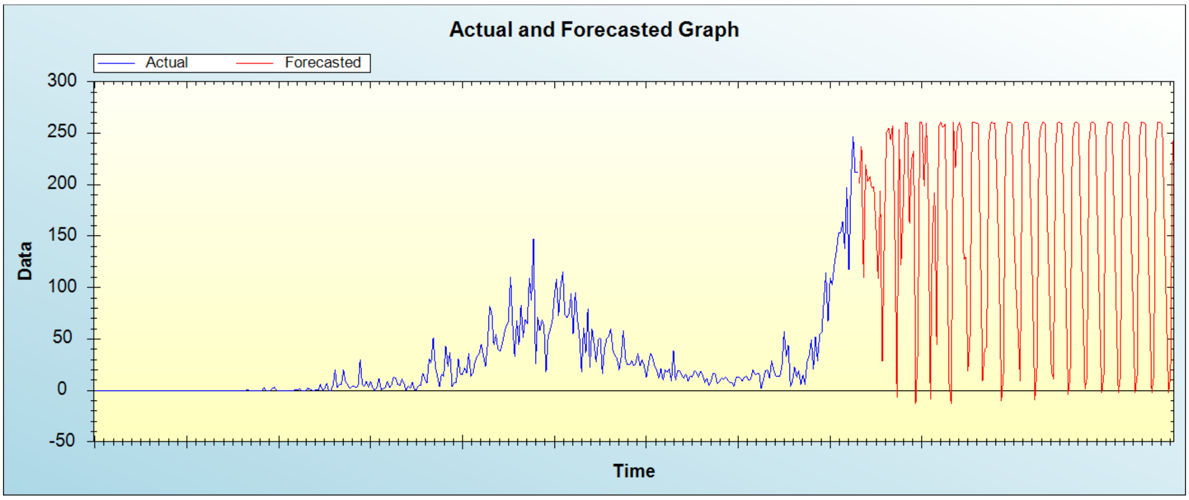

Figure 3: Out-of-sample forecast for P: actual and forecasted graph

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Out-of-Sample Forecast for P: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/year	Forecasted daily COVID-19 cases
01/01/21	201.5753
02/01/21	237.4193
03/01/21	109.4545
04/01/21	218.7287
05/01/21	203.2454
06/01/21	207.6121
07/01/21	196.5995
08/01/21	198.0407
09/01/21	155.4417
10/01/21	108.7166
11/01/21	193.5694
12/01/21	28.7014
13/01/21	152.1418
14/01/21	250.1324
15/01/21	255.2137
16/01/21	243.5162
17/01/21	257.3841
18/01/21	155.4984
19/01/21	-6.4047
20/01/21	253.6114
21/01/21	121.5724
22/01/21	179.6465
23/01/21	260.4139
24/01/21	259.1619
25/01/21	162.1146
26/01/21	224.1058
27/01/21	232.5544
28/01/21	-12.6667

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29/01/21	38.7234
30/01/21	260.5890
31/01/21	260.0524
01/02/21	198.2643
02/02/21	260.0192
03/02/21	197.8019
04/02/21	-8.5953
05/02/21	154.0858
06/02/21	192.0882
07/02/21	44.6947
08/02/21	256.8289
09/02/21	260.6917
10/02/21	255.3556
11/02/21	258.7179
12/02/21	144.1982
13/02/21	7.2997
14/02/21	-12.8474
15/02/21	260.3929
16/02/21	215.8931
17/02/21	255.0045
18/02/21	260.5934
19/02/21	252.3999
20/02/21	127.1712
21/02/21	129.7337
22/02/21	19.1005
23/02/21	52.3281
24/02/21	260.1463
25/02/21	260.6995
26/02/21	259.8144
27/02/21	259.3572
28/02/21	142.2661

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01/03/21	9.1602
02/03/21	40.3182
03/03/21	41.7737
04/03/21	242.9073
05/03/21	260.7006
06/03/21	259.8466
07/03/21	259.9479
08/03/21	192.4094
09/03/21	114.4334
10/03/21	-10.3316
11/03/21	16.4285
12/03/21	244.4671
13/03/21	260.6825
14/03/21	260.6819
15/03/21	259.2367
16/03/21	160.4630
17/03/21	99.3636
18/03/21	55.5762
19/03/21	9.8087
20/03/21	231.9415
21/03/21	260.6322
22/03/21	260.6296
23/03/21	259.7201
24/03/21	183.1039
25/03/21	95.6206
26/03/21	-9.2276
27/03/21	21.0292
28/03/21	241.8584
29/03/21	257.3906
30/03/21	260.6929
31/03/21	259.3521

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01/04/21	164.7102
02/04/21	96.4931
03/04/21	19.1805
04/04/21	11.5213
05/04/21	238.9048
06/04/21	260.6206
07/04/21	260.5569
08/04/21	259.3710
09/04/21	170.3067
10/04/21	86.9061
11/04/21	-4.1526
12/04/21	15.3674
13/04/21	242.1965
14/04/21	260.2167
15/04/21	260.6120
16/04/21	258.8583
17/04/21	166.4785
18/04/21	84.8564
19/04/21	0.8571
20/04/21	13.7950
21/04/21	242.1817
22/04/21	260.5901
23/04/21	260.4841
24/04/21	258.8674
25/04/21	167.6048
26/04/21	81.9512
27/04/21	-2.6016
28/04/21	14.6382
29/04/21	242.6874
30/04/21	260.5669
01/05/21	260.4897

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02/05/21	258.7749
03/05/21	167.5138
04/05/21	82.8704
05/05/21	-2.2324
06/05/21	14.3654
07/05/21	242.6958
08/05/21	260.5966
09/05/21	260.4718
10/05/21	258.7612
11/05/21	167.2910
12/05/21	82.3700
13/05/21	-2.0738
14/05/21	14.4344
15/05/21	242.6778
16/05/21	260.5925
17/05/21	260.4717
18/05/21	258.7625
19/05/21	167.4300
20/05/21	82.3241
21/05/21	-2.2982
22/05/21	14.4660
23/05/21	242.7160
24/05/21	260.5934
25/05/21	260.4714
26/05/21	258.7610
27/05/21	167.4007
28/05/21	82.4331
29/05/21	-2.2246
30/05/21	14.4401
31/05/21	242.7055

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The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that daily COVID cases will generally be between 0-260 cases over the out of sample period.

V. CONCLUSION & RECOMMENDATIONS

The Kingdom of Eswatini is a small country which is battling the epidemics of HIV and TB. The emergence of the COVID-19 pandemic increased the vulnerability of its citizens. Hence the government had to intervene by financially assisting the vulnerable members of the society which included the elderly, socially disadvantage children and disabled persons in the society. The results of this study revealed that daily COVID cases will generally be between 0-260 cases over the out of sample period. Therefore the government should continue following WHO guidelines and protocols for the prevention and control of COVID-19.

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