*International Research Journal of Innovations in Engineering and Technology (IRJIET)*

**ISSN (online): 2581-3048**

**Volume 5, Issue 3, pp 227-236, March-2021**

https://doi.org/10.47001/IRJIET/2021.503038

# Forecasting Daily Covid-19 Case Volumes in Kenya Using Artificial Neural Networks

**[1]Dr. Smartson. P. NYONI, [2]Thabani NYONI, [3]Tatenda. A. CHIHOHO**

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]SAGIT Innovation Centre, Harare, Zimbabwe
[3]Independent Researcher, Harare, Zimbabwe

***Abstract* - In this piece of work, the ANN approach was applied to analyze daily new COVID-19 cases in Kenya. 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 ANN (12, 12, 1) model indicate that the model is stable in forecasting daily new corona virus cases in Kenya. The results of the study indicate that daily COVID-19 cases are likely to increase from 80 cases around 1 January 2021 up to an equilibrium point of 1500 new daily cases around 6 March 2021. Therefore the Kenyan government is encouraged to continue enforcing WHO guidelines on prevention and control of COVID-19.**

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

## I. INTRODUCTION

The COVID-19 pandemic was discovered in December 2019 in Wuhan City of China and the virus then spread to all the regions of the World in a manner that shocked humankind as they had not seen a pandemic of such magnitude (Wang et al, 2020; Wang et al, 2020; Read et al, 2020; Wang, 2020; Tang et al, 2020; CDC, 2020; Nyoni et al, 2020). The pandemic was and is still characterized by high morbidity and mortality, collapse of several business entities, and restricted movement of people, goods and services. Several countries locked down their countries as a panic response to the ferocious pandemic which was causing high fatality and spreading like the Amazon veld fire. Most confirmed cases and fatalities were reported in Europe and North America (Quaife et al, 2020). By the 4$^{th}$ of August 2020 there were more than 18.3 million cases and 694,000 deaths reported worldwide (Dong et al, 2020). The first COVID-19 case in Kenya was reported on the 13$^{th}$ of March 2020 and the government then ordered closure of schools on the 15$^{th}$ of March 2020. Mitigatory measures which were put in place included suspension of international flights, mandatory quarantine of returnees, closure of bars, temporary ban on social gatherings, restriction on opening of restaurants, and nationwide curfew from 7PM to 5AM (Dong et al, 2020). WHO guidelines were followed in order to limit the spread of the virus. The objective of this paper is to model and forecast daily COVID-19 case volume (Daily new cases) in Kenya using the artificial neural network approach. The multilayer perceptron was applied in this study and the model is composed of 3 layers which are connected by acyclic links called connection weights (Arora et al, 2020; Nyoni et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Fojnica et al, 2016; Quazi et al, 2015; Yan et al, 2006; Zhang, 2003; Kishan, 1997; Patterson, 1995). The results of this piece of work are envisioned to reveal the future trends of daily COVID-19 case volume and assist in the assessment of the impact of COVID-19 mitigatory measures.

## II. LITERATURE REVIEW

**Table 1: Review of Literature**

| Author (s) | Study period | Method | Findings |
|---|---|---|---|
| Ye &Yang (2020) | 13February 2020 to 23March 2020 | -ARIMA<br>-Uncertain ARMA model | The uncertain time series analysis was more appropriate for predicting the cumulative number of confirmed COVID-19 cases in China. |
| Mohamed et al (2020) | 21January 2020 to | FPASSA-ANFIS | The model has a high ability to predict the |

 

International Research Journal of Innovations in Engineering and Technology (IRJIET)
ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

| | | | |
|---|---|---|---|
| | 18February 2020. | | number of confirmed cases within ten days. |
| Lounis & Bagal (2020) | February – July, 2020 | SIR model | Peak of epidemic in Algeria will be reached on September 8, 2021, and the total infected persons will exceed 800000 cases at the end of the epidemic |
| Nyoni et al (2020) | 1 January 2020 to 31 October 2020 | ANN model | Daily COVID-19 cases in China; will continue to rise over the out-of sample period |
| Rezki (2020) | February – April, 2020 | Logistic growth regression model | Peak of the pandemic is 10 April 2020 |

## 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 Kenya 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 | R |
|---|---|
| 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 | 0.375800 |
| MSE | 1724.313919 |
| MAE | 29.745965 |

International Research Journal of Innovations in Engineering and Technology (IRJIET)
ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

*Residual Analysis for the Applied Model*

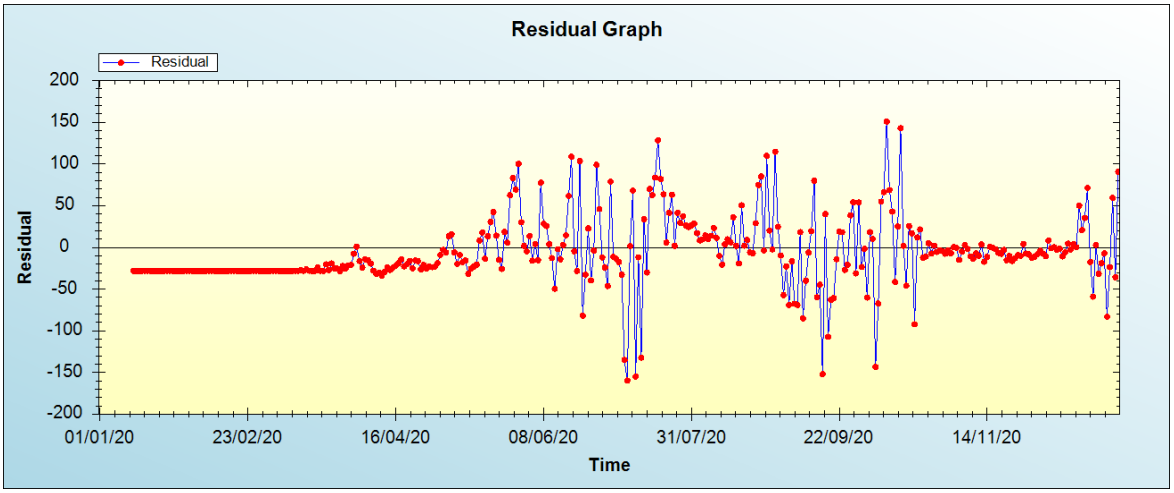


**Figure 1: Residual analysis**

*In-sample Forecast for R*

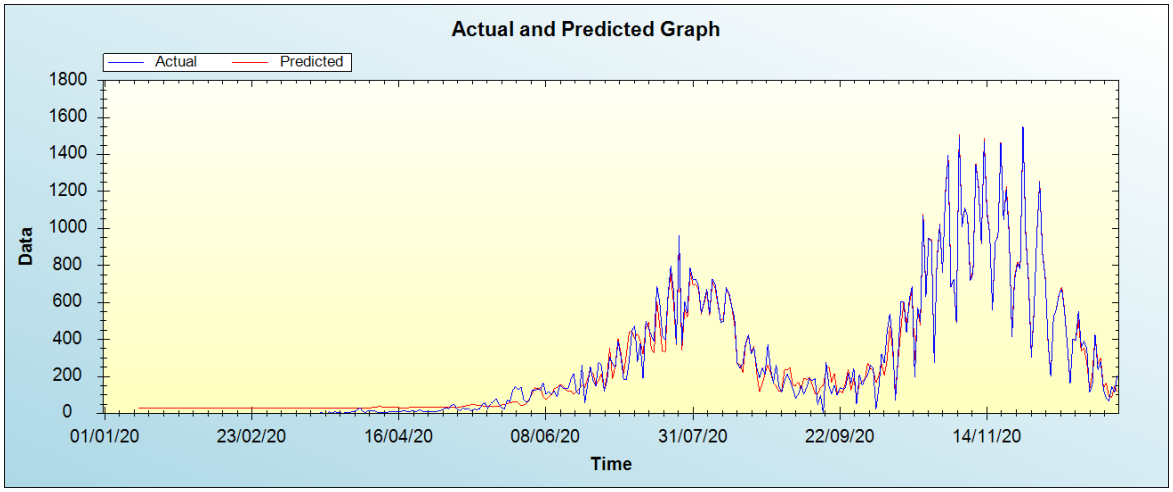


**Figure 2: In-sample forecast for the R series**

*Out-of-Sample Forecast for R: Actual and Forecasted Graph*

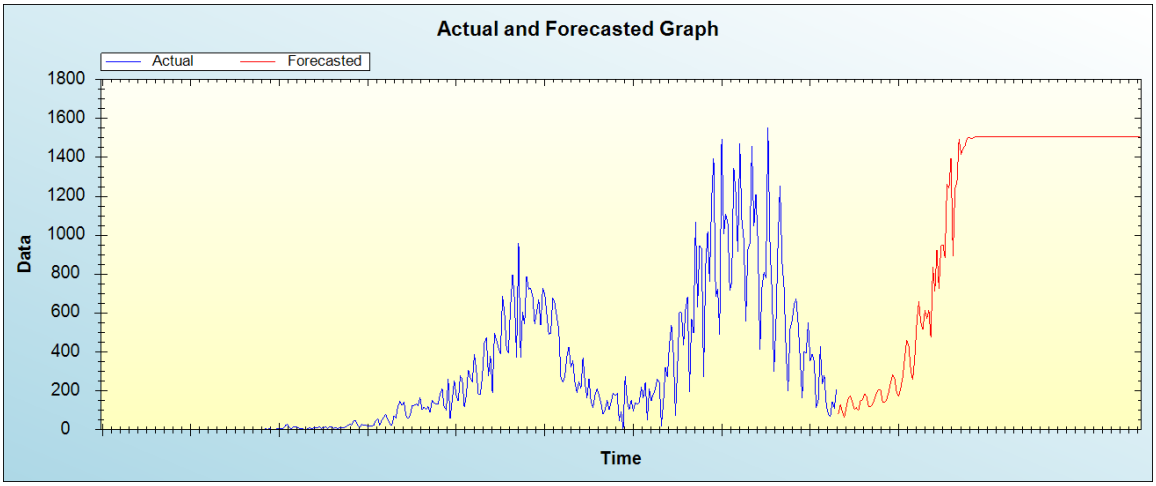


**Figure 3: Out-of-sample forecast for R: actual and forecasted graph**

International Research Journal of Innovations in Engineering and Technology (IRJIET)
ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

*Out-of-Sample Forecast for R: Forecasts only*

**Table 3: Tabulated out-of-sample forecasts**

| Day/Month/Year | Forecasted daily COVID-19 cases |
|---|---|
| 01/01/21 | 80.1076 |
| 02/01/21 | 130.4603 |
| 03/01/21 | 91.4092 |
| 04/01/21 | 66.2744 |
| 05/01/21 | 119.8959 |
| 06/01/21 | 163.3457 |
| 07/01/21 | 174.3096 |
| 08/01/21 | 142.6520 |
| 09/01/21 | 103.4902 |
| 10/01/21 | 113.8416 |
| 11/01/21 | 101.7849 |
| 12/01/21 | 149.6634 |
| 13/01/21 | 153.5633 |
| 14/01/21 | 186.2446 |
| 15/01/21 | 173.7846 |
| 16/01/21 | 121.9140 |
| 17/01/21 | 117.9511 |
| 18/01/21 | 131.4094 |
| 19/01/21 | 159.4721 |
| 20/01/21 | 191.3520 |
| 21/01/21 | 207.3736 |
| 22/01/21 | 208.1208 |
| 23/01/21 | 142.8006 |
| 24/01/21 | 143.6528 |
| 25/01/21 | 156.2210 |
| 26/01/21 | 191.9158 |
| 27/01/21 | 245.1837 |
| 28/01/21 | 282.2046 |

ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

| | |
|---|---|
| 29/01/21 | 263.5177 |
| 30/01/21 | 190.1039 |
| 31/01/21 | 175.0635 |
| 01/02/21 | 214.1730 |
| 02/02/21 | 268.1429 |
| 03/02/21 | 373.8555 |
| 04/02/21 | 461.4612 |
| 05/02/21 | 433.4113 |
| 06/02/21 | 304.5563 |
| 07/02/21 | 258.6111 |
| 08/02/21 | 373.6805 |
| 09/02/21 | 551.4106 |
| 10/02/21 | 661.8148 |
| 11/02/21 | 551.0217 |
| 12/02/21 | 516.0991 |
| 13/02/21 | 614.0267 |
| 14/02/21 | 572.1251 |
| 15/02/21 | 616.0927 |
| 16/02/21 | 474.4173 |
| 17/02/21 | 837.4468 |
| 18/02/21 | 711.3834 |
| 19/02/21 | 923.2801 |
| 20/02/21 | 728.1456 |
| 21/02/21 | 943.8979 |
| 22/02/21 | 952.7962 |
| 23/02/21 | 885.7517 |
| 24/02/21 | 1261.3016 |
| 25/02/21 | 1241.9217 |
| 26/02/21 | 1395.0989 |
| 27/02/21 | 893.0852 |
| 28/02/21 | 1242.5837 |

International Research Journal of Innovations in Engineering and Technology (IRJIET)
ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

| | |
|---|---|
| 01/03/21 | 1273.6469 |
| 02/03/21 | 1494.9804 |
| 03/03/21 | 1416.4648 |
| 04/03/21 | 1444.0062 |
| 05/03/21 | 1460.5490 |
| 06/03/21 | 1497.7347 |
| 07/03/21 | 1504.1697 |
| 08/03/21 | 1493.9750 |
| 09/03/21 | 1502.3078 |
| 10/03/21 | 1504.6821 |
| 11/03/21 | 1507.5968 |
| 12/03/21 | 1507.7666 |
| 13/03/21 | 1507.8888 |
| 14/03/21 | 1507.7933 |
| 15/03/21 | 1508.1348 |
| 16/03/21 | 1508.1870 |
| 17/03/21 | 1508.0931 |
| 18/03/21 | 1508.0535 |
| 19/03/21 | 1508.0874 |
| 20/03/21 | 1508.1124 |
| 21/03/21 | 1508.0993 |
| 22/03/21 | 1508.0911 |
| 23/03/21 | 1508.0848 |
| 24/03/21 | 1508.0857 |
| 25/03/21 | 1508.0865 |
| 26/03/21 | 1508.0857 |
| 27/03/21 | 1508.0846 |
| 28/03/21 | 1508.0848 |
| 29/03/21 | 1508.0852 |
| 30/03/21 | 1508.0851 |
| 31/03/21 | 1508.0849 |

ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

| | |
|---|---|
| 01/04/21 | 1508.0849 |
| 02/04/21 | 1508.0849 |
| 03/04/21 | 1508.0849 |
| 04/04/21 | 1508.0849 |
| 05/04/21 | 1508.0849 |
| 06/04/21 | 1508.0849 |
| 07/04/21 | 1508.0849 |
| 08/04/21 | 1508.0849 |
| 09/04/21 | 1508.0849 |
| 10/04/21 | 1508.0849 |
| 11/04/21 | 1508.0849 |
| 12/04/21 | 1508.0849 |
| 13/04/21 | 1508.0849 |
| 14/04/21 | 1508.0849 |
| 15/04/21 | 1508.0849 |
| 16/04/21 | 1508.0849 |
| 17/04/21 | 1508.0849 |
| 18/04/21 | 1508.0849 |
| 19/04/21 | 1508.0849 |
| 20/04/21 | 1508.0849 |
| 21/04/21 | 1508.0849 |
| 22/04/21 | 1508.0849 |
| 23/04/21 | 1508.0849 |
| 24/04/21 | 1508.0849 |
| 25/04/21 | 1508.0849 |
| 26/04/21 | 1508.0849 |
| 27/04/21 | 1508.0849 |
| 28/04/21 | 1508.0849 |
| 29/04/21 | 1508.0849 |
| 30/04/21 | 1508.0849 |
| 01/05/21 | 1508.0849 |

 

ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

| | |
|---|---|
| 02/05/21 | 1508.0849 |
| 03/05/21 | 1508.0849 |
| 04/05/21 | 1508.0849 |
| 05/05/21 | 1508.0849 |
| 06/05/21 | 1508.0849 |
| 07/05/21 | 1508.0849 |
| 08/05/21 | 1508.0849 |
| 09/05/21 | 1508.0849 |
| 10/05/21 | 1508.0849 |
| 11/05/21 | 1508.0849 |
| 12/05/21 | 1508.0849 |
| 13/05/21 | 1508.0849 |
| 14/05/21 | 1508.0849 |
| 15/05/21 | 1508.0849 |
| 16/05/21 | 1508.0849 |
| 17/05/21 | 1508.0849 |
| 18/05/21 | 1508.0849 |
| 19/05/21 | 1508.0849 |
| 20/05/21 | 1508.0849 |
| 21/05/21 | 1508.0849 |
| 22/05/21 | 1508.0849 |
| 23/05/21 | 1508.0849 |
| 24/05/21 | 1508.0849 |
| 25/05/21 | 1508.0849 |
| 26/05/21 | 1508.0849 |
| 27/05/21 | 1508.0849 |
| 28/05/21 | 1508.0849 |
| 29/05/21 | 1508.0849 |
| 30/05/21 | 1508.0849 |
| 31/05/21 | 1508.0849 |

ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

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-19 cases are likely to increase from 80 cases around 1 January 2021 up to an equilibrium point of 1500 new daily cases around 6 March 2021.

## V. CONCLUSION & RECOMMENDATIONS

The Kenyan government responded well to the COVID-19 pandemic (Quaife et al, 2020), however; the government still has a lot of work to do in ensuring that all vulnerable groups of the society get assistance , both financial and medical assistance in this COVID-19 era. The results of the study indicate that daily COVID-19 cases are likely to increase from 80 cases around 1 January 2021 up to an equilibrium point of 1500 new daily cases around 6 March 2021. Hence the government should continue enforcing WHO guidelines on prevention and control of COVID-19 and encourage its citizens to get vaccinated in order to achieve herd immunity.

## REFERENCES

[1] CDC (2020). The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team, The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. China CDC Weekly 2, 113–122.

[2] Dan W. Patterson (1995) Artificial Neural networks Theory and Applications. Singapore; New York: Prentice Hall.

[3] Dong E., Du H & Gardner L (2020). An interactive web-based dashboard to track COVID-19 in real time. The Lancet infectious diseases. 20, 5,533–4.

[4] Fojnica, A., Osmanoviae & Badnjeviae A (2016). Dynamic model of tuberculosis-multiple strain prediction based on artificial neural network. In proceedings of the 2016 5th Mediterranean conference on embedded computing pp290-293.

[5] Kaushik AC & Sahi. S (2018). Artificial neural network-based model for orphan GPCRs.Neural.Comput.Appl. 29,985-992

[6] Kishan Mehrotra., Chilukuri K., Mohan, & Sanjay Ranka (1997) Elements of artificial neural networks. Cambridge, Mass.: MIT Press

[7] Matthew Quaife., Kevin van Zandvoort., Amy Gimma., Kashvi Shah., Nicky McCreesh., Kiesha Prem., Edwine Barasa., Daniel Mwanga., Beth Kangwana., Jessie Pinchoff., CMMID COVID-19 Working Group., W. John Edmunds., Christopher I. Jarvis and Karen Austrian (2020). The impact of COVID-19 control measures on social contacts and transmission in Kenyan informal settlements BMC Medicine, 18:316 https://doi.org/10.1186/s12916-020-01779-4

[8] Naizhuo Zhao., Katia Charland., Mabel Carabali., Elaine O., Nsoesie., Mathieu MaheuGiroux., Erin Rees., Mengru Yuan., Cesar Garcia Balaguera., Gloria Jaramillo Ramirez., & Kate Zinszer (2020). Machine learning and dengue forecasting: Comparing random forests and artificial neural networks for predicting dengue burden at national and sub-national scales in Colombia. PLOS Neglected Tropical Diseases | https://doi.org/10.1371/journal.pntd.0008056

[9] Qazi, A., Fayaz, H., Wadi, A., Raj, R.G., Rahim, N.A., & Khan, W A (2015). The artificial neural network for solar radiation prediction and designing solar systems: a systematic literature review. Journal of Cleaner Production. 104, 1–12 (2015). https://doi. org/10.1016/j.jclepro.2015.04.041

[10] Read et al (2020). Novel coronavirus 2019-nCoV: Earlyestimationofepidemiologicalparametersandepidemicpredictions. medRxiv:10.1101/2020.01.23.20018549

[11] Smartson P. Nyoni., Thabani Nyoni & Tatenda. A. Chihoho (2020). Prediction of daily new COVID-19 cases in Italy using artificial neural netwotks. IJARIIE-ISSN(O)-2395-4396 Vol-6 Issue-6 2020,

[12] Smartson. P. Nyoni, Thabani Nyoni, Tatenda. A. Chihoho (2020) Prediction of new Covid-19 cases in Ghana using artificial neural networks. IJARIIE Vol-6 Issue-6 2395-4396

[13] Smartson. P. Nyoni., Thabani Nyoni & Tatenda A. Chihoho (2020). Forecasting COVID-19 cases in Ethiopia using artificial neural networks, IJARIIE, 6, 6, 2395-4396

[14] Smartson. P. Nyoni., Thabani Nyoni., Tatenda. A. Chihoho (2020). Prediction of daily new Covid-19 cases in Egypt using artificial neural networks. IJARIIE- Vol-6 Issue-6 2395-4396

[15] Tang. B et al (2020). An updated estimation of the risk of transmission of the novel coronavirus (2019-nCoV). Infectious Disease Modelling 5, 248–255.

[16] Tang. B et al (2020). Estimation of the transmission risk of the 2019-nCoV and its implication for public health interventions. J. Clinical Med. 9, 462.

[17] Wang D et al (2020). Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. JAMA 323, 1061–1069.

 

ISSN (online): 2581-3048
Volume 5, Issue 3, pp 227-236, March-2021
https://doi.org/10.47001/IRJIET/2021.503038

[18] Wang H et al (2020). Phase-adjusted estimation of the number of coronavirus disease 2019 cases in Wuhan, China. Cell Discovery 6, 76.

[19] Wang. W et al (2020). Updated understanding of the outbreak of 2019 novel coronavirus (2019-nCoV) in Wuhan, China. J. Med. Virology 92, 441–447.

[20] Yan, H., Jiang, J., Zheng, J., Peng, C & Li, Q (2006). A multilayer perceptron based medical decision support system for heart disease diagnosis. Expert Syst. Appl. 2006, 30, 272–281.

[21] Zhang G P (2003). "Time series forecasting using a hybrid ARIMA and neural network model", Neurocomputing 50: 159–175.

**Citation of this Article:**

Dr. Smartson. P. NYONI, Thabani NYONI, Tatenda. A. CHIHOHO, "Forecasting Daily Covid-19 Case Volumes in Kenya Using Artificial Neural Networks" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 3, pp 227-236, March 2021. Article DOI https://doi.org/10.47001/IRJIET/2021.503038

*******

 