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32. Saeed.O.B, Abubakar U.Y, **Lawal Adamu**, Usman Abubakar (2021). A Grey-Markov Model for Prediction Of Vehicular Accident's Human Casualties Along Lokoja-Abuja-Kaduna Expressway, A paper presented at 3rd School of Physical Science Biennial International Conference held at Federal University of Technology, Minna from 25th - 28th October, 2021.

FEDERAL UNIVERSITY OF TECHNOLOGY · MINNA · Technology for Empowerment

SPCBIC 2021

25th – 28th October, Minna Nigeria

3RD SCHOOL OF PHYSICAL SCIENCES BIENNIAL INTERNATIONAL CONFERENCE (SPSBIC 2021)

PROCEEDINGS

THEME:
THE ROLE OF SCIENCE AND TECHNOLOGY IN THE REALIZATION OF RESEARCH AND DEVELOPMENT IN THE ERA OF GLOBAL PANDEMIC

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA,
NIGER STATE, NIGERIA

PREFACE

It is a great privilege for us to present the proceedings of 3[rd] School of Physical Sciences Biennial International Conference (SPSBIC) 2021 devoted to the role of science and technology in the realization of research and development in the era of pandemic. We hope that authors, delegates, agencies other individuals will find this compilation very useful and inspiring.

The school of Physical Sciences 3[rd] Biennial International Conference is an interdisciplinary forum for the presentation of new ideas, recent developments and research findings in the field of Science and Technology. The Conference provides a platform to scholars, researchers in the academics and other establishments to meet, share and discuss on the role of science and technology in the realization of research and development in the era of pandemic. Submissions were received both nationally and internationally and severally reviewed by our international program committee. All contributions received were neither published elsewhere nor submitted for publication as asserted by contributors.

This conference brought together experts from varying fields, visions, knowledge and experience with potentials; pre-conference workshop and four keynote speakers with world class experience in varying fields of specialization in addition to over 150 scientific participants who unveiled the latest scientific evidence to boost contemporary scientific and technological research development in the era of pandemic.

The success of the conference was a function of the collective efforts of numerous individuals. Our profound gratitude goes to the Dean School of Physical Sciences Prof. Jonathan Yisa for putting the trust the in us to serves as the Local Organizing Committee (LOC). The Vice Chancellor Prof. Abdullahi Bala and the entire management team for their unflinching support that led to the success story. We are most grateful to our workshop facilitator and his team as well as our keynote speakers for accepting our invitations and travelled long distances to be with us at no cost to the University. We also acknowledge the participants themselves, without whose expert input there would have been no conference. Thank you all for your contributions.

Prof. A. Abdulkadir
Chairperson Local Organizing Committee

individuals. Our profound gratitude goes to the Dean School of Physical Sc

THEME OF THE CONFERENCE

The Role of Science and Technology in the Realization of Research and Development in the Era of Global Pandemic

SUB-THEMES OF THE CONFERENCE

- Sustainable Management of Pandemic
- Global Change, Responses and Strategies for Limiting Pandemic
- Modelling and Monitoring of Pandemic
- Science, Technology, Engineering and Mathematics as Leveraging tools for Management of Pandemic

PRE-CONFERENCE WORKSHOP TITLE

Isolation, Purification and Structural Elucidation of Compounds and Drug Testing on Animals

Local Organizing Committee Members

Prof. (Mrs) A. Abdulkadir (Chairperson)
Dr. M. I. Kimpa
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Dr. S. Ojoye
Dr. U. Mohammed
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Dr. A. A. Ahmed
Dr. A. N. Amadi

KEYNOTE SPEAKERS

Dr. H. A. Shaba

Dr. Halilu Ahmad Shaba was a Director, Strategic Space Applications Department (SSA), National Space Research and Development Agency (NASRDA) as well as HOD, Department of Geo-informatics & GIS Applications, Institute of Space Science and Engineering (ISSE) affiliate of Africa University of Science and Technology (AUST), Abuja.

Dr. Shaba has successfully overseen and implemented over 20 projects among which are:

- Mapping the Drivers of Deforestation and Forest Degradation in Cross River State, Nigeria (Sponsored by FAO)
- Erosion Mapping and Monitoring with Space Technology in South-East and South-South Nigeria (Sponsor by World Bank via NEWMAP).
- Monitoring deforestation and forest degradation in cross river state, Nigeria (Part of the implementation of the UN-NEDD program in Nigeria)
- National Personnel Audit Geospatial Digital Database Development: Sponsor by UBEC
- Geo-referenced Infrastructure and Demographic Data for Development (Grid3) Project in Nigeria (NASRDA, eHealth Africa, Centre for International Earth Science Information Network (CIESIN) USA and Novel T)
- Engagement for harmonization of health facilities database (Phase 1: Geospatial Tracking System (GTS): (Ministry of health, National Primary Health Care Development Agency collaborating with National Space Research & Development Agency, eHealth Africa Foundation and Novel T).
- Space Based Digital Farm Mo...oring from space for 2020 dry season farming (CBN Anchor Borrower)

Dr. Shaba has also provided services to several National and International Committees/Panels throughout his tenure as director SSA, amongst are:

- Member, Nigerian Delegation to United Nations Committee on Peaceful Use of Outer Space (UN-COPUOS) from 2005 to date
- Member, Joint Expert Group 8 (JEG8) on the implementation of an integrated AU-EU Joint Strategy under the 8th Partnership on Science, Information Society and Space, 2010 to date.
- Member, Extended Coordinating Team of Global Monitoring of the Environment & Africa (GMES & Africa), 2010 to date
- Executive Committee Member & GEO Principal for Nigeria, Group on Earth Observation (GEO), Geneva, Switzerland (2013-date)

Finally, Dr. Shaba is a member of several organizations and has been conferred with the award of honorary fellow by the following prestigious bodies;

- Geo-information Society of Nigeria (GEOSON)
- Society of Professional Disaster Risk Managers of Nigeria (SOPDRIMN)
- Nigerian Cartographic Association (NCA)

Dr. M. Alkali

Dr. Muhammad Alkali is a versatile scientist, instructor, and administrator with numerous published articles in academic and scholarly journals. Before he was appointed the Group Head, SIC, Dr Alkali bagged his Ph.D. in Integrated Systems Engineering with a research bias in Spacecraft Power Systems from Kyushu Institute of Technology (KYUTECH/KIT), a prestigious University of Technology in Japan. While in Japan, he participated in the design and development of the Electrical Power System of the Arc Event Generator and Investigator Satellite (AEGIS), a scientific spacecraft also known as Horyu-IV which was successfully launched into orbit on-board the H-2A rocket in February 2016.

He received his Masters degree in Personal, Mobile & Satellite Communications from the University of Bradford, England. His tertiary education commenced with a Bachelor degree (second class- upper division) in Physics/Electronics from the Federal University of Technology Minna, Niger State. Dr. Alkali has had a colourful, impactful career spanning from Advanced Microcomputer Systems to Central Bank of Nigeria (NYSC) to SAGEM SA to the Abuja area office of the United Bank for Africa (UBA) to the National Space Research and Development Agency (NASRDA) and finally to the Nigerian Communications Satellite Limited (NIGCOMSAT) where he has served in various capacities over the years in Satellite Network Control and Applications. He was also a pivotal member of the AFRICARE-NIGERIA's project (Independent Policy Group), a think-tank for the President of Nigeria (2002-2003).

Dr. Alkali has always aimed to have an expansive international and local repertoire of knowledge while keeping abreast with industry trends. This has led to his participation in the study visit on European Union Global Navigation Satellite System in Spain, his attendance at the Indian Institute for Public Administration (IIPA) New Delhi, where he trained in Global Strategic Leadership for Growth and Sustainable Development. He attended the Advanced Visioning and Leadership Programme on Managing Human Capital and Shaping Culture organized by TL First Group/Institute of Leadership and Management of UK. He also attended a practical project management course at CCLL, Cardiff University-United Kingdom. He was among the 50 Scientists/Engineers trained at the China Academy of Space Technology/ Beijing Institute of Tracking & Telecommunications Technology for Know-how Technology Transfer training on NigComSat-1 from 2005. In 2008, he attended a Satellite networking course at PT Telkom learning Centre in Bandung, Indonesia.

Dr. Alkali is a fellow of the African Scientific Institute (FASI), a Fellow of the Institute of Corporate Administration (FCAI), a senior member of the American Institute of Aeronautics and Astronautics, Member Nigerian Institute of Physics, and a Member of the Computer Professionals Registration Council of Nigeria (MCPN). Dr. Alkali has vast interests ranging from Design thinking; energy; CT; science, technology, and innovations (STI) to spacecraft design and systems integrations (payload and bus systems).

Professor Abdul Kabir Mohammed

Professor Abdul Kabir Mohammed is currently serving as Professor and Chair of the Department of Chemistry & Biochemistry at North Carolina Central University, Durham, NC. Previously, he served as the Chair of the Department of Chemistry at Winston Salem State University, Winston-Salem, NC and prior to that appointment he was an Associate Professor at North Carolina A&T State University, Greensboro, NC.

Prof. Mohammed graduated from the University of Benin, Benin-City in 1983 with a B.Sc. (first class honors) degree in chemistry. He worked briefly in 1987 as a Graduate Assistant at Federal University of Technology, Yola (now Modibbo Adama University of Technology), before proceeding to Louisiana State University for his postgraduate education.

He received his Ph.D. in inorganic chemistry in 1982 and did postdoctoral research at Florida State University from 1982 to 1983. He was a Fulbright Scholar at Sultan Qaboos University in Oman from 2003 to 2004; and he served as a Carnegie African Diaspora Fellow at the Federal University of Technology, Minna, Nigeria in the summers of 2017 and 2019. His research interests include photophysics and photochemistry of transition metal complexes and chemical education. He teaches general, inorganic and environmental chemistry courses.

Prof. Makun Hussaini Anthony

Prof. Makun Hussaini has 29 years of experience as a university academic staff and a researcher in areas relating to food safety, environmental health monitoring, mycotoxicology and mycology. He possess a Doctorate degree in Biochemistry (Toxicology) after successful completion of a thesis entitled "Studies on mycoflora and mycotoxins contaminating guinea corn and rice in Niger State, Nigeria" This was preceded by an MSc degree in Biochemistry (thesis titled "Analysis of blood levels of trace metals, total lipids and cholesterol in Ajaokuta Steel Industry workers"). The novelty of finding *Fusarium verticillioides* in Nigerian rice during his PhD work, which is the fungi associated with oesophageal cancer (EC) in South Africa, earned him a National Research Foundation Postdoctoral Fellowship (PDF) with Food Environment and Health Research Group of the University of Johannesburg (UJ).

Being a university teaching staff for over almost three decades, Prof. Makun has taught many biochemistry and environmental toxicology related courses at both undergraduate and postgraduate levels. He has supervised and graduated over 85 B-Tech, 18 M-Tech students and 9 PhDs. The graduate students all worked on mycotoxins.

Prof. Makun has won national and international research grants to the cumulative sum of $8, 647,787. 47. He is a Fellow of Mycotoxicology Society of Nigeria (FMSN), a member of the National Agency for Food and Drug Administration and Control (NAFDAC), National Food Safety Advisory Committee of Nigeria, National Codex Committee of Nigeria, African Union Expert Committee on Contaminants in Food (2011 to date) and Joint FAO/WHO Expert Committee on Contaminants in Food (JECFA) (2012-2020). He coordinated the writing of the "discussion paper on fungi and mycotoxins in Sorghum" which was adopted as a document of the Joint FAO/WHO Experts Committee on Food Additives (JECFA) in 2012 and participated in the writing of "Proposed draft annex for "prevention and reduction of aflatoxins and ochratoxin A in sorghum" in the existing code of practice for the prevention and reduction of mycotoxin contamination in cereals (CAC/RCP 51-2003)". He wrote on the prevention and control of sterigmatocystin and diacetoxyscirpenol for the 83[rd] meeting of JECFA held in November, 2017 in Rome.

Prof. Makun has 72 publications, mostly on mycotoxins in peer review journals, technical papers and books. He was the immediate pass Director of Research, Innovation and Development of the Federal University of Technology Minna, Nigeria. He is currently the Lead Researcher of the Food and Toxicology Research Group and Centre Leader of the Africa Centre of Excellence for Mycotoxin and Food Safety of the Federal University of Technology Minna. Project Coordinator of the West African Food Safety Network (WAFOSAN) and Member of the African Food Safety Network. He has served as election monitor, election collation and returning officers at state and national assembly elections from 1999 to 2015). He has passion for jogging and reading. He is married to Barrister Evelyn Pambelo Hussaini and blessed with four children.

Dr. Eustace Manayi Dogo

Dr Eustace M. Dogo has over ten years of industry experience working in Russia, Europe and Nigeria. He holds a BSc and MEng degrees in Electrical Engineering from Peter the Great Saint Petersburg Polytechnic University, Saint Petersburg, Russia and PhD degree from the University of Johannesburg, South Africa. His PhD research focused on investigating imbalanced learning using Artificial Intelligence algorithms in real-world drinking-water quality detection problems, where he proposed three new dynamic selection algorithms combined with data pre-processing methods.

Among his notable contributions while at the University of Johannesburg during his postgraduate studies, Dr Eustace Dogo served as a volunteer to the 6th International Conference on Soft Computing and Machine Intelligence (ISCMI 2019) held in Johannesburg, South Africa, on November 19-20. In 2019, he served as a tutor in the first Short Learning Programme (SLP) in Computational Intelligence for Industry, organized by the Institute for Intelligence Systems in collaboration with the Department of Information Systems at the University of Johannesburg, and successfully graduated two batches of students drawn across diverse works of life (over 50 students).

Dr Eustace M. Dogo has over ten years of industry experience working in Russia, Europe and

Dr Eustace Dogo was recently among a panel of discussants in the University of Johannesburg's *Cloudebate* on the Fourth Industrial Revolution and Technology for People with Disabilities. Between 2018 and 2019, he co-supervised to completion 16 undergraduate students in the Department of Electrical and Electronic Engineering Science, University of Johannesburg, South Africa. He also presented a technical talk at the *POWER-GEN & DistribuTECH - GEN-X* conference and exhibition which took place in Sandton, Johannesburg in 2017.

Dr Eustace Dogo has extensive knowledge in industry, research, training and teaching. He is an active undergraduate and postgraduate degree supervisor and has authored and co-authored in reputable journals, conferences and several scholarly research books in his areas of interest. He joined the academia in 2012 and currently lectures at the Department of Computer Engineering, Federal University of Technology Minna, Nigeria. His broad research interest includes, theoretical and applied Machine Learning, Intelligent Systems, Cloud Computing and Emerging Technologies. He is married to Barrister Fatima Eustace-Dogo and blessed with three children.

CONFERENCE WORKSHOP FACILITATOR

Prof. Derek Tantoh Ndinteh

Prof. Derek Tantoh Ndinteh is an expert in areas of Natural Products Chemistry; drug discovery and drug delivery platforms. He is currently working on Natural Products Chemistry that deals with extraction, purification, isolation and characterization of chemical substances and evaluation of biological and pharmacological activities of African plants for pharmaceutical industries.

He is interested in collaborating with Federal University of Technology, Minna on the evaluation of the antidiabetic, antimicrobial, antioxidant, anticancer and anti-ulcerogenic potentials of secondary metabolites from Nigerian Medicinal Plants.

Our interaction so far with Prof. Derek Tantoh Ndinteh has been very mutual and beneficial to both Universities involved because it has potential to increase our visibility at global level based on academic activities and mainstreaming and replication of the research and teaching outcomes of this collaboration by the staff and students can be integrated into overall development of Nigeria and South Africa.

CHEMICAL/LIFE SCIENCE

EARTH SCIENCE

MATHEMATICAL/ICT

PHYSICAL /CLIMATE SCIENCE

ADDENDUM

accident deaths from 1990 to 2010 in China and 2001 to 2014 for coal accidents death were predicted accordingly. The result shows that the new model not only discovered the trend of the mine human error accident death toll but also overcomes the random fluctuation of data affecting precision. It was concluded that the model possesses stronger engineering application. Reported in (Xiaxia, *et.al*, 2018) is a driving risk status prediction algorithm base on Markov Chain. In the study, driving risk states were classified using clustering techniques base on feature variables describing instantaneous risk levels within time windows, were instantaneous risk levels are determined in time-to-collision and time-to-headway two-dimensional plane. Multinomial logistic models with recursive feature variable estimation method were developed to improve the traditional state transition probability estimation, which also takes into account the comprehensive effect of driving behaviour, traffic and road environment factors on the evolution of driving risk status. A "100-car" natural driving data from Virginia technology was employed for the training and validation of the prediction model. The results show that under the 5% false positive rate, the prediction algorithm could have high prediction accuracy for future medium-to-high driving risks and could meet the time line requirement of collision avoidance warning. The algorithm could contribute to timely warning or auxiliary correction to drivers in the approaching-danger state. Successful studies of vehicular accidents occurrence have also been reported in (Bamidele, 2006; John *et.al*, 2007; Nyothiri *et.al*, 2018)

Materials and Method

The Grey-Markov model consist of GM(1,1) model and Markov chain model. The Grey model deals with an uncertain system of small sample size and poor information involving both known and unknown information. The goal of Grey prediction is to whitening the system and reveals the unknown. However, in Grey model problem of poor fitting degree and low prediction accuracy may emerge when the change rate of the original data is too large. The Grey –Markov Model (GMM) is an extension of Grey Model (GM) to further reduce the prediction error. The Grey-Markov Model is made up of two components namely Grey and Markov chain model; Markov chain model can handle a situation where the change rate of the original data is too large. Hence, Markov Chain Model makes it possible to solve the problems mentioned in Grey Model. The Grey-Markov Model was established base on the advantage of both methods which adopt GM(1,1) Model to study development regulation of data sequence and uses Markov Models to study vibrating irregularities of data sequence. In general, the combination of the two models have been found to improve the prediction accuracy (Mao and Sun, 2011). As earlier mentioned we shall begin our prediction with GM(1,1) model after which we shall improve the prediction accuracy using Grey-Markov model.

The Grey-System Model GM(1,1)

The raw data series in grey GM(1,1) model is represented by $x^{(0)}(k), k = 1,2,3,\ldots,n, x^{(0)}(k) \geq 0$ and it can also be represented as:

$$X^{(0)}(k) = \left(x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), \ldots, x^{(0)}(n)\right) \quad (1)$$

The accumulated generating sequence is given as:

$$X^{(1)}(k) = \left(x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \ldots, x^{(1)}(n)\right) \quad (2)$$

Where $X^{(0)}(k)=\sum_{i=1}^{k}x^{(0)}(i), k=1,2,\ldots,n$ (3)

$$x^{(0)}(k)+ax^{(1)}(k)=b \quad (4)$$

Equation (4) represents the original form of the GM(1,1) model, is a difference equation. The symbol GM(1,1) stands for first order Grey Model in one variable.

Equation (4) is also represented as equation (5)

$$\frac{dx^{(1)}}{dt}+ax^{(1)}=b \quad (5)$$

Equation (5) is a differential equation, where a and b are parameters to be identified. a is called developing coefficient and b is grey input.

Equation (6) is the solution of equation (5)

$$\hat{x}^{(1)}(k+1)=\left(x^{(1)}(0)-\frac{b}{a}\right)e^{-ak}+\frac{b}{a} \quad (6)$$

Equation (6) is the time response function while parameters a and b are estimated using Least Square Method as follows:

$$\begin{bmatrix}a\\b\end{bmatrix}=\left[B^TB\right]^{-1}B^TY \quad (7)$$

Where, $$B=\begin{bmatrix}\frac{-[x^{(1)}(1)+x^{(1)}(2)]}{2} & 1\\ \frac{-[x^{(1)}(2)+x^{(1)}(3)]}{2} & 1\\ \frac{-[x^{(1)}(3)+x^{(1)}(4)]}{2} & 1\\ \frac{-[x^{(1)}(4)+x^{(1)}(5)]}{2} & 1\\ \frac{-[x^{(1)}(5)+x^{(1)}(6)]}{2} & 1\\ \vdots & \vdots\\ \frac{-[x^{(1)}(n-1)+x^{(1)}(n)]}{2} & 1\end{bmatrix} \quad (8)$$

$$Y=\left[x^{(0)}(2),x^{(0)}(3),x^{(0)}(4),\ldots,x^{(0)}(n)\right]^T \quad (9)$$

The reduction value of equation (6) is given below:

$$\hat{x}^{(0)}(k+1)=\hat{x}^{(1)}(k+1)-\hat{x}^{(1)}(k)=\left(1-e^{a}\right)\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak} \quad (10)$$

Prediction Accuracy Test
To determine the accuracy of our prediction, we shall adopt mean absolute percentage error (MAPE).

This tool is often used for determining prediction accuracy showing the same characteristics i.e. the smaller the value, the higher the prediction accuracy.

MAPE

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right| \times 100\% \qquad (11)$$

Where;

$\hat{y}_i$ is the Grey Model predicted value.

y_i is the Grey-Model actual value.

n is the number of prediction samples.

Lewis (1982) divided the prediction accuracy of models into four grades and the division of prediction accuracy grades is shown in the table below:

Table 1: Prediction Accuracy Test

MAPE	Prediction Accuracy
$<10\%$	High
$10\%-20\%$	Good
$20\%-50\%$	Feasible
$>50\%$	Low

The Grey- Markov Model
The Grey-Markov model (GMM) is an extension of Grey Model (GM) to further reduce prediction errors. In Grey model, the problems of poor fitting degree and low prediction accuracy may emerge when the change range of original data is too large. However, these problems can be well resolved by adopting Markov chain which can narrow down the prediction interval and improve the prediction accuracy. Markov stochastic process improves these limitations of Grey model because it reflects the stochastic volatility impact on elements by determining the transfer law of states (Ducan *et.al*, 1998).

Building the Grey-Markov Model
First step in building the GMM is to divide the residual errors into q states where each state satisfies the equi-probability principle and is defined as $R_1, R_2, \cdots, R_q$. Next, the construction of the transition matrix is done by determining the probability from state R_i to state R_j which results in the transition matrix P.

$$P^{(1)} = \begin{bmatrix} p_{(11)}^{(1)} & p_{(12)}^{(1)} & \cdots & p_{(1q)}^{(1)} \\ p_{(21)}^{(1)} & p_{(22)}^{(1)} & \cdots & p_{(2q)}^{(1)} \\ \vdots & \vdots & \cdots & \vdots \\ p_{(q1)}^{(1)} & p_{(q2)}^{(1)} & \cdots & p_{(qq)}^{(1)} \end{bmatrix} \quad (12)$$

$$P^{(m)} = \begin{bmatrix} p_{(11)}^{(m)} & p_{(12)}^{(m)} & \cdots & p_{(1q)}^{(m)} \\ p_{(21)}^{(m)} & p_{(22)}^{(m)} & \cdots & p_{(2q)}^{(m)} \\ \vdots & \vdots & \cdots & \vdots \\ p_{(q1)}^{(m)} & p_{(q2)}^{(m)} & \cdots & p_{(qq)}^{(m)} \end{bmatrix} \quad (13)$$

Where $P_{ij}^{(m)} = \dfrac{M_{ij}^{(m)}}{m_i}, (i, j = 1,2,3,..., L)$, $M_{ij}^{(m)}$ stands for the transition from R_i to R_j in m steps and m_i is the number of state R_i.

Next, the residual error must be confirmed.

Let the interval median in $[R_{i-}, R_{i+}]$ be residual error forecasting value as follows:

$$\hat{e} = \tfrac{1}{2}[R_{i-} + R_{i+}] \quad (14)$$

Hence, the Grey-Markov model is obtained as:

$$\hat{Y}(k+1) = [1 + \hat{e}]\hat{x}^{(0)}(k+1) \quad (15)$$

Where, $\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k)$

Hence:

$$\hat{Y}(k+1) = \left[1 + \tfrac{1}{2}(R_{i-} + R_{i+})\right]\hat{x}^{(0)}(k+1) \quad (16)$$

Application of Grey System Model for Prediction of Vehicular Accident's Human Casualties along Lokoja-Abuja-Kaduna Expressway

The data used in this research were collected from the archive of Federal Road Safety of Nigeria for the period of ten years (2010-2019).

The summary of the data is presented in table 2 below:

Table 2: Summary of Number of Vehicular Accident's Human Casualties for Period of Ten Years

S/N	YEAR	ACTUAL NUMBER OF HUMAN CASUALITIES WITHIN THE YEAR
1	2010	2883
2	2011	3629
3	2012	2623
4	2013	4273
5	2014	3200
6	2015	2913
7	2016	2822
8	2017	3044
9	2018	3131
10	2019	2790

Using equation (1) and table (2), we obtain equation 17 below

$$X^{(0)} = (2883, 3629, 2623, 4273, 3200, 2913, 2822, 3044, 3131, 2790) \quad (17)$$

From equation (2) we obtain the accumulated generating sequence as given below:

$$X^{(1)} = (2883, 6512, 9135, 13408, 16608, 19521, 22343, 25387, 28518, 31308) \quad (18)$$

Equation (19) below is obtained using equation (7)

$$\hat{a} = \begin{bmatrix} 0.02463 \\ 359226 \end{bmatrix} = \begin{bmatrix} a \\ b \end{bmatrix} \quad (19)$$

Where $a = 0.02463,\ b = 359226$

Substituting for a and b in equation (6), we obtained equation (20) below:

$$\hat{x}^{(1)}(k+1) = 14584896 - 142965.96e^{-0.02463k} \quad (20)$$

Evaluating equation (20) for $k = 0,1,\ldots,9$ we obtained the following values below:

$$\hat{X}^{(1)} = (2883, 6361, 9755, 13066, 16296, 19448, 22524, 25524, 28451, 31308) \quad (21)$$

We compute the simulated value using equation (22) below:

$$\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1) \quad (22)$$

$$\hat{X}^{(0)} = (2883, 3478, 3394, 3311, 3230, 3152, 3076, 3000, 2927, 2857) \quad (23)$$

Equation (23) is the simulated values from 2010-2019

Table 3: Comparison of Actual and Grey simulated Value for Vehicular Accident's Human Casualties along Lokoja-Abuja-Kaduna Express Way from Year 2010-2019.

YEAR OF CRASH	ACTUAL NUMBER OF CRASH WITHIN THE YEAR	GREY-MODEL PREDICTION VALUES	RESIDUAL ERROR	RELATIVE ERROR (%)
2010	2883	2883	0	0
2011	3629	3478	151	4.16
2012	2623	3394	-771	-29.39
2013	4273	3311	962	22.51
2014	3200	3230	-30	-0.94
2015	2913	3152	-239	-8.20
2016	2822	3076	-254	-9.00
2017	3044	3000	44	1.45
2018	3131	2927	204	6.52
2019	2790	2857	-67	-2.40

Using equation (11), we observed from table (3) that:

$MAPE = 8.457\%$

$ACCURACY = 100\% - 8.457\% = 91.543\%$

The above figure indicates that the prediction accuracy is good; however, this prediction accuracy level can be improved using Grey-Markov Model.

Application of Grey-Markov Model for Prediction of Vehicular Accident's Human Casualties along Lokoja-Abuja-Kaduna Express Way

The prediction accuracy of the GM(1,1) can be improve by apply the Grey-Markov model. We begin by finding error state of each year. To achieve this, the error is partitioned into states. Due to the small sample size in this study, the error can be divided into three states respectively, using E_1, E_2, E_3 as shown in the table below:

Table 4: Error Partition

State	$E_1(\%)$	$E_2(\%)$	$E_3(\%)$
Error Range	$-29.39 \sim -12.09$	$-12.09 \sim 5.21$	$5.21 \sim 22.51$

From Table (4), we obtained the error states in Table (5)

Table 5: State Division for Actual Vehicular Accident's Human Casualties along Lokoja-Abuja-Kaduna Express Way

S/N	Year	Actual Number Of Human Casualties Within The Year	Grey Model Simulated Values	Relative Error (%)	Error States
1	2010	2883	2883	0	E_2
2	2011	3629	3478	4.16	E_2

3	2012	2623	3394	-29.39	E_1
4	2013	4273	3311	22.51	E_3
5	2014	3200	3230	-0.94	E_2
6	2015	2913	3152	-8.20	E_2
7	2016	2822	3076	-9.00	E_2
8	2017	3044	3000	1.45	E_2
9	2018	3131	2927	6.52	E_3
10	2019	2790	2857	-2.40	E_2

Grey Forecasting for Vehicular Accident's Human Casualties from Year 2020-2023

Evaluating equation (20) for $k = 9,10,11,12,13$

The predicted values are computed using equation (22) and the results are presented in table 8.

Table 6: Grey-Model Predicted Values from Year 2020-2023

Year	Grey Model Prediction Value
2020	2719
2021	2653
2022	2588
2023	2525

From Table (5), we construct transition probability matrix using equation (12)

$$P^{(1)} = \begin{bmatrix} 0 & 0 & 1 \\ 0.17 & 0.67 & 0.17 \\ 0 & 1 & 0 \end{bmatrix} \tag{24}$$

The two steps, three steps and four steps transition probability matrix is calculated using equation (13), hence we have them respectively:

$$P^{(2)} = \begin{bmatrix} 0 & 1 & 0 \\ 0.114 & 0.619 & 0.284 \\ 0.17 & 0.67 & 0.17 \end{bmatrix} \tag{25}$$

$$P^{(3)} = \begin{bmatrix} 0.17 & 0.67 & 0.17 \\ 0.105 & 0.699 & 0.219 \\ 0.114 & 0.619 & 0.284 \end{bmatrix} \tag{26}$$

$$P^{(4)} = \begin{bmatrix} 0.114 & 0.619 & 0.284 \\ 0.119 & 0.687 & 0.223 \\ 0.105 & 0.699 & 0.219 \end{bmatrix} \quad (27)$$

Evaluating equation (16) for $k = 0,1,2,3,...,9$

$$\hat{Y}_1 = \left[1 + \tfrac{1}{2}(-12.09\% + 5.21\%)\right] * 2883 = 2784$$
$$\hat{Y}_2 = \left[1 + \tfrac{1}{2}(-12.09\% + 5.21\%)\right] * 3478 = 3358$$
$$\hat{Y}_3 = \left[1 + \tfrac{1}{2}(-29.39\% - 12.09\%)\right] * 3394 = 2690$$
$$\hat{Y}_4 = \left[1 + \tfrac{1}{2}(5.21\% + 22.51\%)\right] * 3311 = 3770$$
$$\hat{Y}_5 = \left[1 + \tfrac{1}{2}(-12.09\% + 5.21\%)\right] * 3230 = 3119$$
$$\hat{Y}_6 = \left[1 + \tfrac{1}{2}(-12.09\% + 5.21\%)\right] * 3152 = 3044$$
$$\hat{Y}_7 = \left[1 + \tfrac{1}{2}(-12.09\% + 5.21\%)\right] * 3076 = 2970$$
$$\hat{Y}_8 = \left[1 + \tfrac{1}{2}(-12.09\% + 5.21\%)\right] * 3000 = 2897$$
$$\hat{Y}_9 = \left[1 + \tfrac{1}{2}(5.21\% + 22.51\%)\right] * 2927 = 3333$$
$$\hat{Y}_{10} = \left[1 + \tfrac{1}{2}(-12.09\% + 5.21)\right] * 2857 = 2759$$

We obtained the Grey-Markov Simulated Values presented in Table (6).

Table 7: Comparison of Actual and Grey-Markov Simulated Value for Vehicular Accident's Human Casualties along Lokoja-Abuja-Kaduna Expressway for the Period of 2010-2019

YEAR	ACTUAL NUMBER OF HUMAN CASUALTY WITHIN THE YEAR	GREY-MARKOV MODEL PREDICTION VALUES	RESIDUAL ERROR	Relative Error (%)
2010	2883	2784	-346	-15.2
2011	3629	3358	454	14.8
2012	2623	2690	237	12.6
2013	4273	3770	840	19.8
2014	3200	3119	-171	-5.3
2015	2913	3044	260	9.7
2016	2822	2970	-424	-15.0
2017	3044	2897	-173	-5.7
2018	3131	3333	-176	-5.8
2019	2790	2759	-290	-10.4

Using equation (11), we observed from Table (6) that,

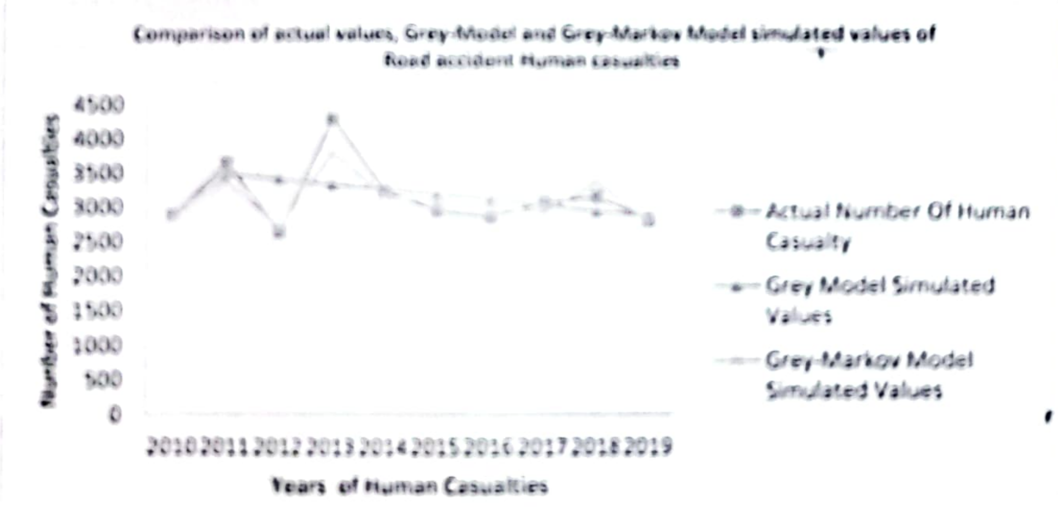
$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right| \times 100\% = 4.988\%$$

$ACCURACY = 100\% - 4.988\% = 95.012\%$. This implies that, the prediction accuracy has been improved from 91.543%to 95.012%

The above figure also indicates high accuracy level.

Table 8: Comparison of Actual Value, Grey Model and Grey-Markov Model Simulated Values for Road Accident's Human Casualties along Lokoja-Abuja-Kaduna Express high way

Year	Actual Number Of Human Casualties Within The Year	Grey Model Simulated Values	Grey-Markov Model Simulated Values
2010	2883	2883	2784
2011	3629	3478	3358
2012	2623	3394	2690
2013	4273	3311	3770
2014	3200	3230	3119
2015	2913	3152	3044
2016	2822	3076	2970
2017	3044	3000	2897
2018	3131	2927	3333
2019	2790	2857	2759



Graph 1: Comparison of Actual Value, Grey Model and Grey-Markov Model Simulated Values for Vehicular Accident's Human along Lokoja-Abuja-Kaduna Express way.

Road accident Human casualties

Grey-Markov Model Prediction from 2020-2023

To achieve this, we obtained the error state for year 2020 to 2023 through the use of equation (25) to (27) and the information in table (5) after which we use equation (16) and the error states to make prediction from 2020 to 2023. The results are presented in table 9.

Table 9: Grey-Markov prediction value from 2020-2023.

Year	Grey-Markov Model Prediction Value
2020	2625
2021	2562
2022	2499
2023	2438

Table 10: Comparison of Grey and Grey-Markov model predicted values from year 2020-2-23

Year	Grey-Model Prediction Values	Grey-Markov Model Prediction Values
2020	2719	2625
2021	2653	2562
2022	2588	2499
2023	2525	2438

5. Conclusion

The G,M(1,1) system model has been used to simulate the number of human casualties recorded in vehicular accidents along Lokoja-Abuja-Kaduna express way. After which a Grey-Markov model was used to improve the accuracy of the simulated values. The performance of the Grey-Markov model was impressive as it recorded 95.012% accuracy when fitted. This shows that the model is reliable and dependable; therefore the prediction made for the future years should be adopted by Nigeria government as source of information for road safety policy formulation on the express way.

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