

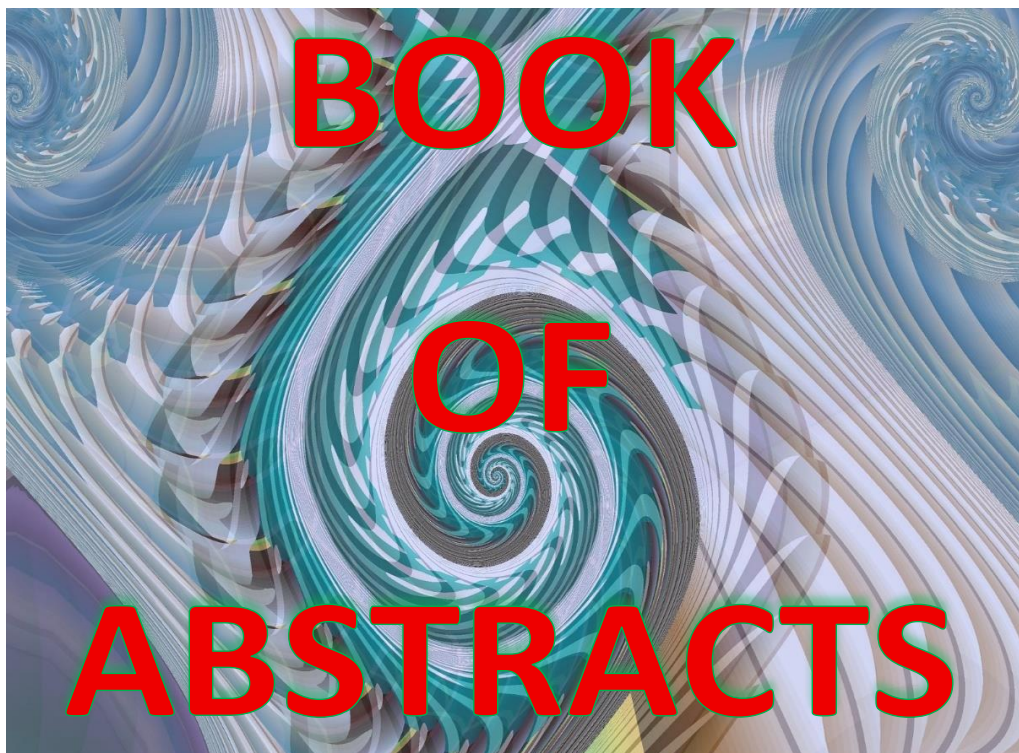
NSMB **Nigerian Society for Mathematical Biology**

9TH INTERNATIONAL WORKSHOP AND CONFERENCE ON

MATHEMATICAL MODELING AND SIMULATIONS

MATHEMATICAL ANALYSIS AND OPERATOR THEORY

(IWCMMMSMAOT, 2026)



Department of Mathematics
Faculty of Physical Sciences
University of Benin, Benin City

16TH – 22ND
AUGUST, 2026

BOOK OF ABSTRACTS

9TH ANNUAL INTERNATIONAL
WORKSHOP AND CONFERENCE

OF THE

NIGERIAN SOCIETY FOR MATHEMATICAL
BIOLOGY (NSMB)

Theme:

**Mathematics in a Data-driven World:
Modelling, Innovation and Sustainable
Future**

Date: 16TH - 22ND AUGUST, 2026

*Venue : Department of Mathematics
Faculty of Physical Sciences
University of Benin, BeninCity*

Programme of Events

Day 1 - 3: Monday, 17th - Wednesday, 19th August 2026

Time	Event
7am	Workshop on Mathematical Modelling, Simulations, Mathematical Analysis and Operator
5pm	Arrival/Registration for Workshop at the Department of Mathematics, UNIBEN Faculty of Physical Sciences

Day 4: Thursday 20th August 2026

Time	Event
9.30-10.00am	- Courtesy visit to the Vice CHancellor
10.00am	- National Anthem
10.10am	- Introduction of Dignitaries (MC)
10.30am	- Welcoming Address by Prof J. E. Mbegbu Dean, Faculty of Physical Sciences, UNIBEN
10.35am	- NSMB, President's Address
	- Prof. G. C. E. Mbah
10.40am	- Address by Prof. Daniel Uhunoma Okuonghae, FNYA, FNMS Head, Department of Mathematics, UNIBEN
10.50am	- Address by the Vice-Chancellor, Prof. Edoba B. Omoregie, SAN University of Benin, Benin City, Nigeria
11.10am	- Good will messages from other invited guests
11.20am - 12.10am	- Keynote address by Prof. Abdon Atangana University of the Free State, Bloemfontein, South Africa
12.10pm	- Closing Remark and Vote of Thanks
	- Prof. Daniel Uhunoma Okuonghae, FNYA, FNMS (LOC Chairman)
12.15pm	- Closing prayer
12.20noon	- National Anthem
12.25pm	- Group photographs
1.00pm - 01.20pm	- Invited Speaker : Prof. Promise Mebine Vice-Chancellor, Federal University, Otuoke, Bayelsa State, Nigeria.
1.30pm	- Lunch Break
03.00pm	- Parallel Sessions
06.00pm	- Closing for the day

Day 5: Friday 21st August, 2026

Time	Event	
10.00am - 10.20am	-	Plenary Talk: Dr. Samson Olaniyi
10.30am	-	Parallel Sessions
01.00pm	-	Lunch break
02.00pm	-	Parallel sessions
04.00pm	-	AGM
07.00pm	-	Closing

Saturday 22nd August, 2026

Time	Event
	Departure

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Part I

Contributed Talks

A: Mathematical Epidemiology and Related Models

A1: Mathematical Modeling of Sickle Cell Impact on Blood Flow through a Capillary in the Presence of Magnetic Field Using Homotopy Perturbation Method

P. Mebine and K.W. Bunonyo

MMDARG and Department of Mathematics and Statistics, Federal University Otuoke, Nigeria

Abstract

The study investigates the influence of sickle cell concentration on blood flow in narrow capillaries under the influence of an externally applied magnetic field. The problem is formulated using modified Navier-Stokes equations with viscosity dependent on sickle cell concentration. The Homotopy Perturbation Method (HPM) is employed to derive an approximate analytical solution for the axial velocity profile. Effects of key parameters, including magnetic field strength and sickle cell concentration, on flow velocity and volumetric flow rate are analyzed. Results indicate a reduction in central velocity and flow rate with increased magnetic field and sickle cell concentration, highlighting implications for microvascular blood flow in sickle cell patients.

Keywords: Sickle Cell, Capillary Flow, Magnetic Field, Homotopy Perturbation Method, Blood Viscosity, MHD.

[Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology \(NSMB\) held at the University of Benin, Benin City 16 - 22 August 2026](#)

A2: Mathematical Analysis of Multiple Forces of Infection in the Co-Infection Dynamics and Control of Malaria Infection

Yusuf, I.

Department of Computer Science, Umaru Sanda Ahmadu College of Education, Minna

Abstract

This research addresses the complexities of malaria transmission by developing a multi-group compartmental model that incorporates multiple forces of infection, specifically accounting for the co-circulation of *Plasmodium falciparum* and *Plasmodium vivax*. Unlike single-pathway models, this model captures the heterogeneous transmission risks associated with varying vector-biting intensities and host susceptibility. The basic reproduction number (R_o)

was derived using the next-generation matrix method and perform stability analysis to define the threshold conditions for disease persistence. Numerical results indicate that the interaction between multiple infection forces leads to a 22% increase in the effective reproduction number compared to models assuming a single uniform force. Sensitivity analysis identifies the transmission probability per bite and the rate of superinfection as the most critical parameters, with Partial Rank Correlation Coefficients (PRCC) values of 0.89 and 0.74, respectively. Simulations of targeted interventions demonstrate that a synchronized treatment approach reduces the total infection burden by 31.5%, significantly outperforming strain-specific clinical strategies.

Keywords: Malaria infection, Compartmental Model, Co-Infection, Stability Analysis, Sensitivity Analysis.

A3: MATHEMATICAL MODEL OF THE DYNAMICS OF TYPE 1 (NEONATAL) DIABETES MELLITUS WITH CONTROL

Kolawole Adefemi Adeyemo
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Abstract

A mathematical model is formulated and confirmed to be mathematically suitable for analysis. Equilibrium point of the model is obtained and the model solution is also obtained. Disease free equilibrium (DFE) point and endemic equilibrium point (EEP) are obtained. The mathematical model established the conditions for the locally asymptotically stability (LAS) and globally asymptotically stability (GAS) of the equilibrium point. Graphical simulation of the numerical solution of the mathematical model is also obtained, and sensitivity analysis of the sensitive parameters are also determined. The graphical simulations and sensitivity analysis provide a guide towards early detection of neonatal diabetes and maximizing the corrections of ineffective activities of the pancreatic glands. The early detection and corrections of the neonatal diabetes reduce the population of type 1 diabetes mellitus. Public enlightenment is incorporated to reduce the progression of Type 1 diabetes from healthy compartment, susceptible compartment and to keep the treated neonatal diabetes in the susceptible group or reverses to the healthy compartment. The aim of the study of Type 1 diabetes is to minimize the cases of Type 1 diabetes, if the model control parameters are interpreted accordingly and strictly adhered.

Keywords: Mathematical model, Equilibrium point, Locally asymptotically stability Globally asymptotically stability and Neonatal diabetes.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A4: AI-Driven Fractional Host–Vector Malaria Modeling with Reinforcement Learning, Optimal Control, and Physics-Informed Numerical Methods

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Abstract

Malaria remains a major global health challenge due to complex interactions between human hosts and mosquito vectors. Traditional integer-order models often overlook memory effects and latent infection persistence, reducing their predictive accuracy. This study develops a fractional-order host–vector malaria model to capture historical dependence and long-term transmission dynamics. To enhance control strategies, reinforcement learning (RL) is integrated as an adaptive framework for optimizing interventions such as vector control, treatment, and vaccination. The RL agent dynamically interacts with the system to minimize infection levels under practical constraints. Additionally, physics-informed neural networks (PINNs) are employed to improve numerical accuracy by embedding the governing fractional differential equations into the solution process. Simulation results indicate that the fractional model better represents long-term malaria dynamics than classical models. The RL-based approach efficiently identifies optimal, adaptive intervention strategies, while PINNs provide accurate and stable system approximations. In general, this integrated framework combines fractional calculus, artificial intelligence, and advanced numerical methods to offer a robust, data-driven approach to malaria control, with potential applications to other vector-borne diseases.

Keywords: Fractional-order modeling; Malaria; Reinforcement learning; optimal control; Physics-informed numerical methods

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A5: Modelling Cholera Disease Dynamics with a Triple-Control Strategy

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Abstract

Despite efforts to control and possibly eradicate cholera by health organizations round the globe, Cholera disease remains a menace to public health especially in regions with poor hygiene and untreated drinking water. In this research, we develop and analyse a deterministic mathematical model that shows the transmission dynamics of the *Vibrio cholera* pathogen by utilizing a system of differential equations to predict the spread of the disease and how it propagates in a human population by incorporating vaccination, treatment, and good hygiene as control measures. It is shown that the formulated model is epidemiologically well-posed and biologically meaningful in the feasible region Ω . The threshold parameter was calculated and it was identified that if the disease free equilibrium is asymptotically stable and if an asymptotically stable Endemic Equilibrium exist. The findings demonstrates that the synergy of this triple control scenario are highly effective strategies for the diseases control. The model provides a quantitative framework for guiding healthcare resource allocation by identifying vaccination, treatment capacity and public campaign on good hygiene as the most impactful lever for reducing cholera incidence and mortality globally.

Keywords: Threshold parameter, vaccination, disease-free and Endemic Equilibrium, asymptotic stability.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A6: ANALYSIS OF A DYNAMIC MODEL OF THE DEVELOPMENT OF PROSTATE CANCER

Precious Chikaedum Agina¹, Godwin C.E. Mbah²

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Abstract

This work examines a mathematical model that captures the key processes driving prostate cancer progression. The model incorporates interactions between cancerous and healthy cells, as well as the influence of treatment factors. Analytical techniques are applied to determine equilibrium states and assess their stability, while numerical simulations illustrate how variations in model parameters affect disease outcomes. The findings reveal critical parameter ranges that can slow, halt, or reverse tumor growth, offering insights that may inform treatment strategies and improve understanding of prostate cancer dynamics.

Keyword: prostate cancer, hormonal imbalance, mutation, equilibrium state equations, stability equations.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

Keywords:

1

A7: A Mathematical Model of Cholera Dynamics in Rural and Urban Communities

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²Department of Mathematics, University of Nigeria, Nsukka, Nigeria

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Abstract

Cholera remains one of the most persistent waterborne diseases, mainly in developing countries where inadequate access to safe drinking water, poor sanitation, and environmental contamination continue to facilitate disease transmission. The burden of cholera differs considerably between rural and urban communities due to variations in sanitation infrastructure, health care accessibility, population density, and environmental conditions. This study develops a deterministic mathematical model describing the transmission dynamics of cholera in rural and urban areas. The total number of human population is divided into compartments representing susceptible, exposed, infectious, treated, recovered, and vaccinated individuals, together with an environmental bacterial compartment responsible for indirect disease transmission. The qualitative properties of the model are investigated. The positivity of solutions is established to show that all state variables remain nonnegative for all future time. Again, the boundedness of solutions and the existence of a biologically feasible invariant region are proved, ensuring that the model is biologically and mathematically well posed. The disease-free equilibrium and endemic equilibrium points are obtained, and the basic reproduction number, R_0 , is computed using the next-generation matrix method. The threshold dynamics of the model are characterized through the value of R_0 , demonstrating that cholera can be eliminated whenever $R_0 < 1$, whereas persistent transmission occurs when $R_0 > 1$. The developed model provides a mathematical framework for understanding cholera transmission in heterogeneous communities and offers insights that may assist public health authorities in designing location-specific intervention strategies for rural and urban populations.

Keywords: Cholera, Mathematical model, Basic reproduction number, Diseasefree equilibrium, Invariant region, Rural communities, Urban communities.

Subject Areas: Applied Mathematics, Mathematical Biology, Mathematical Epidemiology, Biomathematics.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A8: Mathematical Modelling of Silent Transmission and Antimicrobial Resistance in Cholera

Friday, C. K., Agbebaku, D. F., and Ejikeme, C. L.

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Abstract

Cholera remains a major public health challenge, particularly in low-resource settings where silent transmission from asymptomatic carriers and the emergence of antimicrobial resistance undermine control efforts. This study develops an eleven-compartment deterministic mathematical model that incorporates symptomatic and asymptomatic infections, environmental reservoirs, vaccination, and treatment-induced drug resistance. Analytical expressions for the effective reproduction numbers of both drug-sensitive and drug-resistant strains are derived to establish threshold conditions for transmission and resistance emergence. The local stability of the disease-free equilibrium is analysed using the Gershgorin Disc Theorem, while global stability is established through the Castillo–Chávez approach. Sensitivity analysis identifies recruitment rate, environmental exposure, and treatment failure as key drivers influencing the transmission dynamics. Numerical simulations demonstrate that resistant strains can persist under waning immunity or suboptimal treatment, whereas integrated interventions combining high vaccination coverage and improved treatment efficacy can suppress both sensitive and resistant strains. These findings provide theoretical insights to guide the formulation of integrated cholera control strategies that address both pathogen transmission and the containment of antimicrobial resistance.

Keywords: Cholera; mathematical modelling; antimicrobial resistance; asymptomatic transmission; vaccination; drug-resistant strains; sensitivity analysis; stability analysis; Gershgorin Disc Theorem.

Mathematics Subject Classification (MSC 2020): 92D30 (Epidemiology), 34D20 (Stability), 34D23 (Global stability)

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A9: MATHEMATICAL MODELING FOR TUBERCULOSIS DYNAMICS CONSIDERING COUNSELING UNIT AND RE-INFECTION

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Abstract

Tuberculosis (TB) remains a major global health concern, particularly in developing countries where weak health systems and socio-economic challenges exacerbate its spread. This study develops a deterministic compartmental model to analyze the transmission dynamics of tuberculosis incorporating reinfection and the role of a counseling unit. The model divides the population into six compartments: Susceptible (S), Latent (L), Infectious (I), Treatment (T), Counseling Unit (C_u), and Recovered (R). By integrating both biological and behavioral interventions, the model provides a more holistic understanding of TB control. New generation matrix approach is used to derive the basic reproduction number (R_o) and determine the stability of the disease-free and endemic equilibria. Numerical simulations further demonstrate how counseling interventions improve treatment adherence and reduce reinfection risks. The findings highlight that combining treatment with counseling support can significantly reduce TB prevalence, offering valuable insights for public health policies and integrated control strategies.

Keywords: Tuberculosis, counseling unit, re-infection, stability and reproduction number.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A10: A Mathematical Model of the Dynamics of Lassa Fever Disease in Compliance with Control Measures

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Abstract

Lassa fever which is an acute hemorrhagic fever was studied using mathematical modeling approach by applying the compartmental analysis technique. The formulated mathematical model contained control measures in the parameters of both human and rat (rodents) population. The disease-free equilibrium point was analyzed and the endemic equilibrium state equilibrium obtained. The basic reproduction number was obtained and the stability of disease-free equilibrium as analyzed and it was locally asymptotically stable if the basic reproduction number was less than one. The sensitivity analyses of the model parameter was evaluated and tabulated with the corresponding sensitivity indices for each parameter which represent the force of infection. The results obtained have shown that the disease could be eradicated if the control measures are adequately applied. A similar model in the form of non-autonomous system of differential equations is recommended for further research. The cost analysis for implementing the various control measures could be studied.

Keywords: TMathematical modeling, Control, Stability analysis, sensitivity analysis, disease free equilibrium, endemic.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A11: A Mathematical Model for Assessing The Impact Of Zoophylaxis Intervention In Malaria Transmission

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Abstract

Malaria remains a major public health challenge, causing substantial morbidity, mortality, and socioeconomic losses worldwide. In this study, we develop a mathematical model that incorporates a novel vector control strategy involving the administration of a sterilizing drug to a non-human primate population. The treated primates serve as alternative blood-meal hosts for mosquitoes. Following blood feeding, the drug sterilizes the mosquitoes, thereby reducing their reproductive capacity, lowering mosquito population density, and interrupting malaria transmission to humans. The basic reproduction number, R_0 , was derived, and the local and global stability of the disease-free and endemic equilibria were analyzed. Sensitivity analysis identified ξ_m , the mosquito attraction rate to treated primates, and the feeding proportions ρ_1 , ρ_2 , and ρ_3 of susceptible, exposed, and infectious mosquitoes, respectively, as the most influential parameters. Increasing these parameters resulted in a proportional reduction in R_0 . Furthermore, bifurcation analysis established the absence of backward bifurcation, indicating that the disease-free equilibrium is globally attainable when $R_0 < 1$. Numerical simulations support the analytical results, demonstrating that the proposed intervention effectively suppresses malaria transmission and drives the system toward a disease-free state. These findings highlight the potential of host-targeted vector control as a complementary strategy for malaria elimination.

Keywords and phrases: Stability, bifurcation, dynamics, Malaria, Intervention, Transmission, Zoophylaxis.

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A12: STOCHASTIC SEIARV MATHEMATICAL MODEL FOR COVID-19 DISEASE TRANSMISSION WITH INTERVENTION ANALYSIS

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Abstract

This study develops a stochastic Susceptible–Exposed–Infectious–Asymptomatic–Recovered–Vaccinated (SEIARV) mathematical model for investigating COVID-19 transmission and evaluating the effects of vaccination and intervention strategies. The proposed model incorporates demographic recruitment and natural mortality, disease transmission, progression from exposure to symptomatic and asymptomatic infectious classes, recovery, disease-induced mortality, vaccination, and stochastic perturbations to represent random fluctuations in epidemic transmission. The model is formulated as a system of stochastic differential equations and analysed mathematically to establish the positivity and boundedness of its solutions and to determine the disease-free equilibrium. The basic reproduction number, denoted by R_0 , is derived using the next-generation approach and

serves as the principal threshold quantity for assessing disease invasion. Local stability analysis of the disease-free equilibrium shows that the equilibrium is locally asymptotically stable when $R_0 < 1$ and unstable when $R_0 > 1$. For the numerical investigation, an Euler–Maruyama scheme is employed to simulate the stochastic model over a 72-month period corresponding to January 2020 to January 2026. A synthetic monthly dataset and a baseline parameter configuration are used for methodological calibration and simulation. The baseline parameter set gives $R_0 = 1.4197$, indicating that the disease has the potential for sustained transmission in the absence of sufficiently strong control measures. The stochastic simulations demonstrate substantial variability in epidemic trajectories, reflecting the effects of random environmental and transmission disturbances. The combined symptomatic and asymptomatic infectious population reaches a simulated maximum of approximately 2165.70, before declining to approximately 609.78 at the end of the simulation period, corresponding to an approximate reduction of 71.8 from the simulated peak. The vaccinated population increases progressively and reaches approximately 682.96 by January 2026. Intervention simulations further demonstrate that increasing vaccination coverage and vaccination effectiveness can reduce the effective transmission potential and infectious burden. Comparison of vaccination scenarios indicates that accelerated vaccination provides greater control of infection than the baseline vaccination strategy, while insufficient vaccination permits prolonged transmission. The results demonstrate that the stochastic SEIARV framework provides a useful mathematical and computational tool for examining epidemic dynamics and quantifying the potential effects of vaccination interventions. However, because the numerical experiments are based on synthetic data, the reported numerical outcomes should be interpreted as simulation-based methodological findings rather than empirical forecasts. Validation using independently collected epidemiological surveillance data is therefore recommended before the model is applied to policy or public-health decision making.

Keywords: COVID-19; SEIARV model; stochastic epidemic model; vaccination; intervention; basic reproduction number; disease-free equilibrium; Euler–Maruyama method; epidemic dynamics.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A13: A Human–Blackfly Transmission Model for Onchocerciasis Incorporating Treated and Untreated Human Compartments under Ivermectin-Based Mass Drug Administration

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Abstract

Onchocerciasis is a neglected tropical disease caused by *Onchocerca volvulus* and transmitted by infectious blackflies of the genus *Simulium*. Despite ivermectin-based mass drug administration (MDA), transmission persists in some endemic communities. This study developed and analyzed a deterministic compartmental model for onchocerciasis transmission between human and blackfly populations, incorporating ivermectin-based intervention. The human population was divided into susceptible, exposed, early-treated exposed, infectious, treated infectious, untreated infectious, and recovered compartments, while blackflies were classified as susceptible, exposed, and infectious. The model explicitly distinguishes treated and untreated infectious humans, with only untreated infectious humans contributing to blackfly infection. Positivity, boundedness, and an invariant region were established, while disease-free and endemic equilibria were determined. The basic reproduction number (R_0) was computed using the next-generation matrix method, and local stability and sensitivity analyses were performed. Numerical simulations using literature-informed parameter values showed that increased ivermectin treatment reduced untreated infectious humans, and infectious blackflies. The baseline simulation yielded $R_0 \approx 3.04$, while higher treatment intensity substantially reduced transmission, although remained above unity. The findings suggest that sustained high treatment coverage and complementary interventions may be required for elimination.

Keywords: Onchocerciasis; deterministic model; ivermectin; mass drug administration; basic reproduction number.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A14: STOCHASTIC SEIARV MATHEMATICAL MODEL FOR COVID-19 DISEASE TRANSMISSION WITH INTERVENTION ANALYSIS

T. N. Charles and A. B. Okrinya
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Abstract

This study develops and investigates a stochastic Susceptible–Exposed–Infectious–Asymptomatic–Recovered–Vaccinated (SEIARV) mathematical model for analyzing infectious disease transmission and assessing the effects of vaccination and intervention strategies. The model incorporates demographic processes, disease transmission, asymptomatic infection, recovery, vaccination, and stochastic perturbations to account for random variations in epidemic dynamics. A synthetic monthly dataset covering the period January 2020 to January 2026 was employed for model calibration, numerical simulation, sensitivity analysis, diagnostic assessment, and uncertainty quantification. The basic reproduction number was derived to determine the transmission threshold of the model, while numerical simulations were performed using a stochastic numerical scheme. The baseline simulation produced an estimated reproduction number of $R_0 = 1.4197$, indicating that the disease has the potential for sustained transmission under the baseline parameter configuration. The maximum combined infectious and asymptomatic population was approximately 2165.70, while the corresponding population at the end of the 72-month simulation declined to 609.78, representing an approximate 71.8% reduction from the simulated peak. The vaccinated population reached approximately 682.96 at the end of the simulation. Sensitivity and uncertainty analyses were conducted to examine the influence of model parameters on transmission dynamics and to quantify the propagation of parameter uncertainty into epidemic outcomes. Scenario analysis further demonstrated the potential importance of increasing vaccination coverage and strengthening transmission-reduction interventions in lowering the effective transmission potential and infectious burden. Overall, the results demonstrate that the stochastic SEIARV framework provides a useful mathematical and computational approach for investigating epidemic dynamics and evaluating vaccination and intervention strategies. Since the present analysis is based on a synthetic dataset, the findings should be interpreted as simulation-based methodological results. Further validation with independently collected epidemiological surveillance data is recommended before the model is used for empirical prediction or policy decision-making.

Keywords: SEIARV model; stochastic epidemic model; COVID-19; vaccination; basic reproduction number; sensitivity analysis; uncertainty analysis; mathematical modelling; epidemic dynamics.

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A15: MATHEMATICAL MODELLING OF PFEMP1 GENE REGULATION: GF3 INSIGHTS INTO CHROMATIN-MEDIATED VIRULENCE SWITCHING IN PLASMODIUM FALCIPARUM

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Abstract

Plasmodium falciparum possesses complex regulatory mechanisms that enable it to adapt to the host environment and regulate virulence-associated gene expression. PfEMP1, encoded by the var gene family, plays a central role in parasite pathogenicity and immune evasion. However, the mathematical relationship between

PfEMP1 expression and epigenetic regulatory factors remains an important area for understanding parasite transcriptional control. In this study, a finite-field modeling approach was applied to investigate the association between PfEMP1 expression and key epigenetic regulators, including PfSIR2A, HP1, and H3K9me3. The parasite regulatory network was represented as a discrete dynamical system $F : K^9 \rightarrow K^9$, where K represents $GF(3)$, describing three levels of expression. Stable regulatory configurations were identified through the fixed-point condition $F(X) = X$. Analysis of the fixed-point solutions demonstrated a consistent inverse relationship between PfEMP1 expression and the epigenetic repression-associated state represented by PfSIR2A, HP1, and H3K9me3. In the $GF(3)$ model, PfEMP1 expression states 0, 1, and 2 corresponded to epigenetic states (2,2,2), (1,1,1), and (0,0,0), respectively. These findings suggest that PfEMP1 regulation is controlled through an epigenetic switching mechanism embedded within the parasite gene regulatory network.

Keywords or Phrases: Plasmodium falciparum, gene regulation, epigenetic regulation, finite field, fixed points.

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A16: MODELLING THE ROLE OF ISOLATION AND CREMATION IN EBOLA VIRUS DISEASE TRANSMISSION DYNAMICS

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Abstract

The WHO as of Mid-May 2026 declared Ebola Virus Disease (EVD) as constituting a public health emergency of international concern. Before 2026, the Chronology of the disease outbreak reveals that over 35 outbreaks has occurred since its discovery in 1976. The disease which is characterized by a highly lethal hemorrhagic fever is classified as ‘A’ bioterrorism agent whose risk of continuous emergence poses a serious threat to the existence of humans and primates. In this research, a compartmental mathematical model that describes the dynamical flow of the disease from person to person was developed using a schematic diagram which was then translated into a system of ordinary differential equations (ODE) comprising equations of susceptible (S), Latent (L), Infectious (I), Isolated (Q), disease induced death (D) and recovery (R) compartments. The model was confirmed to be well posed and epidemiologically feasible. Next Generation Matrix approach was used to determine R_0 and the stabilities of the equilibrium states were investigated. Sensitivity analysis carried out using the normalized forward sensitivity indices approach revealed that recruitment rate and cremation of disease induced dead bodies are the critical parameters influencing the disease spread while numerical analysis validates the analytical solutions. The discovery offers promising strategies in mitigating Ebola Virus Disease prevalence.

Key words: Ebola Virus, Cremation, Isolation, Equilibrium, basic reproduction number.

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A17: Modeling Mpox Transmission with Vaccination, Testing, and Isolation

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Abstract

Mpox remains an important emerging zoonotic disease with significant public health implications due to its increasing outbreaks and multiple transmission pathways. This study develops and analyzes a deterministic compartmental model that incorporates vaccination, testing, treatment, and environmental pathogen dynamics to investigate Mpox transmission. Fundamental qualitative properties of the model, including positivity, boundedness, and equilibrium existence, are established. The basic reproduction number is derived using the next-generation matrix approach and employed to determine threshold conditions for disease persistence. Local and global stability analyses are performed to characterize the disease-free and endemic equilibria. Sensitivity analysis identifies the parameters with the greatest influence on disease transmission, while an optimal control framework is formulated to evaluate the combined effects of vaccination, public awareness, testing, and treatment strategies. Numerical simulations demonstrate that integrated intervention strategies substantially reduce disease prevalence and environmental contamination compared with individual control measures. The proposed framework provides useful quantitative insights for designing effective public health policies aimed at mitigating Mpox outbreaks.

Key words: Mpox; Mathematical Modelling; Sensitivity Analysis; Optimal Control; Vaccination 1

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A18: Dynamical Method Analysis of Typhoid and Hepatitis A (TYPHOHEPATA) Co-infection model with Climate Resilience Forcing Functions

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Abstract

This study on dynamical method analysis of typhoid and hepatitis a (TYPHOHEPATA) co-infection model proposed and analyzed eight-compartmental delay differential equation with climate variations, sanitation dynamics. The study identified two time delays as incubation and latency periods, climate force of transmission, government WASH intervention and population pressure terms. The basic reproduction number R_0 was derived using the next generation matrix method, and the stability of disease-free and endemic equilibria were analyzed. Numerical simulations are carried out using Nigeria demographic and climatic data to measure the effect of sanitation enhancement, seasonal rainfall, and delays on TYPHOHEPATA co-infection dynamics. The results show that poor sanitation and increased rainfall increase the co-infection burden with significant effect, while targeted WASH interventions can decrease the peak and delay outbreaks. The findings provide policy insights for integrated control of Typhoid and Hepatitis A in resource-limited locations in overcrowded cities.

Key words: Delay Differential Equations; Typhoid; Hepatitis A; Co-infection; Sanitation Climate Forcing functions; WASH

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A19: Mathematical Modelling of Tuberculosis Dynamics Considering Re-Infection and Counseling Unit.

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Abstract

Tuberculosis (TB) remains a major global health concern, particularly in developing countries where weak health systems and socio-economic challenges exacerbate its spread. This study develops a deterministic compartmental model to analyze the transmission dynamics of tuberculosis incorporating reinfection and the role of a counseling unit. The model divides the population into six compartments Susceptible (S), Latent (L), Infectious (I), Treatment (T), Counseling Unit (C_u), and Recovered (R). By integrating both biological and behavioral interventions, the model provides a more holistic understanding of TB control. New generation matrix approach is used to derive the basic reproduction number (R_o) and determine the stability of the disease-free and endemic equilibria. Numerical simulations further demonstrate how counseling interventions improve treatment adherence and reduce reinfection risks. The findings highlight that combining treatment with counseling support can significantly reduce TB prevalence, offering valuable insights for public health policies and integrated control strategies.

Keywords: Tuberculosis, Counseling Unit, Re-infection, Stability and Reproduction Number.

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A20: A Mathematical Model of the Dynamics of Lassa Fever Disease in Compliance with Control Measures

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Abstract

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Lassa fever which is an acute hemorrhagic fever was studied using mathematical modeling approach by applying the compartmental analysis technique. The formulated mathematical model contained control measures in the parameters of both human and rat (rodents) population. The disease-free equilibrium point was analyzed and the endemic equilibrium state equilibrium obtained. The basic reproduction number was obtained and the stability of disease-free equilibrium as analyzed and it was locally asymptotically stable if the basic reproduction number was less than one. The sensitivity analyses of the model parameter was evaluated and tabulated with the corresponding sensitivity indices for each parameter which represent the force of infection. The results obtained have shown that the disease could be eradicated if the control measures are adequately applied. A similar model in the form of non-autonomous system of differential equations is recommended for further research. The cost analysis for implementing the various control measures could be studied.

Keywords: Mathematical modeling, Control, Stability analysis, sensitivity analysis, disease free equilibrium, endemic.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A21: A MATHEMATICAL MODEL ON THE BLOOD GLUCOSE CONCENTRATION IN A TYPE 1 DIABETIC PATIENT WITH ENHANCED INSULIN PRESENCE IN THE BLOOD.

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Abstract

In this work, we formulate and study a fractional model of glucose-insulin dynamics in a treated Type 1 diabetic patient. The model modifies classical nonlinear ODEs by introducing Caputo fractional derivatives to capture memory effects and long-range physiological dependencies. Drug intervention is incorporated through a parameter that enhances insulin effectiveness and prolongs its activity in the bloodstream, without directly increasing secretion. The resulting nonlinear fractional system is solved using the Laplace Adomian Decomposition Method (LADM), which provides convergent semi-analytical solutions. Simulations in MATLAB assess the impact of varying glucose intake (Q) on system behavior. The results highlight the suitability of fractional modeling for accurately describing physiological regulation and drug-enhanced insulin-glucose feedback mechanisms in chronic disease systems.

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A22: ANALYSIS OF A DYNAMIC MODEL OF THE DEVELOPMENT OF PROSTATE CANCER.

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Abstract

This work examines a mathematical model that captures the key processes driving prostate cancer progression. The model incorporates interactions between cancerous and healthy cells, as well as the influence of treatment factors. Analytical techniques are applied to determine equilibrium states and assess their stability, while numerical simulations illustrate how variations in model parameters affect disease outcomes. The findings reveal critical parameter ranges that can slow, halt, or reverse tumor growth, offering insights that may inform treatment strategies and improve understanding of prostate cancer dynamics.

Keywords: prostate cancer, hormonal imbalance, mutation, equilibrium state equations, stability equations.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A23: STABILITY ANALYSIS OF THE DISEASE-FREE EQUILIBRIUM STATE OF TRACHOMA MODEL WITH PUBLIC ENLIGHTENMENT CAMPAIGNS AND CONTAMINATED ENVIRONMENT COMPARTMENT.

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Abstract

The aim of this work is to formulate and analyze a deterministic model for the transmission dynamics of trachoma in Nigeria, in which we take into account direct transmission (human-human), vector transmission (human-fly-human), and environmental transmission (human-contaminated objects), using ordinary differential equation. After showing the existence and uniqueness of solutions, we compute the basic reproduction number, using the next generation method approach. Conditions for stability or otherwise of the disease-free equilibrium (DFE) were analyzed, which showed that the disease-free equilibrium (DFE) is stable whenever .The result showed that high rate of public enlightenment campaign and compliance couple with treatment is very important for curbing the transmission of the disease.

Keywords: Trachoma Model, Basic Reproduction Number, Disease-Free Equilibrium, Stability.

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A24: A Mathematical Model of HumanMetaPneumoVirus (HMPV) dynamics.

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Abstract

Human metapneumovirus is a viral infectious disease of health concern. In this paper; we developed a mathematical model on HMPV spread and showed that the modeled equation was mathematically well posed and epidemiologically meaningful. We adopted the dynamical system analysis technique in the model, particularly obtaining the threshold quantity R_0 , the basic reproduction number via the next generation matrix approach and also proved the existence of fixed points (steady states). The study on sensitivity analysis informed that the exposure rates of human population are the most significant in influencing new infections in the system. Lastly, we examined the short and long term dynamics of the disease within the basin of attractions using appropriate tools, and found out that there is possibility of wiping out HMPV from the populace with time provided attention is paid to awareness, exposure, and improved dietary to boost immunity level.

Keywords: Humanmetapneumovirus, dynamics.

MSC Classification: Epidemiological Mathematical Model.

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A25: EFFECTS OF TRANSMISSION RATE ON THE DYNAMICS OF TWO-STRAIN MODEL OF TUBERCULOSIS.

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Abstract

This study explores tuberculosis (TB) transmission, focusing on drug-sensitive (DS-TB) and drug-resistant (DR-TB) strains. TB, caused by *Mycobacterium tuberculosis*, remains a major global health threat despite vaccines and WHO-led control efforts, ranking second only to COVID-19 in infectious disease mortality. In 2023, around 10.8 million people were infected globally. The study introduces a mathematical model comprising seven compartments representing different TB stages and resistance types. It simulates natural population growth, infection dynamics, and treatment effects. Key concepts such as disease-free equilibrium (DFE), endemic equilibrium (EE), and the basic reproduction number (R_0) are analyzed. Using the Routh-Hurwitz criterion and the Lasalle-Lyapunov function, the model identifies conditions under which TB can be eradicated. Results suggest that reducing transmission rates of both DS-TB and DR-TB, alongside natural death rates, is critical to achieving disease elimination.

Keywords: Tuberculosis; Drug-resistance; Drug- susceptible; Positivity of Solution; Two-strain.

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A26: AN ALGEBRAIC APPROACH TO MODELING THE ACTIVATION OF GENES ASSOCIATED WITH MALARIA DRUG RESISTANCE IN HUMAN.

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Abstract

The knowledge of the dynamics of drug resistance mechanism in malaria is very important for developing a good and impact making therapeutic strategies. In this work, we examine the behaviour of a Boolean network model whereby key genes and drug resistance mechanism in *Plasmodium falciparum* were represented, with attention on the effects of chloroquine (CQ), artemisinin (ART), and pyrimethamine (PYR) drug pressures. We represented the Boolean network model rules and state transitions in Square-free polynomial form over the finite field F_2 . By analyzing the network under various drug pressure conditions, we obtained both synchronous and asynchronous phase states. We identify stable configurations that gives critical insights into the gene interactions that controls resistance. For a better understanding of the system's dynamics, we provide a comprehensive graphical representation of the state transitions and state evolution graphs, thereby illustrating how the network evolves under different drug pressures.

Keywords: Algebraic Modeling, Malaria, Drug resistance, Boolean network and Square-free polynomial.

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A27: MATHEMATICAL FRAMEWORK TO DELINEATE THE COMPLEXITY OF THE DNA OF *PLASMODIUM FALCIPARUM*.

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Abstract

Plasmodium falciparum, the most virulent and deadliest human malaria parasite, exhibits a complex and highly regulated genome essential for its survival and adaptability within the human host. This study introduces a novel algebraic modeling framework that integrates Boolean networks, finite field algebra, and graph theory to systematically explore the structural and functional complexity of the parasite's DNA regulation within the human host. A comprehensive analysis of the network was carried out to delineate the complex and highly regulated genome of the parasite. The Boolean network model rules and state transitions were represented in Square-free polynomial form over the finite field F_2 . In order to identify stable configurations that correlate with parasite survival, virulence, resistance and gives critical insights into the gene interactions of the genome, we obtained both synchronous, asynchronous phase states and the fixed points states. Graphical representations of the state transitions and state evolution were provided which further illustrate how the genes interact within the human body.

Keywords: Mathematical framework, genome, Boolean network, Square-free polynomial and fixed points.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

A28: Mathematical Modelling of Autonomous and Optimal Control Model of Cholera Transmission Dynamics Incorporating Logistic Growth and Vaccination Strategies

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Abstract

Cholera, caused by *Vibrio cholerae*, remains a significant public health challenge transmitted through contaminated food and water. Despite a number of mathematical models on cholera dynamics, the combined impact of bacterial logistic growth, vaccination and optimal control remains underexplored. This study develops and analyses a novel cholera model incorporating these features. The population is classified into Susceptible $S(t)$, Exposed $E(t)$, Infectious $I(t)$, Vaccinated $V(t)$, Recovered $R(t)$, and *Vibrio cholerae* concentration $B(t)$. Positivity and boundedness principles confirmed model well-posedness. The effective reproduction number R_e was derived using the next generation matrix operator, and normalized forward sensitivity analysis assessed parameter impacts on R_e . Three time-dependent controls were incorporated: pre-exposure vaccination $V(t)$, treatment $u_1(t)$, and sanitation $u_2(t)$. Optimal control existence was established via Pontryagin's Maximum Principle. Efficiency and economic analyses using ACER, ICER, and IAR evaluated intervention scenarios. The cholera-free equilibrium was locally asymptotically stable when $R_e < 1$. Vaccination, recovery rate, and *Vibrio cholerae* death rate yielded negative sensitivity indices, while transmission probability, shedding rate, and intrinsic growth rate yielded positive indices. Scenario Z4, combining all three interventions, proved most efficient and cost-effective. Combined pre-exposure vaccination, treatment, and environmental sanitation are recommended to guide public health policy.

Keywords: Cholera, Optimal Control, Logistic Growth, Effective Reproduction Number, Cost-Effectiveness Ratio.

MSC Classification: Biomathematics (Mathematical Epidemiology) .

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A29: Mathematical Analysis of Multiple Forces of Infection in the Co-Infection Dynamics and Control of Malaria Infection.

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Abstract

This research addresses the complexities of malaria transmission by developing a multi-group compartmental model that incorporates multiple forces of infection, specifically accounting for the co-circulation of *Plasmodium falciparum* and *Plasmodium vivax*. Unlike single-pathway models, this model captures the heterogeneous transmission risks associated with varying vector-biting intensities and host susceptibility. The basic reproduction number (R_0) was derived using the next-generation matrix method and perform stability analysis to define the threshold conditions for disease persistence. Numerical results indicate that the interaction between multiple infection forces leads to a 22% increase in the effective reproduction number compared to models assuming a single uniform force. Sensitivity analysis identifies the transmission probability per bite and the rate of super-infection as the most critical parameters, with Partial Rank Correlation Coefficients (PRCC) values of 0.89 and 0.74, respectively. Simulations of targeted interventions demonstrate that a synchronized treatment approach reduces the total infection burden by 31.5%, significantly outperforming strain-specific clinical strategies.

Keywords: Malaria infection, Compartmental Model, Co-Infection, Stability Analysis, Sensitivity Analysis.

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A30: SPATIO-TEMPORAL MODELLING OF MALARIA AND TYPHOID FEVER CO-DISTRIBUTIONS FOR SUSTAINABLE URBAN HEALTH PLANNING IN KANO METROPOLIS, NIGERIA.

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Abstract

Climate-sensitive diseases such as malaria and typhoid fever remain significant public health burdens in sub-Saharan Africa, yet their spatial and temporal dynamics are often analysed separately. Understanding their co-distribution through data-driven modelling is critical for sustainable disease control in rapidly urbanising environments. This study applies spatio-temporal statistical modelling to analyse a decade (2013–2022) of clinically confirmed malaria and typhoid cases across eight Local Government Areas (LGAs) of Kano Metropolis, Nigeria, to identify environmental drivers, disease hotspots, and intervention priorities. The data was analysed using GIS-based choropleth map (ArcMap 10.8) and two-way ANOVA with post hoc Tukey HSD tests (SPSS v21), modelled the monthly and annual incidence of both diseases against LGA-level and temporal factors. Mean cumulative incidence maps were generated to visualise heterogeneity in disease burden. The results showed significant spatial ($F=5.37$, $p=0.001$) and temporal ($F=14.05$, $p=0.001$) variation in malaria, with Ungogo (55,641 mean cases), Nassarawa (47,667), and Gwale (47,644) identified as persistent high-incidence zones. Typhoid exhibited strong spatial clustering ($F=192$, $p=0.001$) but no significant inter-annual variation ($p=0.999$), with Kumbotso (4,439 mean cases) and Tarauni (3,738) as consistent hotspots. Notably, Kumbotso emerged as a low-malaria but high-typhoid zone, indicating divergent environmental determinants: malaria correlates with stagnant water and poor drainage, while typhoid reflects unsafe water and inadequate sanitation. Malaria incidence followed a clear seasonal peak (July–October), whereas typhoid spikes aligned with water scarcity (March–April) and heavy rains (August–October). The study demonstrates that mathematical and statistical modelling—specifically ANOVA-based inference and spatial autocorrelation—can disentangle overlapping disease ecologies. Persistent malaria hotspots demand vector control and drainage improvements, while typhoid hotspots require water, sanitation, and hygiene (WASH) interventions and targeted vaccination. This data-driven, spatio-temporal approach provides a replicable framework for sustainable urban health planning in low- and middle-income countries.

Keywords: Spatio-temporal modelling, malaria, typhoid fever, ANOVA, GIS, environmental sustainability, urban health, Kano Metropolis. .

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A31: Non-Linear Dynamical System Approach on MPOX Disease Model.

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Abstract

Mpox remains a persistent global public health challenge affecting human populations. It is a viral zoonotic disease caused by an orthopoxvirus, similar to smallpox but generally less severe, though potentially fatal. This study investigates the nonlinear dynamics of Mpox transmission using a deterministic compartmental model formulated under the assumption of a homogeneously mixing population. Qualitative analysis of the model establishes key properties, including positivity and boundedness of solutions, and identifies the equilibrium points. The basic reproduction number (R_0), which governs disease transmission dynamics, is derived using standard

methods. Stability analysis shows that the disease-free equilibrium is locally and globally asymptotically stable when ($R_0 < 1$), while the endemic equilibrium is both locally and globally stable when ($R_0 > 1$). Sensitivity analysis of (R_0) reveals that the transmission parameters β_1 , β_2 , and β_3 have positive sensitivity indices, indicating that increases in these parameters enhance disease spread. Conversely, parameters such as ω , α_1 , α_2 , μ , and μ_p exhibit negative sensitivity indices, suggesting that their increase contributes to reducing disease transmission and controlling outbreaks. Numerical simulations are conducted to illustrate both short-term and long-term dynamics of the model. Baseline simulations of the nine-compartment system are performed using realistic initial parameter values. Further simulations examine the effects of varying the infection rate β_2 , as well as the impact of intervention strategies including vaccination, public awareness, and combined control measures.

Keywords: Mpox, Nonlinear Dynamical Systems, Basic Reproduction Number, Stability Analysis, Sensitivity Analysis, Numerical Simulation.

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A32: Nonlinear Dynamics of a Multi-Host Marburg Virus Disease Transmission Model with Artificial Neural Network (ANN).

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Abstract

In recent years, Ethiopia, Tanzania and many other African countries have suffered a resurgent outbreak of Marburg virus disease (MVD) which has caused several deaths. In this research, we developed a deterministic compartmental human-bat mathematical model of the Marburg virus disease. The positivity and boundedness of the model, disease-free and endemic equilibrium points and basic reproduction number R_0 were derived. Further, the stability analysis, bifurcation analysis, numerical analysis, 3-D and contour plot and sensitivity analysis and of the model was conducted. Additionally, the approximation of the model using artificial neural network (ANN) was visualised. Keywords:

Keywords: Marburg virus disease; Basic reproduction number; Positivity and boundedness; Equilibrium point; Basic reproduction number; Stability analysis; Bifurcation analysis; Sensitivity analysis; Artificial neural network.

MSC2020: 92D30; 34D20; 65L07; 62P10; 92B05; 34A34; 37N25.

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A33: Mathematical Analysis of Peptic Ulcer Disease Dynamics with Prevention and Treatment Interventions

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Abstract

Peptic ulcer disease (PUD) remains a significant gastrointestinal disorder driven by *Helicobacter pylori* infection, inappropriate use of nonsteroidal anti-inflammatory drugs (NSAIDs), and unhealthy lifestyle factors. This study presents a deterministic Susceptible, Protected, Infected, Recovered (SPIR) mathematical model to examine the dynamics of PUD transmission and evaluate the effects of prevention and treatment interventions. The model incorporates susceptible, protected, infected, and recovered populations and is analysed using equilibrium and stability theory. The disease-free and endemic equilibrium points are derived, while the basic reproduction number (R_0) is obtained to determine the threshold for disease persistence. Local stability analysis shows that the disease-free equilibrium is stable when $R_0 < 1$, whereas the endemic equilibrium persists when $R_0 > 1$. Numerical simulations demonstrate that enhanced preventive measures, increased treatment effectiveness, and reduced transmission significantly lower disease prevalence. The findings provide a quantitative framework for understanding PUD dynamics and offer valuable insights for designing effective prevention, treatment, and public health intervention strategies.

Keywords: Basic Reproduction Number (R_0); Mathematical Modelling; Peptic Ulcer Disease (PUD); SPIR Compartmental Model; Stability Analysis.

2020 AMS Subject Classification: 37Nxx, 37N25.

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A34: MATHEMATICAL MODELLING OF THE EFFECTS OF OPTIMIZED DRAINAGE SYSTEMS ON MOSQUITO DYNAMICS IN PREVENTING THE SPREAD OF ZIKAVIRUS

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Abstract

This research develops a six compartmental mathematical model that combines both human and mosquito population dynamics, focusing on the impact of drainage systems, to evaluate their role in controlling ZIKV. The model includes susceptible, infected, and recovered classes in both populations and introduces parameters (k_o and k_e) to represent how drainage reduces mosquito breeding habitats. The analysis shows that when $k_o + K_e$, the disease-free equilibrium becomes locally asymptotically stable, completely stopping the spread of the disease. The basic reproduction number R_o is derived, and results confirm that optimized drainage can bring $R_o < 1$, a necessary condition for disease elimination. Using optimization techniques such as Lagrangian methods, the study finds that distributing drainage resources equally ($k_o D_o = k_e D_o = c/2$) yields the most efficient reduction in mosquito populations. Stability analysis shows that higher mosquito reproduction (ρ_m) and contact rates (β_e) makes the disease lasts longer, stressing the need for combined control methods.

Keywords: Mathematical modelling, optimized drainage system, Mosquito dynamics and Reproduction Number.

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B: Non-Epidemiological and Fluid Dynamics Models and Other Applied Mathematics

B1: CONCENTRATED LOAD ON NON-UNIFORM RAYLEIGH BEAM WITH VARIABLE AXIAL FORCE AND DAMPING TERM

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Abstract

This paper aims to explore concentrated load on Rayleigh beam whose moment of inertia and mass per unit length varies with position x along the span L of the beam. The foundation models considered in this work are Winkler and Pasternak foundation models while the axial force considered is not constant but varies with position x of the beam. In order to reduce the risk of resonance effect on the dynamical system, the damping term is taken into consideration in the model equation. The solutions as shown in the graphs are obtained using weighted residual method and integral transformation. The results reveals that, increases in the axial force (N_o), damping coefficient (Δc), Winkler foundation parameter (K_o), Pasternak foundation parameter (F_o), rotatory inertia (R_o) reduces the response amplitudes and this will in effect lead to an increases in the critical speed of the moving load and reduces the risk of resonance in the dynamical system. It was also reveals that, a reduction in the length (L) of the beam lead to reduction in the response amplitude of the beam. That is, the smaller the length of the beam, the lesser will be the effect of the moving load on the structures and hence reducing the risk of resonance as well. Also, the effects of damping and rotatory inertial on the beam subjected to concentrated load is higher compares to any other structural parameters. Finally, taking all the above into consideration during the designing and implementation stages of the structures under moving loads can guarantee the safety of lives.

Keywords: Variable Axial Force, Damping Term, Non-Uniform Beam, Winkler Foundation Model, Pasternak Foundation Model.

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B2: A Mathematical modeling perspectives on hard skills and soft skills for sustainable national development

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Abstract

This study explores the synergy between mathematical modeling, hard skills and soft skills in fostering entrepreneurial ecosystems that drive sustainable national development by using a system of nonlinear first order partial differential equations with MATLAB ODE45 numerical scheme. This study revealed that integrating mathematical modeling with hard and soft skills creates entrepreneurial ecosystems which can be optimized to promote innovation, job creation and economic development; identified the type of skills required for national development; the role of hard skills for entrepreneurial productivity and economic growth; and a balanced approach that integrates both hard skills and soft skills for sustainable national development. The proposed mathematical framework also leverages mathematical modeling to inform decision-making, predict outcomes and allocate resources efficiently. Balancing hard skills (data analysis, computational thinking, exact-solutions method) with soft skills (communication, collaboration, leadership e.t.c) is crucial for creating a thriving entrepreneurial ecosystems. This study provides insights for policymakers, entrepreneurs, curriculum planners and educators seeking to develop entrepreneurial ecosystems to drive sustainable national growth. This study recommends among others that the state and federal governments should enforce the implementation of hard skills acquisition into the school curriculum; loan should be given to entrepreneurs as to alleviate poverty and regular sustainable national development.

Keywords: Entrepreneurial ecosystems, Mathematical modeling, Hard skills, Soft skills, Sustainable national development.

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B3: Mathematical Modeling of the Impact Acoustic Wave on Multiphase Fluid Flow through a porous media

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Abstract

Background: This study investigates the impact of acoustic waves on multiphase fluid flow through a porous media. The research focused on analyzing how acoustic energy changes flow patterns, and assessing how effective acoustic stimulation can disrupt multiphase flow.

Method of Solution: We modified the Navier-Stoke equation and incorporate the acoustic terms on the system and scaled it to be dimensionless. The scaled mathematical models were solved analytically and we adopt Wolfram Mathematica, version 12, to simulate and investigate the influence of acoustic wave propagation on multiphase flow behavior in porous media.

Results: The simulated results reveal that the introduction of acoustic energy induces oscillatory velocity profiles and flow rates, indicating dynamic coupling between acoustic forcing and fluid motion. These oscillations are strongly dependent on acoustic wave parameters such as frequency and amplitude as well as pore geometry and fluid properties.

Conclusion: The results suggest that acoustic fields can be strategically tuned to enhance fluid mobility, overcome capillary barriers, and promote redistribution of phases in porous networks.

Keywords: Acoustic, Wave, Multiphase, porous media, mathematical modeling, Fluid and Haemodynamics Research Group (FHRG).

MSC: 76D05, 76D07

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B4: MEDICOLEGAL MODEL FOR TIME OF DEATH OF A HOMICIDE VICTIM USING COMPUTATIONAL APPROACH

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Abstract

The study explores the medicolegal model for time of death of a homicide victim using computational approach. Matlab software using Runge-kutta ODE45 numerical scheme was used to simulate the results output which was analyzed as well. Three statements of problem were studied computationally and various time of death were predicted using step size $h=1$, $h=0.1$ and $h=0.01$. The decaying rate parameter which was used in the construction of the predictive model equations for the four three statements of problem were computed as well with the values of β_1 , β_2 , β_3 and β_4 being stated as 0.0028, 0.6931, 0.1335, and 0.2877 respectively. The study achieved the following results: construction of predictive model equation for various statements of homicide victims' cases using secondary data, computation of the various decaying rate parameters, predictions of the time of dead using computational method.

Keywords: Time of death, homicide victim, computational approach, medico-legal model, decaying rate parameters.

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B5: Dynamic Analysis of Human Ribs as Curved Elastic Orthotropic Plates Resting on Pasternak-type Media under External Loading

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Abstract

This study investigates the dynamic behavior of human ribs, idealized as curved orthotropic plates, resting on a Pasternak-like elastic foundation. This model captures the combined effects of skeletal stiffness and surrounding soft tissues. We derive the governing partial differential equation from classical plate theory, incorporating bending stiffness, inertia, foundation support (Winkler springs coupled with shear interaction), and time-varying external loading. Boundary conditions reflect realistic physiological constraints such as rib-vertebra and rib-sternum connections. A finite-element discretization uses bilinear shell elements and central-difference explicit time integration to capture rapid transient behavior. Frequency and amplitude-dependent terms which include bending stiffness matrices, foundation stiffness and shear modulus, inertial mass, and external load are implemented directly in the element formulation. Stability is ensured by adherence to the Courant–Friedrichs–Lewy (CFL) condition, with vibration modes validated against analytical orthotropic plate solutions. We perform parametric studies over varying Young's moduli (E_x, E_y), foundation properties (K_0, G_0), and rib thickness (h). Results show systematic trends such as increasing stiffness, foundation support, or thickness reduces response amplitudes significantly, while rib anisotropy influences modal frequencies and deformation shapes. The model accurately replicates physical phenomena such as reduced rib deflection with age-related calcification or increased rib compliance in osteoporotic subjects. These findings hold practical value for biomedical engineering applications, including rib-protection gear design, surgical planning, and implant development, offering insights into rib mechanical behavior under physiological and pathological conditions.

Keywords: Curved orthotropic plates, Pasternak-like elastic foundation, Rib-vertebra, Rib-sternum, Central difference.

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B6: On the Economic Consequence of the Charcoal Industry on the Sustenance of the Natural Biomass

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Abstract

This paper proposes and analyzes a nonlinear mathematical model that studies the extent of population growth, population pressure and a thriving charcoal industry on the resources biomass of a developing community. It considers the role of economic efforts in controlling population pressure. The modelling approach assumes that cumulative biomass density of forestry resources as well as the density of population are logistic in nature and that biomass density would influence the growth of a rural population which in turn expands the charcoal industry. Analysis of the model shows that as population pressure increases; the demand for woods to sustain the charcoal business also increases thereby exerting depleting pressure in the cumulative biomass density of forestry resources. It was thus found that controlling population pressure using sustainable economic efforts would significantly influence sustainability in biomass density of forestry resources and that doing otherwise would lead to the depletion of forestry resources even onto extinction.

Keywords: Population density, mathematical model, stability, charcoal.

Mathematics Subject Classification: 34A34, 34D23, 93C15, 93D20

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B7: Mathematical Modelling of the Depletion Dynamics of Forested Fields due to Unsustainable Anthropogenic Activities on Farm Fields

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Abstract

In this paper, we proposed and analysed a nonlinear mathematical model that studies the depletive consequence of population growth and the attendant increase in agronomic and other economic activities on forest resources and the fertility of topsoil. It was found from analyses of the model, using the stability theory of differential equations, that the density of vegetation cover would continue to decrease with increasing unsustainable anthropogenic activities. This was further found to affect the growth rate of crops on farm fields. Our results are further described numerically through simulations.

Keywords: Mathematical model, stability analysis, Population density, Farm field, Forest resources.

Mathematics Subject Classification: 34A34, 34D20, 34D23, 93C15, 93D20, 92D25

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B8: INVESTIGATING ASYMMETRICAL ROCK-PAPER-SCISSORS (RPS) INTERACTION MODELS ACROSS HETEROGENEOUS HABITATS

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Abstract

Rock-Paper-Scissors (RPS) competition have long served as a theoretical framework for understanding cyclic, intransitive interactions in ecological systems. While classical RPS models often assume symmetric interaction rates and homogeneous environments, natural ecosystems frequently exhibit asymmetries in competitive strengths and spatial heterogeneity in resource distribution. In this study, we employ and analyze an asymmetric RPS interaction model that incorporates habitat heterogeneity through spatially varying carrying capacities and competition coefficients. The model is formulated as a system of coupled ordinary differential equation, where asymmetry is introduced via unequal interaction rates and heterogeneity is represented by habitat-dependent parameters. Analytical methods are applied to determine equilibrium points and assess local stability through Jacobian analysis, while numerical simulations explore transient dynamics and long-term coexistence patterns. Our results demonstrate that both asymmetry and environmental variability can significantly alter species persistence, stability boundaries, and oscillatory behavior, potentially promoting coexistence under conditions where symmetric, homogeneous models predict extinction. These findings highlight the importance of incorporating realistic ecological complexities into cyclic competition frameworks, with implications for biodiversity management and conservation in spatially structured ecosystems. **Keywords:** Asymmetrical competition; ecological modeling; heterogeneous habitats; rock- paper-scissors (RPS) dynamics.

Keynotes: Asymmetrical competition; ecological modeling; heterogeneous habitats; rock-paper-scissors (RPS) dynamics..

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

B9: Stochastic Modeling of Soil Biogeochemical Processes in Drought-Prone Ecosystems

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Abstract

Stochastic modeling of soil biogeochemical processes in drought-prone ecosystems provides a framework for understanding how random fluctuations in precipitation and temperature influence microbial efficiency, nutrient cycling, and ecosystem resilience. This review show how these fluctuations directly affect microbial metabolic rates, such as drought conditions suppressing carbon use efficiency (CUE) and altering enzyme-mediated decomposition, thereby disrupting nutrient cycling. It couples stochastic differential equations (SDEs) with microbial biomass dynamics, thus revealing how soil moisture variability drives nonlinear feedbacks, such as reduced nutrient mineralization during prolonged droughts The model further explores resilience through metrics like return time after disturbances, variance-based stability thresholds, and early warning signals (e.g., increased variance in CO fluxes) that may precede ecosystem tipping points. Monte Carlo simulations and Fokker-Planck equations help quantify probabilistic outcomes, such as the likelihood of soil organic matter persistence under increasing climatic extremes. It highlights how stochastic forcing can either buffer or amplify nutrient losses, depending on the frequency and intensity of drought events, and underscore the role of microbial adaptation in maintaining function under stress. This work advances predictive land models by integrating climate variability with biogeochemical feedbacks, offering insights for managing degraded ecosystems and informing restoration strategies in water-limited regions.

Keywords: Theoretical Ecology and Applied Climatology, Soil Health and Biochemistry, Stochastic Differential Equations (SDEs), Drought and Climate Extremes / Change, Soil Biogeochemical Processes.

Subject area/ Classification: Environmental and Sustainability Modelling,

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B10: A MATHEMATICAL MODEL AND SIMULATION OF A GENERALIZED NON- NEWTONIAN BLOOD FLOW THROUGH OPHTHALMIC ARTERY FOR OPTIMAL HUMAN VISION

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Abstract

This study presents a mathematical model and numerical simulation of generalized non-Newtonian blood flow through the ophthalmic artery with the aim of understanding its role in optimal human vision. Blood is modeled as a non-Newtonian fluid due to its complex rheological behaviour, especially in small arteries where viscosity varies with shear rate. The governing equations for incompressible pulsatile flow are formulated using the principles of fluid dynamics and transformed into dimensionless form for analysis. Numerical simulations are carried out to investigate the effects of key physiological parameters such as Reynolds number, viscosity variation, pressure gradient, and arterial radius on blood velocity, wall shear stress, and flow resistance within the ophthalmic artery. The results reveal that non-Newtonian characteristics significantly influence blood flow distribution and ocular perfusion. Increased viscosity and arterial narrowing reduce flow velocity and may impair adequate blood supply to the visual system, while optimal flow conditions enhance retinal and optic nerve nourishment. The study provides valuable insight into the hemodynamic mechanisms associated with ocular health and may contribute to improved diagnosis and management of vision-related vascular disorders such as glaucoma, retinal ischemia, and diabetic retinopathy.

Keywords: Non-Newtonian blood flow, ophthalmic artery, mathematical modeling, numerical simulation, hemodynamics, wall shear stress, ocular perfusion, human vision.

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B11: A Mathematical Model for the Determination of Wall Shear Stress and Blood Flow Rate in the Human Interlobar Artery

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Abstract

Mathematical models were developed considering wall movement, blood pulsation and flow dynamics of the blood in the interlobar artery with and without stenoses. The formulated models were based on the fact that the motion of interlobar artery was not only influenced by pulsation, but also other physiological processes like heartbeat, breathing, and body posture. The Newton's second Law of motion was employed in assembling the forces acting on the interlobar artery channel under study. The wall shear stress (WSS), resistance to flow and blood flow rates were studied alongside, arterial walls to study the actual flow dynamics and investigate the blood flow behaviour. The results of the study were presented on both two – dimensional (2D) and three

(3D) – dimensional graphs showing a more realistic interaction between the arterial wall and the blood flow dynamics. The study also established that increase in the WSS from $8.106 \times 10^{(-4)}$ Pa to $8.640 \times 10^{(-4)}$ Pa together with the flow rate from $1.43 \times 10^{(-2)}$ to $1.517 \times 10^{(-2)}$ as well as the resistance to flow increased from $-6.1829N$ to $-4.0877N$ with time and change in interlobar artery geometry. It was recommended that the model be extended to handle and establish special cases at graduated points of critical blood flow in the HIA with reference to specific issues of interlobar arterial bifurcation flow dynamics.

Keywords: Stenoses, atherosclerosis, wall shear stress, interlobar arteries, blood flow.

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B12: Thermal Analysis of Ternary Hybrid Nanofluids for Advanced Cooling of AI Chips and Data Centers

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Abstract

The rapid advancement of artificial intelligence (AI) and the growing demand for high-performance computing have intensified thermal management challenges in AI chips and data centers. Excessive heat reduces computational efficiency, system reliability, and energy sustainability. This study investigates the thermal performance of ternary hybrid nanofluids (AlO–CuO–GNP/ethylene glycol) as advanced coolants, with comparisons to binary hybrid and conventional nanofluids over a flat surface. The governing nonlinear partial differential equations were transformed into ordinary differential equations using similarity transformations and solved numerically in *Mathematica 11.3* via the Chebyshev Collocation Method (CCM) and Galerkin Weighted Residual Method (GWRM). Excellent agreement between both methods confirms the accuracy and robustness of the numerical solutions. Parametric analyses examine the influence of magnetic field, suction, thermal radiation, viscosity, and internal heat generation on fluid flow and heat transfer. Results demonstrate that the ternary hybrid nanofluid provides superior heat dissipation, higher Nusselt numbers, and lower thermal resistance owing to the synergistic thermal properties of Al_2O_3 , CuO, and graphene nanoplatelets. These findings highlight the potential of ternary hybrid nanofluids for efficient cooling of AI processors, microelectronic devices, and next-generation sustainable data centers.

Keywords: AI chips; Data centers; Thermal management; Ternary hybrid nanofluids.

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B13: Multi-Parameter Optimization and Mechanistic Analysis of Low-NO_x Combustor Performance Using Coupled CFD and Thermochemical Modeling

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Abstract

This study presents a validated computational framework for the multi-parameter optimization of a low-NO_x combustor by deploying Computational Fluid Dynamics (CFD) and detailed thermochemical (stoichiometric) analysis. Unlike conventional studies limited to isolated modeling approaches, this work couples flow-field

resolution with combustion chemistry to establish mechanistic relationships between mass flow rate, flame temperature, and NO_x formation. Simulations were conducted in ANSYS Fluent using a realizable $\kappa - \epsilon$ turbulence model coupled with the eddy dissipation concept (EDC) and a thermal NO_x sub-model, across a parametric range of mass flow rates (1.0–1.5 kg/s). Grid independence and model validation were performed against benchmark literature data, achieving deviations below 6% for temperature and emissions predictions. Results show that increasing mass flow rate enhances turbulent mixing and combustion intensity, raising peak flame temperatures by up to 8%, which in turn increases thermal NO_x formation by approximately 20%. Despite this, lean operating conditions ($\Phi = 0.7$ – 0.75) maintained combustion efficiency above 99%, highlighting the robustness of lean-burn strategies. A clear exponential correlation between peak temperature and NO_x formation is established, consistent with Zeldovich kinetics.

Keywords: Stoichiometry, combustor, multi-parameter, optimization.

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B14: Nonlinear dynamics of herbivorous effect of animal species on a depleting forest resource and its impact on environmental sustainability

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Abstract

Wildlife survival is becoming increasingly threatened by unsustainable activities. Excessive grazing of grasslands in tropical and subtropical regions is leading to colossal losses in densities of savannas and mounting irreversible pressures on the ecosystem. In this paper, a nonlinear mathematical model is proposed and analysed to assess the impact of overgrazing on the biomass density of a region. By assuming a nonlinear ecological relation, the proposed model is analysed using stability theory of differential equations and numerical simulations to reveal that uncontrollable herbivorous activities create a cycle of resource imbalance leading to collapsing biodiversity of the region.

Keywords: nonlinear model, resource biomass, overgrazing, stability analysis.

Mathematics Subject Classification: 34A34, 34D20, 34D23, 93C15, 93D20, 92D25

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B15: COMPUTATIONAL APPROACH OF PREDICTING DICLOFENAC DRUG CONCENTRATION IN HUMAN BODY COMPARTMENTS AND ITS RESPONSE TO DOSAGE

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Abstract

Computational approach of predicting diclofenac drug concentration in human body compartments and its response to dosage over time at time intervals 5:5:60 and 60:5:115 has been considered using MATLAB24.2. From the results output, we observed that at an interval of five (5) minutes up to fifty five (55mins), indicated that at the initial time of administering the dosage shown in example 1, the concentration (the active mass) of diclofenac in stomach compartment is observed to be zero when the time was five (5) minutes the concentration which is known as the active mass that was being used up was 0.1943 ml/dm^3 and the volume of solvent was

6.995281 units. Furthermore, from example two (2) to example eleven (11), when the time ranges from ten (10) minutes to fifty five (55) minutes, the concentration decreased down the trend from a value of $0.167156\text{ml}/\text{dm}^3$ up to a value of $0.119173\text{ml}/\text{dm}^3$ when the time was fifty five minutes whereas the solvent in the stomach compartment ranges from 8.692112 to 23.357951 units. Table 4.2 shows when the time ranges from sixty (60) minutes up to one hundred and fifteen (115) minutes. The concentration which is the active mass of diclofenac drug that was being used up decreased down the trend from a value of $0.117902\text{ml}/\text{dm}^3$ up to a value of $0.110637\text{ml}/\text{dm}^3$ when the time is one hundred and fifteen (115) minutes whereas the volume of solvent containing the drug mixture in the stomach compartment ranges from 24.995253 at the sixty five (65) minutes, and increases down the trend up to 42.927294 units at one hundred and fifteen (115) minutes. This observation is normal with the usual medical practice and serves as a guide.

Keywords: Concentration, diclofenac drug, computational approach, prediction, body compartments.

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B16: RHEUMATOID ARTHRITIS MODEL FOR ESTIMATING THE EFFECTS OF PARAMETERS ON REGULATORY SYSTEM USING COMPUTATIONAL APPROACH

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Abstract

Investigating rheumatic arthritis model for estimating the effects of parameters on regulatory system using computational approach over time at time interval $0.1(10)290$ was carried out using MATLAB. From the various results obtained, we observed that on the base day of our experimental time called the initial condition, cells in the cartilage recorded 10,000 whereas the B-cells recorded 300,000,000 having an impact of 99.99667 in terms of expected percentage effect quantification. Furthermore, when the time ranges from 10 minutes to 290 minutes, the cells in the cartilage decreases monotonically downward the table from a value of 9875 to 6375 for the time of 290 minutes whereas, the B-cells ranges from 300,000,000 when the time is 10 minutes increases monotonically downward the table to a converging value of 517,500,000 at 290 minutes with a very slight expected percentage rise that ranges from 99.9968 to 99.9988. Also recorded are the helper T cells and the regulatory cells population under observation at a time interval of $0.1(10)290$ minutes. On the base called the initial condition, the helper T-cells recorded 35,000,000 whereas the regulatory cell population recorded 45,000,000 having a negative impact of expected percentage effect of 28.5714. Furthermore, when the time ranges from 10 minutes to 290 minutes, the cells in the helper T-cells increases monotonically downward the table from the value of 3,775,000 to 11,475,000 at the time of 290 minutes whereas, the regulatory T-cells ranges from 4,430,000 when the time is 10 minutes and decreases monotonically downward the table to a converging value of 3,275,000 at 290 minutes with an expected percentage depletion that ranges from 17.35099 to 71.45969 quantification.

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B17: Modelling Depression Dynamics among Adolescent Girls and Young Women in South-East Nigeria: The Role of Gender and Socio-Economic Determinants

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Abstract

Depression remains a significant public health challenge among adolescent girls and young women (AGYW), with gender-related socio-economic inequalities increasing their vulnerability to poor mental health outcomes. This study proposes a deterministic compartmental model to investigate the dynamics of depression among AGYW in South-East Nigeria. The model classifies the population into psychologically healthy, vulnerable, depressed, under-treatment, and recovered compartments, with transitions influenced by key determinants such as poverty, education, employment, social support, gender inequality, and access to mental health care. Model parameters will be estimated using relevant secondary data. The proposed analysis will include threshold analysis, equilibrium and stability analysis, sensitivity analysis, and numerical simulations implemented in Python to evaluate the potential impact of interventions, including improved access to mental health services and socio-economic empowerment programmes. The study is expected to identify the key drivers of depression dynamics and provide quantitative evidence to support gender-responsive mental health policies and targeted public health interventions aimed at reducing the burden of depression among AGYW in Nigeria and similar sub-Saharan African settings.

Key word: Depression dynamics; adolescent girls and young women; mathematical modelling; gender determinants; mental health.

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B18: Modelling RSV Transmission dynamics with vaccination and intervention measures

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Abstract

Respiratory syncytial virus (RSV) is a common, contagious virus that causes infections of the respiratory tract, mostly in infants and the elderly. A two-group RSV model is formulated and theoretically analyzed. The two groups considered are children below 5 years and adults above 50 years. Analysis of the model showed the existence of a stable disease-free equilibrium (DFE) and a stable endemic equilibrium (EE), when the associated reproduction number is less than one. The basic reproduction number for each group was obtained and a sensitivity analysis carried out on the parameters of the model to obtain the most sensitive parameters related to each group. Results showed that most sensitive parameters are related to children under 5 years old. Numerical simulations reveal the effects of the intervention measures and vaccination on the model.

Key word: RSV, Reproduction number, Sensitivity Analysis, Vaccination, Intervention Measures

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B19: A Generalized Atangana–Baleanu Fractional Model for Predictive Analysis of Complex Engineering and Physical Processes

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Abstract

This paper presents a generalized mathematical framework based on the Atangana–Baleanu–Caputo (ABC) fractional derivative with a non-singular Mittag-Leffler kernel for the predictive modeling of complex engineering and physical processes. The proposed model unifies fractional viscoelastic relaxation, anomalous diffusion, and nonlinear oscillatory phenomena within a single operator-theoretic structure. We establish rigorous existence

and uniqueness theorems via Banach fixed-point theory, derive stability criteria in the sense of Ulam–Hyers, and develop a computationally efficient numerical scheme based on Lagrange polynomial interpolation. Ten high-resolution three-dimensional simulations are generated to elucidate the parametric dependence of the kernel function, relaxation modulus, creep compliance, phase-space dynamics, stability regions, Mittag-Leffler surfaces, fractional diffusion solutions, sensitivity indices, operator discrepancy maps, and chaotic bifurcation structures. The results demonstrate that the generalized ABC operator captures memory-dependent hereditary effects with enhanced regularity compared to classical Caputo and Riemann–Liouville formulations, offering superior predictive fidelity for multi-scale engineering systems. The work contributes a simplified yet comprehensive mathematical foundation suitable for high-impact publication in fractional calculus and applied nonlinear dynamics.

Key word: Atangana–Baleanu derivative; fractional calculus; Mittag-Leffler kernel; predictive modeling; viscoelasticity; anomalous diffusion; stability analysis; numerical simulation

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B19: Deterministic Mathematical Modeling of Osteoporosis Progression with Optimal Control

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Abstract

Osteoporosis is a condition in which bones become weak, brittle, and more likely to fracture. It occurs when bone loss happens faster than new bone formation, leading to decreased bone density and strength. Osteoporosis can also be defined as a chronic metabolic bone disease characterized by reduced bone mass and structural deterioration, leading to increased fracture risk. This study develops a deterministic mathematical model describing the dynamics of bone remodeling, incorporating osteoblast and osteoclast interactions. The model integrates key physiological processes governing bone density loss and introduces control variables representing therapeutic interventions such as calcium supplementation, vitamin D intake, and pharmacological treatment. Analytical and numerical techniques are used to examine system stability and long-term behavior. Simulations demonstrate the effectiveness of control strategies in mitigating bone loss. The results provide insights into optimal intervention policies for managing osteoporosis progression.

Key word: Osteoporosis, Physiological Processes, Control Strategies, Osteoclast and Osteoblast.

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B20: Mathematical Modeling and Analysis of the Dynamics and Control of Psychogenic Polydipsia

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Abstract

Psychogenic Polydipsia (PP) is a behavioral disorder characterized by excessive water consumption beyond physiological requirements, commonly associated with psychiatric conditions such as schizophrenia, anxiety disorders, and obsessive-compulsive disorders. Although not infectious, PP can lead to severe electrolyte imbalance, hyponatremia, cerebral edema, seizures, and death. This study develops and analyzes a deterministic mathematical model describing the dynamics of Psychogenic Polydipsia and evaluates the effectiveness of various control measures. The model divides the population into susceptible individuals, psychologically predisposed individuals, psychogenic polydipsia patients, treated patients, and recovered individuals. Equilibrium states are determined, and stability analyses are performed. The model demonstrate that psychological counseling, early diagnosis, and behavioral therapy significantly reduce the prevalence of PP. The findings provide useful insights for clinicians, psychiatrists, and public health policymakers.

Key word: Psychogenic Polydipsia, Mathematical Modeling, Stability Analysis, Control Strategies, Behavioral Disorders, Simulation.

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B21: MODELLING THE EFFECTS OF THERMAL AND CHEMICAL REACTIONS ON HYDROMAGNETIC FLOW OVER HEATED STRETCHING SURFACES

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Abstract

In this research, we model the effects of thermal and chemical reactions on hydromagnetic fluid flow over heated stretching surfaces with emphasis on Climate resilience and water security. A viscous incompressible fluid was considered, the magnetic field is applied normal to the flow. The governing nonlinear equations emanated from momentum, energy, and concentration equations in form of partial Differential Equations were transformed into Nonlinear Ordinary Differential Equations using suitable similarity transformation and boundary layer approximation. The resulting nonlinear coupled Nonlinear Ordinary Differential Equations were solved numerically using computer embedded Runge-Kutta iteration method along with shooting techniques. We used maple 2018 as well as maple 18 to solve the modeled equations. Computational results obtained for skin-friction, local Nusselt number and sherwood number were presented in tabular and graphical form.

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B22: A One-Step Fourth-Order Implicit–Explicit Second-Derivative Parameter-Dependent General Linear Method for Stiff and Non-Stiff ODEs

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Abstract

In this paper, a one-step fourth-order implicit–explicit second-derivative parameter-dependent general linear method (IMEX-SD-PD-GLM) is developed for the numerical integration of stiff and non-stiff ordinary differential equations. The proposed method combines an explicit treatment of the non-stiff components with a diagonally implicit treatment of the stiff components, while incorporating second-derivative information to achieve higher-order accuracy with a reduced number of stages. A free parameter is introduced in the implicit

part of the scheme, allowing the stability properties to be tuned without affecting the algebraic order of the method. Order conditions up to fourth order are derived, and a concrete one-step method satisfying these conditions is constructed. Linear stability analysis shows that the method is A-stable and exhibits $L(\alpha)$ -stability for appropriate choices of α . Numerical experiments on linear and nonlinear stiff test problems demonstrate the efficiency, accuracy, and strong stiff decay of the proposed scheme, and comparisons with classical IMEX Runge–Kutta and BDF2 methods confirm its superior performance in terms of accuracy and stability for stiff problems.

Key word: IMEX, one-step fourth-order, second-derivative methods, parameter dependent general linear method, stiff ODEs, L-stability, and numerical integration.

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B23: A STUDY ON FRACTIONAL MODEL OF UNSTEADY COUETTE FLUID FLOW THROUGH COMPOSITE MACRO CHANNELS USING NUMERICAL TECHNIQUES

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Abstract

This study presents a computational analysis of a fractional model for unsteady Couette fluid flow in composite parallel-plate channels consisting of a porous medium and a clear fluid region. To better capture memory and hereditary effects absent in classical models, Caputo fractional derivatives—formulated via the Riemann–Liouville integral operator—are employed. The flow in the porous region is governed by the Brinkman-extended Darcy model, while the Stokes equation describes the clear fluid region. Analytical and numerical solution methods, including the Laplace transform, Adomian decomposition, and new iterative techniques, are applied to obtain solutions. Graphical results illustrate velocity profiles and pressure gradients, highlighting the behavior of generalized Couette flow. The study examines the effects of key parameters such as fractional order, permeability, porosity, Darcy number, interfacial resistance, and pressure gradient on velocity distribution, interface velocity, and skin friction. Findings reveal that these parameters significantly influence transient flow characteristics and interfacial dynamics. The results also show strong agreement between analytical, closed-form, and numerical solutions for steady-state conditions, as well as reliable approximations for unsteady flow over time. Overall, the study demonstrates that fractional models provide enhanced accuracy, flexibility, and physical realism in modeling transport phenomena in heterogeneous channels, contributing meaningfully to advancements in fractional fluid mechanics.

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B24: Integrating Machine Learning and Ecological-Health Risk Indices for Pollution Assessment in River Gwagwalada, Nigeria: A Multi-Compartment Approach

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Abstract

This study integrated machine learning techniques and pollution index models to evaluate the physico-chemical characteristics, heavy metal contamination, sediment geochemistry, and bioaccumulation patterns in River Gwagwalada. Water, sediment, and fish samples were collected across fourteen sampling stations and analyzed using multivariate statistical tools including Principal Component Analysis (PCA), Hierarchical Cluster Analysis (HCA), spatial distribution mapping, and heat map normalization. Pollution assessment was further performed using Water Quality Index (WQI), Heavy Metal Pollution Index (HPI), Contamination Factor (CF), Geo-accumulation Index (Igeo), Pollution Load Index (PLI), and Bioaccumulation Factor (BAF). The results revealed progressive downstream deterioration in water quality characterized by elevated conductivity, total dissolved solids, nutrients, COD, BOD, and heavy metals, particularly at stations S8–S11. PCA and HCA identified strong anthropogenic influence, redox-controlled metal mobility, and distinct geochemical clustering patterns. WQI values classified downstream stations as unsuitable for consumption, while HPI values indicated severe heavy metal toxicity dominated by Pb, Cd, and Cr contamination. In contrast, sediment indices showed low contamination, indicating a clear water–sediment decoupling where metals remained largely dissolved and bioavailable. Fish tissue analysis demonstrated significant organ-specific bioaccumulation, following the order liver > gills > intestine > bone > flesh, with positive BAF values for toxic metals.

Keywords: Machine learning, River, Water, Fish, Sediment, PCA.

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B25: BIOCONVECTIVE WILLIAMSON HYBRID NANOFLUID FLOW OVER A NON – LINEAR STRETCHING SURFACE WITH JOULE HEATING, ACTIVATION ENERGY AND CATTANEO – CHRISTOV HEAT FLUX

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Abstract

This study investigates the magnetohydrodynamic bioconvective flow of a Williamson hybrid nanofluid over a nonlinear stretching sheet in the presence of Joule heating, activation energy, nonlinear thermal radiation, and Cattaneo–Christov heat flux. The mathematical model incorporates Brownian motion, thermophoresis, chemical reaction, and gyrotactic microorganisms to examine the coupled heat and mass transfer characteristics of the non-Newtonian hybrid nanofluid. The governing partial differential equations are transformed into ordinary differential equations using suitable similarity variables and solved numerically through the Runge–Kutta fourth-order method combined with the shooting technique. The influence of various physical parameters on velocity, temperature, nanoparticle concentration, and microorganism distributions is analyzed and presented graphically. The results reveal that increasing the magnetic parameter decreases fluid velocity due to the Lorentz force, while thermal radiation and Joule heating significantly enhance the temperature distribution within the boundary layer. Activation energy is found to increase nanoparticle concentration, whereas a stronger chemical reaction parameter reduces species concentration. Additionally, gyrotactic microorganisms improve the bioconvective stability of the flow system. The Cattaneo–Christov thermal relaxation parameter suppresses the temperature profile compared to the classical Fourier heat conduction model. The findings demonstrate the applicability of the model to advanced thermal systems, biomedical transport processes, cooling technologies, and energy-related industrial applications involving non-Newtonian hybrid nanofluids.

Keywords: Williamson hybrid nanofluid, MHD, bioconvective

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B26: Modelling and analysis of alcohol drinking dynamics considering socioeconomic status and relapse effects

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Abstract

Alcohol consumption remains a serious public health and socioeconomic concern, especially in settings where social influence, treatment access, and relapse patterns differ across population groups. This study develops and analyzes a deterministic compartmental model for alcohol drinking dynamics by incorporating socioeconomic status and relapse effects. The population is classified into low and high socioeconomic groups, with each group divided into potential drinkers, moderate drinkers, heavy drinkers, individuals undergoing treatment, and quitters. The model further distinguishes between public and private treatment access and allows quitters to relapse either into moderate or heavy drinking. Basic properties of the model are established. The alcohol-free equilibrium is obtained, and the basic reproduction number, R_a , is derived using the next-generation matrix method. Stability analysis shows that the alcohol-free equilibrium is globally asymptotically stable whenever $R_a < 1$, while an endemic equilibrium exists when $R_a > 1$. Bifurcation analysis reveals the possibility of backward bifurcation, indicating that reducing R_a below unity may not always be sufficient for eliminating alcohol drinking dynamics when relapse and socioeconomic effects are strong. Sensitivity analysis identifies the effective influence rates, especially among the low socioeconomic group, as the dominant drivers of alcohol drinking persistence. Intervention simulations show that a combined strategy involving reduced drinking influence, increased treatment admission, and relapse prevention produces the greatest reduction. The findings emphasize the need for integrated prevention, treatment, and relapse-control strategies to reduce alcohol drinking burden across socioeconomic groups.

Keywords: Alcohol drinking dynamics; socioeconomic status; relapse effects; mathematical modelling; numerical simulation.

Mathematics Subject Classification (MSC 2020): 92D30; 34C60; 34D20; 34D23; 34C23; 37N25.

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B27: MATHEMATICAL MODELLING OF BANDITRY WITH INTERVENTION AND SOCIO-ECONOMIC INTERVENTIONS

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Abstract

Banditry has emerged as a persistent security challenge in many regions, driven by a complex interplay of socio-economic vulnerabilities and weak institutional responses. This study develops a mathematical model to analyze the dynamics of banditry by incorporating key socio-economic factors such as: poverty alleviation, precautionary measures and ransom payments, and intervention strategies. The population is compartmentalized into relevant classes, including susceptible individuals, active bandits, captives, repentant bandits, Aiders, and individuals undergoing rehabilitation are integrated into the model as driving forces that influence recruitment into bandit groups. The model further incorporates intervention mechanisms, including security enforcement, community engagement, and Government intervention. Qualitative analysis is conducted to determine the basic reproduction number and equilibrium states, while stability analysis is used to assess the long-term behavior of the system. Numerical simulations are performed to evaluate the impact of various intervention strategies and socio-economic improvements on reducing banditry prevalence. The results indicate that reducing socio-economic disparities and strengthening targeted interventions significantly lower the reproduction threshold

of banditry and contribute to long-term stability. In particular, combined strategies involving both security measures and socio-economic development are more effective than isolated interventions. The study provides a quantitative framework for policymakers to design informed and sustainable strategies for mitigating banditry and enhancing societal stability.

Keyword: Banditry, ransom payment, precautional measures, poverty alleviation and reproduction number.

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B28: Influence of Growth Voltage on Electrodeposited ZnS Film Properties Investigated by UV Spectroscopy

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Abstract

Zinc sulfide (ZnS) thin films have attracted considerable attention due to their broad applications in optoelectronic devices. This study explores the impact of growth voltage on the properties of electrodeposited ZnS films using UV spectroscopy. ZnS thin films were deposited on fluorene-doped tin oxide (FTO) coated glass substrates at various growth voltages ranging from 1 V to 5 V. The structural, optical, and morphological characteristics of the films were examined using X-ray diffraction (XRD), UV-visible spectroscopy, and scanning electron microscopy (SEM), respectively. The XRD analysis indicated that all deposited films exhibited a cubic zinc blende structure with a preferred orientation along the (111) plane. The size of crystallites increased with rising growth voltage, indicating enhanced crystallinity at higher voltages. UV-visible spectroscopy measurements demonstrated that the optical bandgap of the films decreased from 3.89 eV to 3.61 eV as the growth voltage increased, suggesting a transition towards the visible region with improved light absorption.

Keyword: Growth voltage, UV spectroscopy, Optical, X-ray diffraction (XRD), Zinc sulfide (ZnS), thin films.

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B29: Nonlinear Dynamical Modelling and Simulation of Informal Tricycle Transport Flow Along Selected Urban Roads in Kano Metropolis, Nigeria

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Abstract

Rapid urbanization, rising travel demand, and inadequate formal transportation in Kano have increased dependence on informal tricycle transport, leading to ongoing congestion, unstable traffic flow, and operational inefficiencies along major urban routes. Despite the growing role of informal transport in urban mobility, little attention has been given to its flow behaviour through nonlinear dynamical modelling approaches. This study develops a data-driven nonlinear dynamical systems framework to analyse and simulate tricycle transport flow along selected urban corridors in Kano Metropolis. It conceptualizes corridor transport as a dynamic

interaction among traffic demand, congestion levels, vehicle speed, waiting times, and neighbouring land-use activities. Data were collected through traffic counts, travel time surveys, GPS-based movement observations, and structured corridor studies across various residential, commercial, institutional, industrial, and mixed-use areas. Nonlinear transport flow equations were formulated and implemented in R to simulate system behaviour under different traffic conditions and planning scenarios. Results from the simulations reveal critical congestion thresholds and flow instability patterns along major corridors, including Ibrahim Taiwo Road, Zoo Road, Murtala Muhammad Road, and Sharada Road. This research demonstrates how nonlinear dynamical systems and simulation techniques can support sustainable corridor planning in rapidly growing cities.

Keyword: Nonlinear dynamical systems, Informal transport flow, Traffic flow simulation, Corridor dynamics, Sustainable urban mobility.

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B30: YOLOV8 – BASED DEEP LEARNING MODEL FOR TOMATO DISEASES DETECTION

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Abstract

This study introduces a You Only Look Once (YOLO) model for detecting diseases in tomato leaves, which is implemented using YOLOv8s as the based framework. The tomato leaf images, both healthy and diseased, were sourced from the Plant Village dataset. These images were enhanced, implemented, and trained using YOLOv8s with the Ultralytics Hub interface. The Ultralytics Hub environment provides an optimal setting for training YOLOV8 and YOLOV5 models. The YAML file was carefully programmed to identify sick leaves. The results of the detection demonstrate the efficiency of the YOLOV8s model in accurately recognizing unhealthy tomato leaves, surpassing the performance of both the YOLOV5 and Faster R-CNN models. YOLOv8s attained the highest mean average precision (mAP) of 92.5%, surpassing YOLOV5's 89.1% and Faster R-CNN's 77.5%. In addition, the YOLOV8s model is considerably smaller and demonstrates significantly faster inference efficiency. The YOLOV8s model has a significantly superior frame rate, attaining 121.5 FPS, in contrast to YOLOV5's 102.7 FPS and Faster R-CNN's 11 FPS. This illustrates the lack of real-time detection capability in Faster R-CNN, whereas YOLOV5 is comparatively less efficient than YOLOV8s in meeting the standard detection characteristics required. Finally, the results demonstrate that the YOLOV8s model is comparably more efficient than the other examined models in this work.

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B31: Numerical Simulation of Multi-Dimensional Gradient Elution: Impact of Retention Models on the Spatiotemporal Dynamics of the 2D General Rate Model

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Abstract

This study presents a numerical investigation of multicomponent gradient elution chromatography using a fully two-dimensional General Rate Model (GRM) with solvent-dependent nonlinear competitive adsorption. The mobile phase, stationary phase, and solvent composition are described by coupled convection-dispersion

equations in cylindrical coordinates. Adsorption equilibrium is modeled using a multicomponent nonlinear Langmuir isotherm with parameters that vary with local solvent composition. Several solvent strength relationships, including linear, quadratic and Neue-Kuss-type models, are incorporated to evaluate their influence on retention and peak dynamics. The resulting nonlinear, convection-dominated system is solved using a high-resolution finite volume method with Koren's third-order Total Variation Diminishing flux limiter, enabling accurate capture of steep concentration fronts without spurious oscillations. Results show that solvent-dependent competitive adsorption strongly affects peak velocity, radial heterogeneity, band broadening, and nonlinear front formation. Differences among retention models become more pronounced under strong gradients and high loading conditions, where nonlinear interactions dominate transport behavior. This work provides a systematic comparison of solvent-dependent retention models within a fully coupled two-dimensional GRM, offering insights into gradient dynamics, competitive adsorption, and multidimensional mass transfer for improved chromatographic design.

Keyword: Multicomponent gradient elution chromatography, Two-dimensional general rate model, Solvent-dependent adsorption, Nonlinear competitive Langmuir isotherm, High-resolution finite volume method.

Subject Classification: Chemical Engineering – Separation Processes Modelling and Simulation

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B32: Beyond Access: A Dynamic Spatial Equilibrium Model of Infrastructure, Quality of Life, and Urban Change — Evidence from Kano Metropolis

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Abstract

Research on infrastructure in sub-Saharan African cities often evaluates success through a narrow set of indicators, especially improvements in access and mobility. Questions such as whether travel times have fallen or whether roads now connect residents more efficiently to markets and schools tend to dominate policy assessments. While important, these measures overlook the broader social and environmental transformations that accompany urban infrastructure investment. In rapidly expanding cities such as Kano, roads, drainage systems, and green projects do far more than improve circulation; they reshape land markets, alter neighbourhood composition, and redistribute environmental burdens across space. This paper develops a dynamic spatial equilibrium model in which infrastructure investment, residential sorting, and neighbourhood quality evolve together over time. Rather than treating quality of life as a fixed characteristic of place, the model conceptualises it as an endogenous outcome shaped by environmental conditions, green amenities, and neighbourhood social composition linked to income distribution. The framework is calibrated to the urban structure of Kano metropolis, including the old walled city, Sabon Gari, the industrial districts, and the expanding peri-urban fringe. Four policy scenarios are simulated: arterial road expansion, neighbourhood greening and drainage improvements, peri-urban road densification, and an integrated policy package combining infrastructure with environmental mitigation and limited rent controls. Under conventional access-based evaluation, all interventions appear welfare-enhancing. However, once housing markets, displacement dynamics, and environmental feedbacks are incorporated, the distribution of gains becomes highly uneven. Lower-income households are progressively displaced from improving neighbourhoods toward poorly serviced peripheral areas, where environmental and social conditions are weaker. Among the simulated policies, only the integrated package produces broadly shared welfare gains. The paper does not claim to predict Kano's future with precision; rather, it provides a framework for rethinking how infrastructure appraisal is conducted in rapidly urbanising African cities and for asking more carefully who benefits after urban adjustment processes unfold.

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B33: A MULTI-DIMENSIONAL INDEX APPROACH TO MEASURING URBAN DEGENERATION IN KANO METROPOLIS, NIGERIA

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Abstract

Rapid urbanization and environmental degradation brought about the need for sustainable urban regeneration techniques aimed at revitalizing and rejuvenating urban spaces to foster vibrant and resilient communities. This study employed multiple index technique of measuring urban degeneration to assess the degree of physical, infrastructure and service blight in new and traditional residential areas of Yan -Awaki, a neighbourhood in Tarauni Local Government Area of Kano State. Findings reveals significant disparities between the new and traditional residential areas in terms of living condition, access to basic amenities and income level. **Infrastructure** in both areas have index below 50% indicating poor conditions. **Water supply** in traditional residential area has 55.8% index, compared to the new area's 89.4%. **Educational facilities score** 67% and 59.3%, sanitation has 22.2% and 24.4% respectively. Index analysis for housing reveals that the new residential area has a relatively better housing condition (80.1%), with more housing been rating as good or fair than old residential areas (52.9%), indicating poorer housing. The study therefore recommends improve infrastructure, housing and basic services especially in the traditional areas where the index was found to be lower, with many structures exhibiting signs of neglect and poor construction standards.

Keywords: Urbanization; Planning; Urban regeneration; environmental degradation; Neighbourhood infrastructure.

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B34: RESILIENCE AND MITIGATION STRATEGIES OF SMALL HOLDER FARMERS TO CLIMATE VARIABILITY IN KABO LOCAL GOVERNMENT AREA KANO STATE, NIGERIA

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Abstract

This research aimed at determining the resilience and mitigation strategies of small holder farmers to climate variability with a view to achieve sustainable production in the Kabo Local Government Area Kano State, Nigeria. Purposive and stratified sampling technique was used to select study villages across the LGA, which includes Dugabau, Gude, Garo, Kanwa, and Kabo ward. The distribution of the questionnaire was done proportionately based on the cooperative register farmers making a total of 210 respondents across the five sample wards. The data collected from questionnaire was coded and analyze using statistical package for social sciences (SPSS version 20) and MS excel software, was also subjected to descriptive analysis such as percentage, frequency and charts. The findings finding reveals that, a large number (89%) of small holder farmers in the study area had some local adaptation and mitigation, which may include such as adopting Early planting of crops (25%) and mixed cropping (30%), use of drought resistant crops (10%) as well as livelihood diversification (10%) in the study area. Furthermore, the findings of this study reveals that the smallholder farmers experienced some barriers and hindrance in their resilient and mitigation strategies such as lack of improved seed (20%), lack of

proper information to climate variability (31%), lack of access to fund (40%) to climate variability adaptation in the study area. The findings concluded that although farmers in the area show some awareness of climate change some seem to take step to adjust their farming practices. Some of the major resilience and mitigation strategies in the area, change in cropping pattern, mixed cropping, early planting (altering agricultural calendar), use of drought resistant crops, livelihood diversification and also smallholders also use to pray to God as a resilience strategy in the area. It was also recommended that, there is need for the extension workers and other stakeholders to give enlightenment to the small holder Farmers on how to use modern mitigation and adaptation strategies that are less cost effective in the study area.

Keywords: Resilience, Mitigation, Smallholder Farmers and Climate Variability.

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B35: DETERMINATION OF OPTIMUM TRUNCATION LEVEL OF HEAT PIPE BASED COMPOUND PARABOLIC COLLECTOR BY RAY TRACING TECHNIQUES

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Abstract

The concentrator of Compound Parabolic Collector (CPC) tends to be long especially at low concentration and most of the top parts are not contributing to the radiation collection. Truncating those parts was found to increase the optical efficiency at the expense of the concentration ratio. This work presents simulation and experiment on the effects of truncation level of heat pipe based compound parabolic collector (HPCPC) on its optical performance using solar radiation data of Kano, Nigeria (12.05oN). Two computer programs were developed for geometric characterization of symmetric low concentration HPCPC and validated advanced ray tracing technique was used for its optical simulation. Results showed that as the truncation levels increases the collector height, aperture width, concentration ratio and average number of reflections decrease while the acceptance angle increases. Also results have showed that truncation increases the optical efficiency of the HPCPC but with decrease in the concentration ratio. From the graph of optical efficiency and concentration ratio against truncation level, results have showed that the HPCPC with acceptance angle of 60 and receiver radius of 12.5 (HPCPC60R12.5), HPCPC40R12.5 and HPCPC30R12.5 can be truncated respectively by 62%, 55% and 43% to achieve optical efficiencies/concentration ratios of 84%/1.65, 71%/2.55 and 55%/3.5 respectively.

Keywords: Truncation level, Ray tracing techniques, Compound parabolic collector, Optical Simulation, Optical Efficiency.

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B36: HYBRID OPTIMIZATION MODELLING OF SOLAR-WIND HYBRID ENERGY SYSTEMS

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Abstract

Solar Photovoltaic is intermittent in the amount of irradiance receives on the earth's surface due to cloud covers, shading and temperature changes, likewise the kinetic energy of wind is also intermittent due to variability of local wind speed distribution. But the integration of these two energies in hybrid energy system, reduces the intermittence nature of these renewable energy sources, because solar and wind complement each other. Therefore, to mathematically model a solar-wind hybrid energy system, we combine the physics of photovoltaic (PV) generation and wind turbine dynamics, and then integrate them through power electronics and optimization techniques. The goal here is to predict the energy output, ensure stability, and optimize cost and reliability. The paper access the solar and wind energy resources availability, through correlation of the two energy lines, to determine the energy yield of each of the two renewable energy sources. The hybrid system configurations is set using the optimized design parameters, in the Hybrid Optimization of Multiple Energy Resources (HOMER) software, and simulated to assess the performance of the system in terms of hybrid optimization models on solar fraction, renewable energy penetration and the energy cost.

Keywords: Solar-wind hybrid energy system, Correlation of energy lines, Energy yield and Hybrid optimization of multiple energy resources.

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B37: Steady Rotating Natural Convection and Mass Transfer in a vertical Porous Channel with Soret- Dufour Effects and Nonlinear Buoyancy

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Abstract

This study presents an analytical investigation of steady combined heat and mass transfer in a rotating fluid confined within a vertical porous channel, incorporating Soret and Dufour cross-diffusion effects. The fluid is assumed to rotate with a constant angular velocity, while nonlinear buoyancy forces, quadratic in temperature and concentration, are taken into account. A regular perturbation technique is employed under the assumption of weak cross-diffusion to obtain closed-form solutions for the velocity, temperature, and concentration fields. The influence of key governing parameters, including the Ekman number, Schmidt number, Prandtl number, suction parameter, Dufour number, Soret number, and nonlinear buoyancy parameters, on the flow behavior and skin friction at the channel walls is analyzed. The results indicate that the presence of Soret and Dufour effects significantly enhances the velocity fields and increases the skin friction at both walls. The present analysis extends the classical work of Raptis and Perdikis by incorporating cross-diffusion effects, nonlinear buoyancy, and channel geometry.

Keywords: Rotating effect, Soret effect, Dufour effect, Heat and Mass transfer and Suction parameter, Nonlinear buoyancy force.

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B38: UNIFORM STABILITY OF A THERMOELASTIC LAMINATED TIMOSHENKO BEAM SUBJECTED TO A NEUTRAL DELAY

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Abstract

In this work, we study a laminated Timoshenko system of two identical beams of uniform thickness. The slip between the beams is taken into consideration, and it is subjected to linear frictional /damping as well as distributed neutral delay. Moreover, the system is coupled with a heat equation. We prove, by using multiplier technique, the uniform stability of the system under equal speeds of wave propagation.

Keywords: laminated beam, neutral delay, multiplier technique, stability, Timoshenko system.

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B39: Analyses of Vibrational Resonance Occurrence in a Mathews-Lakshmanan Oscillator with Tri-stable Potential and Space-Dependent Damping

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Abstract

The widespread and intriguing nature of nonlinear systems has drawn attention of researchers over the years, leading to extensive studies of their various dynamical behaviors. Among these, resonance-induced phenomena such as coherence resonance, stochastic resonance, and vibrational resonance have been particularly prominent. In recent times, Stochastic Resonance (SR) and Vibrational Resonance (VR) have received significant focus. SR refers to a process in which noise perturbation enhances the detection of weak low-frequency signal in a nonlinear system. In contrast, VR improves the detection of such signals through the influence of a high-frequency excitation. VR has been explored across a wide range of systems and in different contexts. In this study, we numerically examine the occurrence of VR in a Mathews-Lakshmanan Oscillator model, which represents the motion of a particle within a tri-stable potential under space-dependent damping and subject to two external driving forces. The findings demonstrate the presence of the VR effect under a fixed damping amplitude and further show that the system's response is strongly influenced by variations in the damping parameters.

Keywords: Vibrational Resonance, Mathews-Lakshmanan Oscillator, Space-Dependent damping, Tri-stable potential, weak signal detection.

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B40: Role of Oligomer Size and Binding Modes of GH11 Xylanase by Lignin-Derived Inhibitors: A Computational Modelling

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Abstract

Lignin and phenolic compounds are widely recognized as major contributors to the recalcitrance of biomass, primarily due to their inhibitory effects on lignocellulose-degrading enzymes. An understanding of the inhibition mechanisms, as well as the energetic competition between lignin-derived compounds and native substrates, is crucial for the development of lignin-resistant enzymes. In this study, the size-dependent effects and binding interactions of lignin-derived molecules namely monomeric coniferyl alcohol, dimeric oligolignol, and tetrameric oligolignol on GH11 xylanase were studied using molecular docking and molecular dynamics (MD) simulations. The MD simulation results revealed notable changes in both protein structure and ligand positioning. Binding interactions involving the “thumb” region were consistently observed across all oligolignol models. Structural stability and flexibility were assessed using root mean square deviation (RMSD) and root mean square fluctuation (RMSF), which served as quantitative measures of conformational changes and residue mobility. The lower RMSF value means the protein residues are more rigid/stable upon binding to a ligand. This suggests the inhibitor is forming strong, stable interactions, preventing the protein from undergoing significant conformational changes. Key binding residues responsible for these interactions were identified, providing valuable insights for future protein engineering aimed at enhancing lignin resistance in GH11 enzymes. Furthermore, the findings provide a detailed molecular-level understanding of lignin-enzyme interactions and support the development of more efficient enzymes for biomass conversion applications.

Keywords: Binding affinity, GH11 Xylanase, Oligolignol, RMSD and RMSF.

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B41: Modelling of Tamburawa Water Treatment Plant using Nonlinear Approach

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Abstract

Complex nonlinear and uncertain systems such as water treatment plant are often quite difficult to model. Most of the available mechanistic models do not capture some of the variables which poses a threat health and causes environmental pollution. This paper presents a Nonlinear Auto-Regressive with Exogeneous input (NARX) for the plant. Experimental (full-scale) data from the water treatment plant was utilized in developing the model. For the sake of comparison, a Hammerstein-Wiener (HW) was used. Simulation results demonstrated that the NARX model outperformed the HW model by achieving Root Mean Square Error (RMSE) of 0.6497 and Mean Absolute Deviation (MAD) of 0.0458. The NARX model could serve as valuable for the plant.

Keywords: Binding affinity, GH11 Xylanase, Oligolignol, RMSD and RMSFSystem, Model, Nonlinear, Dynamics.

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B42: Molecular Dynamics-guided screening of NNRTIs Targeting HIV-1 Reverse Transcriptase

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Abstract

Human immunodeficiency virus type 1 (HIV-1) remains a major global health challenge, with the emergence of resistant strains limiting the long-term efficacy of current therapies. Non-nucleoside reverse transcriptase inhibitors (NNRTIs) play a central role in antiretroviral regimens, yet resistance mutations and safety concerns necessitate the search for novel alternatives. In this study, a library of NNRTI-like compounds was retrieved from the ChEMBL database and evaluated through a multi-scale computational strategy. Molecular docking was first employed to investigate binding affinities and interaction profiles against HIV-1 reverse transcriptase, identifying several promising candidates. Top-scoring compounds were further subjected to pharmacokinetic and ADMET analyses to assess drug-likeness, oral bioavailability, and potential toxicity risks. To refine compound selection, density functional theory (DFT) calculations were conducted to determine frontier molecular orbital energies, global reactivity descriptors, and electronic stability, offering mechanistic understandings into molecular reactivity. Finally, molecular dynamics (MD) simulations were performed to validate the stability of selected protein-ligand complexes within the reverse transcriptase binding pocket. Results revealed multiple ChEMBL-derived NNRTIs with strong docking scores, favorable ADMET properties, and low predicted toxicity, while DFT descriptors confirmed electronic stability consistent with drug-like behavior. MD simulations further supported the dynamic stability and favorable conformational retention of lead candidates, highlighting their potential as robust inhibitors of HIV-1 reverse transcriptase. The identified compounds represent promising leads for further optimization and experimental validation, contributing significant knowledge toward the development of next-generation anti-HIV therapeutics.

Keywords: Non-nucleoside reverse transcriptase inhibitors (NNRTIs), HIV-1 reverse transcriptase, Molecular docking, ADMET prediction, Density functional theory (DFT), Computational drug discovery.

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B43: Integrating Random Forest Classification and Markov Chain Modelling for Spatio-Temporal Analysis and Prediction of Land Use Change in the Sudan Savannah of Nigeria (2000–2035)

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Abstract

Land use and land cover (LULC) change constitutes one of the most consequential dimensions of environmental transformation in dryland regions of sub-Saharan Africa. This study presents a comprehensive multi-temporal assessment of LULC dynamics across Jigawa and Yobe States in the Sudan Savannah zone of northeastern Nigeria, covering a continuous 25-year period (2000–2025) at five-year intervals. Six land cover classes Water, Settlement, Bareland, Farmland, Vegetation, and Grassland/Wetland were mapped using multi-temporal Landsat satellite imagery (Landsat 7 ETM+ and Landsat 8 OLI) processed within the Google Earth Engine cloud computing platform through a Random Forest (RF) machine learning classifier. Classification accuracy was consistently high across all epochs, with Overall Accuracy ranging from 94.04% (2000) to 97.78%

(2025) and Kappa coefficients from 0.8949 to 0.9605, exceeding accepted international thresholds. Results reveal a complex, non-monotonic pattern of LULC transformation driven by the compound interaction of rapid population growth, agricultural expansion and contraction, agropastoral intensification, conflict-induced land abandonment, and inter-annual climatic variability. Farmland, the dominant land cover (70% of total area), exhibited a net contraction of $2,785.44\text{km}^2$ (5.7%) over the study period, with a pronounced loss of $5,571.71\text{km}^2$ between 2015 and 2025 alone. Bareland expanded dramatically from 744.04km^2 in 2000 to $5,152.78\text{km}^2$ in 2025 (+592.5%), representing the most persistent and structurally significant land degradation signal (Kendall $\tau = +0.733, p = 0.056; R^2 = 0.872, p = 0.006$). Settlement increased monotonically by +51.6%, reflecting sustained urbanisation pressure, while Grassland/Wetland exhibited cyclical dynamics, declining to a minimum in 2015 before recovering by $4,457.52\text{km}^2$ by 2025, largely associated with conflict-driven agricultural abandonment and subsequent natural vegetation succession. To extend the analysis beyond retrospective assessment, a Markov Chain predictive model was applied to simulate LULC conditions for 2035. The projection indicates continued and accelerated bareland expansion to over $7,000\text{km}^2$, accompanied by further farmland contraction of up to 10%, and sustained settlement growth exceeding 40% relative to 2025 levels. These results confirm that the land system is on an unsustainable trajectory characterised by progressive degradation and declining agricultural capacity. The study demonstrates the value of integrating machine learning classification with predictive modelling to support evidence-based decision-making in fragile dryland environments.

Keywords: Land Use/Land Cover Change; CA-Markov; Random Forest; Google Earth Engine; Predictive Modelling.

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B44: Mathematical and Computational Optimization of Draft Tube Geometry for Enhanced Hydropower Sustainability

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Abstract

The drive toward sustainable energy systems necessitates the integration of mathematical modelling and data-driven optimization techniques in engineering design. This study investigates the optimization of draft tube geometry in hydroelectric power plants to enhance turbine efficiency and reduce hydraulic losses. A mathematical model based on Bernoulli's principle and kinetic energy balance is developed to analyze head losses within the draft tube. Computational Fluid Dynamics (CFD) simulations are conducted for both laminar and turbulent flow regimes, incorporating advanced turbulence models such as the Realizable $\kappa - \epsilon$ and SST $\kappa - \omega$ models. A parametric study is performed to examine the influence of draft tube angle on flow behavior and efficiency. The results indicate that optimal efficiency is achieved within a narrow angular range, with variations depending on flow conditions and modelling assumptions. To align with data-driven approaches, simulation outputs are utilized to inform performance trends and guide design optimization. The findings demonstrate that improved draft tube design can significantly enhance energy recovery, contributing to more efficient and sustainable hydropower generation. This work highlights the importance of mathematical modelling and simulation-driven optimization in advancing renewable energy technologies.

Keywords: Mathematical modelling, CFD, hydropower, optimization, data-driven analysis, sustainability.

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B45: Modelling the riparian vegetation impact on fish distribution and abundance in kano Nigerian rivers

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Abstract

Riparian vegetation plays a fundamental role in structuring aquatic habitats, yet its influence on fish distribution in tropical river systems remains underexplored. This study developed a predictive modelling framework to assess riparian vegetation impact on fish community structure in selected rivers within Kano, Nigeria. Field data were collected during wet and dry seasons, measuring riparian metrics (cover width, canopy density, root complexity), water parameters, and fish abundance. Generalized Linear Models and Redundancy Analysis were employed. Results indicated that sites with well-developed native riparian vegetation supported significantly higher fish species richness ($\beta = 0.42, p < 0.01$) and abundance ($\beta = 0.57, p < 0.001$). Canopy cover ($R^2 = 0.31, p < 0.01$) and root complexity ($R^2 = 0.28, p < 0.05$) were key positive predictors for juvenile fish abundance. Areas with sparse vegetation showed reduced diversity ($t = -3.24, df = 28, p < 0.01$). Seasonal variations modulated these effects ($F = 6.72, p < 0.01$). The final model explained 68% of variance in fish distribution ($adjustedR^2 = 0.68, F(6, 33) = 11.45, p < 0.001$). These findings underscore the importance of riparian zone conservation for sustaining riverine fish communities in Kano's semi arid environment.

Keywords: Riparian vegetation; fish distribution; predictive modelling; Kano rivers; Nigeria.

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B46: Transition Pathways toward Sustainable Mobility in Kano Metropolis, Nigeria: A Multi-Method Inferential Analysis

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Abstract

Kano Metropolis, the most populous city in northern Nigeria, faces severe mobility challenges due to heavy reliance on informal transport, particularly tricycles, and the absence of formal mass transit. Guided by Banister's Sustainable Mobility Paradigm (SMP), this study assesses transition pathways toward sustainable mobility using survey data from 400 commuters across five core Local Government Areas. Sustainability performance was evaluated using a revised STAR rating scale covering system efficiency, economic, social, environmental, and governance readiness dimensions. Binary logistic regression revealed that modal split ($Exp(B) = 3.736, p = 0.003$), environmental awareness ($Exp(B) = 2.038, p < 0.001$), service quality perception ($Exp(B) = 1.631, p = 0.004$), travel time reliability ($Exp(B) = 1.557, p = 0.005$), and public transport use frequency ($Exp(B) = 1.365, p = 0.003$) significantly predicted improved environmental sustainability ($NagelkerkeR^2 = 0.514; AUC = 0.874$). Chi-square analysis showed strong associations between gender and modal split ($V = 0.867$), income and mode choice ($V = 0.877$), and vehicle ownership and willingness to adopt improved public transport ($V = 0.591$). Notably, 85% of respondents expressed willingness to adopt formal transit, indicating strong latent demand. The study recommends Bus Rapid Transit (BRT) investment, fare subsidisation, gender-responsive design, and environmental education supported by STAR-based performance monitoring.

Keywords: Environmental Sustainability; STAR Rating; Mobility Justice; Gender Mobility; Kano Metropolis.

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B47: Multi-scale in silico screening of potential inhibitors targeting key enzyme *Trypanosoma cruzi*

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Abstract

Chagas disease, caused by *Trypanosoma cruzi*, remains a major neglected tropical disease with limited treatment options, especially during its chronic phase where current drugs, benznidazole and nifurtimox, show reduced efficacy and significant toxicity. This study employed an integrated in silico drug discovery pipeline to design and evaluate novel inhibitors targeting the Amyloid-beta A4 protein, an emerging therapeutic target implicated in host-parasite interactions and neuroinflammatory processes. A robust 2D-QSAR model with correlation coefficient (R^2) value of 0.872, adjusted R^2 ($adjR^2$) of 0.849, and cross-validation coefficient (Q^2_{cv}) of 0.815 was developed to identify key molecular descriptors influencing antiparasitic activity, which guided the selection of a lead compound and rational design of ten novel derivatives (D10a-D10j). Homology modelling generated a validated 3D structure of the *T. cruzi* protein, followed by molecular docking that revealed stronger binding affinities for several derivatives, notably D10a and D10f, compared with the lead and reference drug nifurtimox. Long-timescale molecular dynamics simulations (300 ns) demonstrated that these derivatives stabilized the protein structure, reduced flexibility, and improved compactness of the complexes. MM/PBSA free energy analysis further confirmed favourable binding energies, with D10f exhibiting the strongest affinity ($bind$ of - 42.52 kcal mol⁻¹). ADMET and drug-likeness evaluations indicated high oral absorption, non-mutagenicity, and favourable pharmacokinetic profiles, with D10a and D10f emerging as the most promising candidates. Collectively, these research presents some potential small molecules as novel anti-*T. cruzi* agents and provide a rational basis for further experimental validation toward effective Chagas disease therapy.

Keywords: Chagas Disease, *Trypanosoma cruzi*, Neglected tropical disease, Drug Design, MMPBSA.

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B48: Effects of Internal Heat and Mass Generation on Dufour-Driven MHD Natural Convection in Concentric Annuli

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Abstract

This study investigates the Magnetohydrodynamic (MHD) natural convection of heat and mass transfer in a vertical concentric annulus, focusing on the influence of the Dufour effect, heat generation (S), annular region (λ) and chemical reaction (K'). The governing equations are analyzed to understand the physical behavior of velocity, magnetic field, temperature, concentration and induced current density profiles. Results reveal that increasing the Hartmann number (Ha) suppresses fluid velocity and induced current density due to the Lorentz force. Conversely, the Dufour number (Du) acts as a thermal and kinetic booster, enhancing the temperature, velocity, and volumetric flow rate (Q) by introducing additional energy flux from concentration gradients. The analysis of Nusselt numbers (Nu) reveals that heat transfer efficiency at the inner wall increases with higher Du values but decreases with increased heat generation (S) and wider annular regions (λ). Furthermore, while skin friction (τ) is amplified by wider gaps and heat generation, it is consistently mitigated by the Dufour-induced thermal energy. A notable crossover effect is identified where Isothermal boundaries optimize transport in narrow gaps, whereas Isoflux boundaries are more effective in wider annular configurations. This research

provides an insights for the design of MHD-based thermal systems, such as liquid metal cooling and chemical reactors, where cross-diffusion effects are prominent.

Keywords: MHD, Natural Convection, Concentric Annulus, Dufour Effect, Heat and Mass Transfer.

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B49: Computational Analysis of Kuka (*Adansonia digitata*) for HER3-Targeted Breast Cancer Therapy

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Abstract

Computational approaches have transformed drug design by enabling efficient exploration of bioactive compounds through molecular modeling and simulation techniques. In this study, Kuka (*Adansonia digitata*) was investigated for its potential therapeutic role in breast cancer treatment using molecular docking methods. Docking simulations were performed with AutoDock 4 between selected phytochemicals and the breast cancer-associated receptor HER3 (ERBB3), a key protein involved in cancer progression, alongside the standard inhibitor, Lapatinib. Binding interactions were evaluated based on binding affinity and inhibition constant, with compounds exhibiting values below 7kcal/mol indicating strong ligand–receptor interactions. ADMET analysis was further conducted to assess pharmacokinetic and toxicity properties of the compounds. The docking results were analyzed using LigPlot and Discovery Studio for both two-dimensional and three-dimensional visualization of molecular interactions. Findings revealed that several phytochemicals demonstrated favorable binding interactions comparable to the reference inhibitor, with stable interaction patterns at the active site. These results suggest promising inhibitory potential and indicate that *Adansonia digitata* may serve as a viable source of lead compounds for HER3-targeted breast cancer therapy, although further experimental validation is required.

Keywords: Drug design, *Adansonia digitata*, binding affinity, inhibition constant, ADMET analysis.

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B50: Critical Diffusion Coefficient Ratios for Pattern Onset in Linear Cross-Diffusion Models

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Abstract

This paper investigates the emergence of diffusion-driven spatial patterns in a two-species reaction-diffusion system with linear cross-diffusion. Particular attention is devoted to the determination of critical ratios of diffusion coefficients responsible for the onset of Turing instability. Explicit threshold conditions involving self-diffusion and cross-diffusion parameters are derived through linear stability analysis. It is shown that the ratio between diffusion coefficients plays a decisive role in pattern selection, while cross-diffusion substantially reduces the classical threshold requirement. Numerical illustrations demonstrate transitions from homogeneous states to stripe and spot patterns as the diffusion ratio crosses critical values. The results provide useful criteria for calibration of ecological, biological, and chemical transport models.

Keywords: Diffusion ratio, Turing instability, cross-diffusion, bifurcation, pattern formation.

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B51: A Deterministic Stage-Structured Compartmental Model for Stillbirth Risk During Pregnancy in Nigeria

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Abstract

A deterministic stage-structured compartmental model is developed to investigate the progression of pregnancy complications and their impact on stillbirth risk. The model incorporates healthy pregnancies, mild and severe complications, enhanced antenatal care, cumulative stillbirths and cumulative live births. Qualitative properties, sensitivity analysis and numerical simulations are used to assess pregnancy outcomes. The results indicate that faster progression of pregnancy complications increases stillbirth risk, whereas enhanced antenatal care reduces the burden of stillbirth. The proposed model provides a quantitative framework for understanding stillbirth dynamics and supporting strategies aimed at reducing stillbirth incidence in Nigeria.

Keywords: Stillbirth; Antenatal care; Pregnancy; Mathematical modelling.

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B52: A Pharmacokinetic-Pharmacodynamic Mathematical Model of the Double Edged Effects of Corticosteroid Therapy in Ocular Infection and Glaucoma.

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Abstract

Excessive ocular inflammation can be control by Corticosteroid therapy but its administration during active infection emerge a therapeutic trade off between intraocular pressure (IOP) regulation, inflammatory suppression, pathogen clearance . A nonlinear PK–PD model that captures the dynamics of antibiotic and corticosteroid across vitreous and aqueous compartments and their interactions with pathogen dynamics, inflammatory phagocytes, cellular debris, outflow resistance, and IOP is formulated. Result from qualitative analysis showed that glaucoma free equilibrium is local asymptotic stable when the pathogen invasion threshold satisfies ($\chi_0 < 1$). A transcritical bifurcation at ($\chi_0 = 1$) seperate the infection clearance regime from the pathogen persistence regime ($\chi_0 > 1$). Sensitivity analysis identifies pathogen growth, antimicrobial efficacy, corticosteroid mediated immune suppression, and outflow resistance as primary determinants of persistent infection and IOP elevation. The framework understudy the double edged nature of corticosteroid therapy, balancing its anti-inflammatory benefits against impaired pathogen clearance and secondary glaucoma, and provides a quantitative foundation for optimizing treatment strategies that maintain ($\chi_0 < 1$).

Keywords: PK–PD Model, Glaucoma, Antimicrobial efficacy, Sensitivity Analysis, Corticosteroid Therapy.

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B53: Kinematically generated micropolar fluid flow in a grooved channel.

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Abstract

This study investigates the boundary-driven flow of a micropolar fluid through a channel with a grooved wall, focusing on how geometric and micropolar parameters influence the flow. Grooves are found to significantly alter the flow field by generating an additional microrotation component and modifying the stress distribution, thereby affecting drag. Although grooves generally increase drag, long-wavelength grooves induce less drag than short-wavelength ones. Under the same geometry, a Newtonian fluid experiences lower drag, highlighting the unique impact of micropolar microstructure on flow behaviour. The presence of grooves reduces the flow rate in the channel relative to that in a smooth-walled passage.

Keywords: Keywords: grooves, velocity, microrotation, stress, flow rate.

MSC 2020: 76A05, 76M45

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

C: Differential Equations Operator Theory and Other Pure Mathematics

C1: A trigonometrically adapted 6(4) singly diagonally implicit Runge-Kutta-Nystr om pair for oscillatory systems.

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Abstract

This paper presents the construction and analysis of a trigonometrically-fitted singly diagonally implicit Runge-Kutta-Nystr om pair of order 6(4) with five stages. The developed adapted pair integrates exactly (except for round-off errors) the standard test equation $u'' = \lambda^2 u$. The local truncation errors of the proposed schemes are derived, and importantly, the orders of the original RKN pair are preserved. Stability analysis of the new pair reveals a periodicity interval. Numerical experiments demonstrate the superior efficiency of the newly developed pair when compared with some existing DIRKN methods.

Keywords: Trigonometrically-fitted approach, Runge-Kutta-Nystrom pair, Oscillatory Problems, Initial Value Problems

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C2: Tropical Bi-Objective Pseudolinear Optimization and Parametric Mean-Payoff Games

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Abstract

We extend the parametric mean-payoff game framework of Parsons, Sergeev and Wang to bi-objective tropical pseudolinear optimization with general two-sided constraints. The problem is to simultaneously minimize two tropical pseudolinear objectives over the feasible set of a two-sided system $Ux \leq Vx \leq d$; we characterize the Pareto front via a parametric mean-payoff game in two parameters (λ_1, λ_2) simultaneously. The feasibility region R in parameter space is convex, and the Pareto front P is a convex piecewise-linear curve with finitely many breakpoints; for integer data every breakpoint has half-integer coordinates, extending the denominator bound of Parsons, Sergeev and Wang to the bi-objective setting. Optimality and infeasibility certificates are given in terms of the cycle structure of the parametric game. Two algorithms are developed: a directional bisection algorithm computing Pareto-optimal triples in $O(\log M)$ iterations for data bounded by M , and a Newton scheme tracing the complete Pareto front in at most S steps, independent of M , where S is the

set of Max strategies. Numerical experiments on random instances confirm both complexity bounds. **Key words:** Tropical algebra; bi-objective optimization; mean-payoff games; Pareto front; parametric optimization; piecewise-linear convexity.

MSC: 15A80; 90C26; 90C29; 91A46.

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C3: On a version of Strong Convergence theorems for the Jungck Picard-Multistep hybrid iterative scheme for a general class of Functions

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Abstract

This paper establishes a version of strong convergence results for the Jungck Picard-Multistep hybrid iterative scheme. The results improve, generalize and extend some of the known ones in literature especially those of Olatinwo and Imoru, Berinde, Olaleru and Akewe.

Keywords: Strong convergence, Convergence theorems, General class of function, Jungck Picard-Multistep hybrid iteration, Iterative scheme.

MSC. 47H06; 54H25.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

C4: Analysis of the Compact Finite Difference-Boole's Approximation Method for Integro-Differential Equations of First and Second Orders Using Maximum and Euclidean Errors)

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Abstract

This study is on a fourth-order compact finite difference-Boole's rule method for the numerical solution of linear first- and second-order integro-differential equations. The differential part is discretized using a compact finite difference scheme, while the integral term is approximated using the composite Boole's quadrature rule, thereby producing a fully discrete system of linear algebraic equations. The resulting banded system is solved efficiently to obtain approximate solutions at grid points. Accuracy is measured using both the maximum norm and the Euclidean norm of the error. Numerical experiments on benchmark problems show that high accuracy is attained through the proposed method with errors decreasing at the expected fourth-order rate as the mesh is refined. The approach is computationally efficient, easy to implement, and appropriate for solving a broad class of linear integro-differential equations with nontrivial integral kernels.

Keywords: Boole' Rule, Euclidean Error, Compact Finite Difference Method, Maximum Error, Integro-Differential Equations.

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C5: Polynomial Growth Classification of Diagonal Multiplier Operators and Their Evolution Dynamics on Weighted Coefficient Spaces

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Abstract

Diagonal multiplier operators on spaces of analytic functions are investigated within an operator-theoretic framework, shifting the focus from classical coefficient inequalities to diagonal operator and semigroup theory on weighted coefficient spaces. For multiplier sequences satisfying $\omega_n \asymp n^m$, $m > 0$, we establish that the growth order determines the natural regularity scale $T_\theta : X_{p+m} \rightarrow X_p$, compactness of the associated evolution family for $t > s$, and the quantitative smoothing estimate $\|U(t, s)\|_{X_p \rightarrow X_{p+q}} \leq C_q(ts)^{q/m}$. The quadratic case $m = 2$, corresponding to the Makinde-type multiplier $\omega_n = (\alpha + n\beta + n^2\gamma)/(\alpha + \beta + \gamma)$, is analyzed in full detail. Explicit formulas are derived for the operator norm, optimal mapping property, generator spectrum, evolution spectrum, Fredholm essential spectrum, compactness, and smoothing rate. The results provide a systematic treatment of polynomial multiplier deformations of analytic function spaces, clarifying the role of multiplier growth in weighted-space dynamics. This framework further establishes a foundation for investigating multiplier-induced subclasses of univalent, starlike, and convex functions through coefficient estimates and extremal problems, thereby bridging operator theory with geometric function theory.

Keywords: Diagonal multiplier operator; Polynomial growth; Evolution family; Essential spectrum; Makinde-type operator.

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C6: Construction and Operator-Theoretic Properties of a Climate-Sensitive Human–Mosquito Interaction Operator

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Abstract

Linear multiplier operators constitute a fundamental tool in the study of analytic and univalent functions in Geometric Function Theory. Motivated by recent advances in generalized multiplier transformations, this paper introduces a new Climate-Sensitive Human–Mosquito Interaction Operator by incorporating the climate-dependent parameter vector into a generalized multiplier framework. The proposed operator extends several classical multiplier operators as special cases and provides a unified setting for investigating climate-sensitive analytic function classes. Four operator-generated subclasses, namely the climate-sensitive univalent, starlike, convex and close-to-convex classes, are introduced and studied. Employing classical techniques from Geometric Function Theory, including Carathéodory functions, convolution theory, coefficient methods and differential subordination, sufficient conditions for univalence, starlikeness, convexity and close-to-convexity are established. Convolution properties, coefficient inequalities and inclusion relationships for the newly defined subclasses are also obtained. Furthermore, appropriate choices of the climate-sensitive parameters recover several existing multiplier operators, thereby demonstrating the generality of the proposed formulation. The results establish a unified operator-theoretic framework for investigating climate-sensitive subclasses of analytic functions and broaden the scope of multiplier operator theory within Geometric Function Theory.

Keywords: Geometric Function Theory; Multiplier Operator; Univalent Functions; Differential Subordination; Convolution.

Subject Area: Pure Mathematics – Complex Analysis (Geometric Function Theory)

Mathematics Subject Classification (2020): 30C45, 30C50, 47B38

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C7: A One-Step Fourth-Order Implicit–Explicit Second-Derivative Parameter-Dependent General Linear Method for Stiff and Non-Stiff ODEs

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Abstract

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In this paper, a one-step fourth-order implicit–explicit second-derivative parameter-dependent general linear method (IMEX-SD-PD-GLM) is developed for the numerical integration of stiff and non-stiff ordinary differential equations. The proposed method combines an explicit treatment of the non-stiff components with a diagonally implicit treatment of the stiff components, while incorporating second-derivative information to achieve higher-order accuracy with a reduced number of stages. A free parameter α is introduced in the implicit part of the scheme, allowing the stability properties to be tuned without affecting the algebraic order of the method. Order conditions up to fourth order are derived, and a concrete one-step method satisfying these conditions is constructed. Linear stability analysis shows that the method is A-stable and exhibits $L(\alpha)$ -stability for appropriate choices of α . Numerical experiments on linear and nonlinear stiff test problems demonstrate the efficiency, accuracy, and strong stiff decay of the proposed scheme, and comparisons with classical IMEX Runge–Kutta and BDF2 methods confirm its superior performance in terms of accuracy and stability for stiff problems.

Keywords: IMEX, one-step fourth-order, second-derivative methods, parameter dependent general linear method, stiff ODEs, L-stability, and numerical integration.

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C8: A Parametric Hydrodynamic Model for Flood Risk Management In Esan West Local Government Area, Ekpoma, Edo State, Nigeria

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Abstract

Flooding is a major environmental and socio-economic problem faced in Esan West Local Government Area and this is as a result of the combined effects of intense seasonal rainfall, rapid urbanization and inadequate drainage infrastructure. Yet another factor is the unfavorable terrain of Esan West Local Government Area. This problem of flooding often results in the damage of infrastructures, disruption of transportation networks, and adverse impacts on livelihoods. Despite these challenges, flood management strategies in Esan West Local Government Area remain unresponsive and this is due to the limited application of predictive and data-driven approaches. This study tends to develop a parametric hydrodynamic model for flood risk management in Esan West Local Government Area. The formulation of this model will be based on the two-dimensional shallow water equations, which describe the conservation of mass and momentum in fluid flow. The key physical and environmental variables are incorporated, including rainfall intensity, terrain elevation, drainage efficiency, and surface resistance. A free parameter will be introduced into the drainage function and this will aid the simulation and quantitative evaluation of different flood mitigation scenarios. The model will be implemented numerically using a stable computational scheme to simulate flood dynamics across a discretized spatial domain representing Esan West Local Government Area. Simulation outputs include flood depth distribution maps, rainfall–flood response relationships, and intervention-based flood reduction scenarios. Results will indicate a nonlinear increase in flood depth with increasing rainfall intensity, with peak flood levels occurring under high-intensity rainfall events. Spatial analysis will reveal that flood risk is concentrated in low-lying areas

and regions with poor drainage capacity. Furthermore, the introduction of the intervention parameter will demonstrate that improvement in drainage infrastructure can lead to a significant reduction in flood depth, exceeding 50% under optimal conditions. This highlights the critical importance of targeted infrastructure development in mitigating flood risks. The study tends to provide a robust, scalable, and decision-support modeling framework for flood risk assessment and management in semi-urban environments. Its findings will offer practical insights for engineers, urban planners, and policy-makers, and will be directly applicable to flood mitigation planning in Esan West Local Government Area and similar regions. The model will also align with national priorities on environmental sustainability and disaster risk reduction.

Keywords: parametric, hydrodynamic model, flood risk management, Esan West LGA, Edo State.

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C9: A STUDY ON FRACTIONAL MODEL OF UNSTEADY COUETTE FLUID FLOW THROUGH COMPOSITE MACRO CHANNELS USING NUMERICAL TECHNIQUES

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Abstract

This study presents a computational analysis of a fractional model for unsteady Couette fluid flow in composite parallel-plate channels consisting of a porous medium and a clear fluid region. To better capture memory and hereditary effects absent in classical models, Caputo fractional derivatives—formulated via the Riemann–Liouville integral operator—are employed. The flow in the porous region is governed by the Brinkman-extended Darcy model, while the Stokes equation describes the clear fluid region. Analytical and numerical solution methods, including the Laplace transform, Adomian decomposition, and new iterative techniques, are applied to obtain solutions. Graphical results illustrate velocity profiles and pressure gradients, highlighting the behavior of generalized Couette flow. The study examines the effects of key parameters such as fractional order, permeability, porosity, Darcy number, interfacial resistance, and pressure gradient on velocity distribution, interface velocity, and skin friction. Findings reveal that these parameters significantly influence transient flow characteristics and interfacial dynamics. The results also show strong agreement between analytical, closed-form, and numerical solutions for steady-state conditions, as well as reliable approximations for unsteady flow over time. Overall, the study demonstrates that fractional models provide enhanced accuracy, flexibility, and physical realism in modeling transport phenomena in heterogeneous channels, contributing meaningfully to advancements in fractional fluid mechanics.

Keywords: SEI and SEIR model, yellow fever, variational iteration method.

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C10: Functional Analysis Techniques in Sustainable Systems Modelling

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Abstract

The growing need to address environmental degradation, climate change, resource scarcity, and sustainable economic development has increased the importance of robust mathematical approaches for analyzing complex systems. Sustainable systems modelling provides a structured means of understanding the interactions among environmental, social, and economic factors, thereby supporting informed and evidence-based decision-making. Among the advanced mathematical tools available for this purpose, functional analysis offers a thorough framework for examining the behaviour, stability, and optimization of complex systems. This paper highlights the relevance of functional analysis techniques in sustainable systems modelling, focusing on key concepts such as Banach spaces, Hilbert spaces, linear operators, fixed-point theorems, and optimization methods. The study discusses how these concepts can be applied to the analysis of environmental, economic, and engineering systems, particularly in improving model reliability, assessing system stability, and enhancing long-term forecasting. Drawing on existing theoretical and applied literature, the paper highlights the contribution of functional analysis to understanding the dynamics of sustainable systems and developing effective solutions to contemporary sustainability challenges. The paper concludes that the integration of functional analysis into sustainability research can strengthen modelling frameworks, improve decision-making processes, and support the achievement of sustainable development goals.

Keywords: Functional Analysis, Mathematical Modelling, Banach Spaces, Hilbert Spaces, Fixed-Point Theory.

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D: Statistic, Computer Science and Other Sciences

D1: An efficient Dai-Yuan CG method based on structured secant conditions for NLS problems and its application

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Abstract

Nonlinear least squares (NLS) problems are commonly encountered in many scientific and engineering fields, often demanding robust and efficient optimization methods for their solution. Traditional approaches for solving NLS problems frequently encounter difficulties related to high computational costs and memory usage, particularly in large-scale scenarios. This study introduces a novel structured Dai-Yuan two-term conjugate gradient (CG) method to address the minimization of NLS problems. A structured vector approximation, representing a matrix-vector interaction, is constructed by leveraging a Taylor series expansion of the objective function's Hessian. This formulation adheres to a quasi-Newton condition. The method utilizes this structured approximation to enrich the conventional search direction with additional curvature information from the Hessian. The resulting search direction satisfies the required descent condition. Furthermore, numerical experiments on a range of benchmark problems demonstrate that the proposed method offers superior performance, outperforming several existing techniques.

Keywords: conjugate gradient, least-squares, quasi-Newton, inverse kinematics, robotics.

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D2: Neural Networks for Dynamical System: Analysis of a Variant Quadratic Lorenz System

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Abstract

This article presents an in-depth analysis of a variant Lorenz system characterized by a quadratic modification in the velocity equation. We replace the linear term $\sigma(y - x)$ with a nonlinear quadratic coupling, leading to symmetry breaking and altered stability at the equilibrium points. Furthermore, we provide a neural network structure for the identification and prediction of the variant system's chaotic trajectories, demonstrating how deep learning can capture higher-order nonlinear interactions that traditional linear approximations may overlook. **Keywords:** Variant Lorenz System, New Lorenz Attractor, Neural Networks, Symmetry breaking, stability analysis.

Paper read at the 9th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 16 - 22 August 2026

D3: A Cubic-Accelerated RMIL Conjugate Gradient Method for Nonlinear Least Squares with Application to Robotic Arm Modeling

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Abstract

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This paper proposes a cubic-accelerated conjugate gradient method based on the RMIL parameter for solving nonlinear least squares problems. The method introduces an adaptive acceleration parameter k_i , obtained by minimizing a cubic model of the change in each component function along the search direction using a third-order Taylor expansion. Unlike classical acceleration strategies based on quadratic models, the proposed approach incorporates higher-order curvature information, leading to improved step-size scaling and enhanced convergence behavior. To maintain computational efficiency, the second- and third-order directional curvature scalars are approximated using successive gradient differences, avoiding explicit Hessian or higher-order tensor evaluations. The acceleration parameter is computed component-wise, while shared curvature terms are evaluated once per iteration. Under standard assumptions, including Lipschitz continuity and boundedness of the objective function, the method guarantees sufficient descent independently of the line search, and global convergence is established. Numerical experiments on benchmark problems demonstrate superior performance over existing CG methods. The effectiveness of the proposed method is further validated through its application to robotic arm modeling, where accurate and efficient parameter estimation is achieved.

Keywords: Acceleration Scheme, Sufficient Descent, Adaptive Step Size, Global Convergence, Robotic Modeling.

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D4: Modeling Nonlinear and Delayed Climate Effects on Malaria Incidence Using Distributed Lag Non-Linear Models: Evidence from Kano State, Nigeria

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Abstract

Malaria remains a major public health challenge in northern Nigeria, with transmission dynamics strongly influenced by climatic variability. This study investigated the nonlinear and lagged effects of key meteorological variables on malaria incidence in Kano State. Monthly malaria incidence data obtained from the District Health Information System and corresponding meteorological variables from the Nigerian Meteorological Agency were analyzed over the period 2015–2025. Spearman correlation and cross-correlation analyses indicated that rainfall and relative humidity were positively associated with malaria incidence, exhibiting significant lag effects of approximately 1–3 months, while temperature showed weaker and more complex relationships. Model comparison demonstrated that the DLNM outperformed both Poisson and Negative Binomial models, achieving the lowest AIC (2,589.80) and BIC (2,699.95), indicating superior model fit. Exposure–lag–response analysis revealed that moderate rainfall and specific humidity ranges significantly increased malaria risk after 2–4 months, whereas extreme conditions reduced transmission. Temperature effects were nonlinear, with lower temperatures

associated with higher malaria risk at longer lag periods. The model further demonstrated strong predictive performance, accurately capturing seasonal transmission patterns with a Mean Absolute Percentage Error (MAPE) of 5.85%. These findings highlight the importance of incorporating nonlinear and delayed climatic effects in malaria modeling. **Keywords:**

Key words: Distributed Lag Non-Linear Model (DLNM), Malaria Incidence, Meteorological Factors, Cross-Correlation Analysis, Lag Effects

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D5: Exploration of Landcover Dynamics and Anthropogenic Activities Amidst the Extinction of Woody Species in Gashaka Gumti National Park, Taraba

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Abstract

Gashaka Gumti National Park (GGNP) a center for tourism and recreation is the largest park in Nigeria with abundance of tree species yet experienced changes in landcover dynamics posed by anthropogenic influence. This paper examines the park morphological changes over time using supervised machine learning model in GIS and inferential statistical models. The image classification reveals a decreasing area coverage of Lowland Tropical Forest (LTF) with an increase in Savannah woodland (SWL) from 2006 to 2022 with a correlation coefficient of -1.000 and $p = 0.01$ indicating absolute inverse relationship. Shannon Weiner index in GGNP was observed to be 2.48-3.72, showing a medium to high biodiversity across the zones. Quadrat analysis of point pattern shows uniform distribution of trees in LTF area $Z = (135.9)$, random distribution in SWL $Z = (-1.85)$ and cluster pattern of distribution in MGL $Z = (-2.29)$ manifested by the high rate of deforestation in GGNP with 50.7% of the inhabitants engaging in rigorous grazing and 46.7% attributed forest depletion to logging activities. Degree of freedom for Regression and Residual confirmed the tested parameters as function of species richness with $F(5, 64) = 605.952$ and $p < 0.001$ thus, recommend integrated management strategies for a sustainable park.

Keywords: Gashaka Gumti National Park, Landcover change, Woody species, Logging, Climate Change.

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D6: Response Surface Modelling of Process Quality in a Bread Production System: A Central Composite Design Approach

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Abstract

This study applies Response Surface Methodology (RSM) to model and optimize the bread production process in a commercial bakery in Ogharefe, Delta State, Nigeria. A face-centred Central Composite Design (CCF) with two controllable factors was employed over 12 experimental runs. The response variable is the proportion of defective bread per oven load (lot). Sequential model selection via Type I sum of squares, lack-of-fit analysis, and model summary statistics collectively identified the quadratic model as most appropriate. The fitted quadratic surface achieved an adjusted R^2 of 0.9619 and a predicted R^2 of 0.9318 with no significant lack-of-fit ($p = 0.7682$). The findings from the analysis of the response surface located the optimum operating region at an oven temperature of approximately 218°C and a baking duration of approximately 22 minutes, yielding a predicted minimum proportion defective of about 14.2 defects per 1000 loaves.

Keywords: Response surface methodology; Central composite design; Bread production; Process optimization; Proportion defective; Quadratic model.

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D7: Modelling the effects of urban growth on Peri-Urban Agricultural Land in Dutse Town, Nigeria

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Abstract

Peri-urban agricultural land is a critical resource for enhancing food security and sustaining the livelihoods of farming households in rapidly growing cities. However, accelerating urban growth continues to exert increasing pressure on peri-urban farmland through land-use conversion and fragmentation. Since the creation of Jigawa State from the former Kano State, Dutse Town—the state capital—has experienced rapid urban expansion, resulting in significant changes in peri-urban agricultural land use and declining farmland availability. This study assessed the effects of urban growth on peri-urban agricultural land use in Dutse Town, Jigawa State, Nigeria, over a 25-year period (1998–2023). Landsat satellite imageries for 1998, 2013, and 2023 were analyzed using GIS techniques to map urban expansion and changes in agricultural land. Four peri-urban wards—Kachi, Limawa, Jigawa Tsada, and Madobi—were purposively selected, followed by random sampling of farmers whose farmlands had been acquired for urban development. Out of 1,511 affected farmers, 306 were proportionately sampled and surveyed using structured questionnaires, complemented by interviews with agricultural officers, community leaders, and local farmers. Data were analyzed using descriptive statistics and the Wilcoxon Signed-Rank Test. Findings reveal a decline in agricultural land from 72% in 1998 to 66% in 2023, while built-up areas expanded from 2.67% to 6.96%. Land productivity also declined: whereas 74.7% of farmers rated their land as productive in 1998, 58.9% described it as less or not productive in 2013–2023. Access to farmland decreased from 67% reporting easy access to 23.7%, while dominant income ranges shifted downward from ₦51,000–₦100,000 to ₦30,000–₦60,000. Wilcoxon test results confirmed significant declines in land productivity, farm income, and resource access ($Z = 9.193, 9.716, 12.164$; $p < 0.001$). The study recommends enforcing urban growth boundaries supported by GIS-based monitoring to protect peri-urban agricultural land, alongside promoting climate-smart farming, soil conservation, and farmer training. Expanding access to affordable credit, improving market linkages, encouraging livelihood diversification, and strengthening community participation in urban planning are essential for balancing urban growth with peri-urban agricultural sustainability.

Keyword: Urban growth, Peri-urban Agriculture, Agricultural land use, Land-use change, Dutse Town, Food security.

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D8: Predicting Tick-Borne Disease Risk Using Random Forests with Satellite-Derived Environmental Variables in Kano State, Nigeria

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Abstract

Tick-borne diseases (TBDs) including Crimean-Congo hemorrhagic fever threaten livestock and public health in Kano State, Nigeria. This study compared a Random Forest (RF) model against logistic regression (LR) for predicting TBD risk across 44 local government areas using satellite-derived environmental variables. Tick infestation data were collected from 1,250 livestock across major markets and rural settlements, alongside human CCHF cases from state health records. Predictors included land surface temperature (LST), NDVI, precipitation, and soil moisture from MODIS and CHIRPS satellites. The RF model significantly outperformed LR, achieving an AUC of 0.87 compared to 0.71 for LR. SHAP analysis identified daytime LST as the most important predictor, followed by NDVI and cattle density. Critical thresholds showed infestation risk increased sharply when LST exceeded 34°C and was highest in moderately vegetated areas (NDVI 0.25–0.40). Spatial mapping identified Makoda (risk probability 0.89), Bichi (0.86), Bagwai (0.84), and Shanono (0.82) as highest-risk LGAs. Peak risk occurred in August–September following the rainy season. This study provides the first LGA-level TBD risk map for Kano State, offering an evidence-based tool for targeted tick control and surveillance. The methodology is replicable across other Sahelian regions.

Keywords: Random Forest; tick-borne disease; Kano State; satellite remote sensing; spatial risk mapping

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D9: Bridging the Analytics Gap: Data-Driven Skills for Sustainable Urban Analysis in Nigerian Planning Education

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Abstract

This study examines the awareness and utilization of urban data analytics tools among 243 undergraduate and postgraduate students of Urban and Regional Planning at a Nigerian public university. A quantitative survey design employed descriptive statistics and independent-samples t-tests to compare cohorts and identify factors for tool choice. Results show high awareness ($M = 4.32, SD = 0.81$) and motivation to learn tools ($M = 4.26, SD = 0.89$), but heavy reliance on Excel ($M = 0.68, SD = 0.47$) and minimal use of advanced tools like Python ($M = 0.16, SD = 0.37$), R ($M = 0.02, SD = 0.16$), and Tableau ($M = 0.00, SD = 0.01$). Postgraduates reported significantly higher SPSS use ($Levene's F = 11.95, p = 0.001; t(241) = 6.94, p < 0.001$). Both cohorts expressed moderate confidence in the institutional capacity and sufficiency of the curriculum. Key adoption determinants were training/resources availability ($M = 0.43, SD = 0.50$) and perceived ease of use ($M = 0.37, SD = 0.48$), indicating structural barriers. This awareness–utilization gap weakens the skills pipeline for data-informed planning and smart governance in Nigeria. Recommendations include curriculum reform, faculty development, and policy alignment to strengthen analytics capacity in planning education.

Keywords: urban data analytics, planning education, statistical analysis, smart cities, curriculum reform

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D10: Comparative Analysis Between Mathematics Achievement using Robotic Artificial Intelligent (RAI) and Conventional Learning Method (CLM) among Senior Secondary School Students in Minna Metropolis, Niger State.

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Abstract

This finding investigated the comparative analysis between mathematics achievement using Robotic Artificial Intelligent (RAI) and Conventional Learning Method (CLM). The expanding integration of Robotic Artificial Intelligent in education provided potential to moves pedagogical approaches from traditional teaching-based methods to personalized interactive learning. This study compares the impact of robotic (AI) supported learning against conventional teaching methods on student's mathematics achievement, specifically in conceptual understanding and problem-solving skills. Three research questions and hypotheses guided the study. The pre-test, post-test, non-equivalent control group, quasi-experimental design was adopted. The population of the study comprised all senior secondary school (class 2) in Minna Metropolis. The sample of the study was Two Hundred and Forty (240), - 180 males and 80 females, this were selected by simple random sampling technique in Minna Metropolis. The instrument used was Mathematics Achievement Robotic Artificial Intelligent Test (MARAIT) and Mathematics Achievement Conventional Learning Method Test (MACLMT), the instrument was subjected to pivot test and the reliability coefficient was 0.86. The data collected was analyzed using SPSS version 20 with inferential statistics, such as Analysis of Covariance (ANCOVA) at 0.05 level of significance. The result of the study has shown that students taught using robotic (AI) attained significantly higher mean scores, demonstrated greater motivation and reduced mathematics anxiety compare to the control group. However, robotic (AI) serve as an effective catalyst for improving mathematical achievement and it was recommended that stakeholders, educational planners and government should introduce robotic (AI) to the educational sectors, to serve as alternative methods of impacting knowledge, especially during spreads of communicable diseases.

Key words: Artificial Intelligence, Educational Robots, Mathematics Education, Comparative Analysis, Conventional Learning Method, Student Achievement.

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D11: Forecasting Snake Encounter Risk in Recreational Parks: A Gradient Boosted Model for Hiker Safety Education in ADUSTECH Wudil, Kano.

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Abstract

Forecasting Snake Encounter Risk in Recreational Parks: A Gradient Boosted Model for Hiker Safety Education in ADUSTECH Wudil, Kano snake encounters in recreational parks pose under-reported health risks in Nigerian savanna ecosystems. No predictive tool exists to forecast snake encounter risk for hiker safety education at ADUSTECH Wudil, Kano. A cross-sectional mixed-methods design was employed. All recreational park users and green areas within ADUSTECH Wudil campus. Seven transects (18.4 km) were purposively selected across football pitches, walking trails and green belts; 420 students were selected via stratified random sampling by faculty. Ecological data sheet, Landsat-8 imagery (NDVI, land surface temperature), and a validated snakebite knowledge questionnaire ($\alpha = 0.82$). Weekly transect walks over two wet and two dry seasons recorded snake encounters, foot traffic, temperature, humidity and rainfall; the questionnaire was administered to students. An XGBoost gradient boosted model achieved AUC of 0.84 (95% CI: 0.79–0.89), sensitivity 82%, specificity 79%. Recent rainfall, NDVI and foot traffic density were top predictors. Student mean knowledge score was 6.2/20; only 1.4% demonstrated adequate snakebite prevention knowledge. The gradient boosted model effectively forecasts weekly snake encounter risk and can inform targeted campus safety education.

Key words: Snake encounter risk, Gradient boosted model (XGBoost), Hiker safety education, Recreational parks, ADUSTECH Wudil, Machine learning, Ecological modelling, Snakebite prevention.

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D12: Machine Learning Model for Predicting Grey Relational Signal-to-Noise Ratio in Reinforced PTFE Composite Wear Behaviour

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Abstract

Abrasive wear in reinforced PTFE composites reduces the durability and performance of engineering parts; thus must be minimised. One operative way is the optimisation and prediction of wear behaviour using mathematical and artificial intelligence (AI) models. This study used advanced AI models, namely multi-layer perceptron (MLP), emotional artificial neural network (EANN), and genetic algorithm-based emotional artificial neural network (GEANN), to predict the signal-to-noise ratio (SNR) of grey relational analysis for reinforced PTFE composites under abrasive wear conditions. The predictive accuracy of these models was compared with that of the multi-linear regression (MLR) model. The input parameters were sliding distance, sliding speed, grit size, and applied load, while the output response was the signal noise ratio (SNR). Experimental data was obtained from abrasive wear tests based on the Taguchi L27 orthogonal array. Model performance was appraised using regression coefficient (R), coefficient of determination (R^2), mean squared error (MSE), root mean square error (RMSE), and mean absolute error (MAE). Results depicted that the AI models outperformed the MLR model, achieving predictive accuracies above 99%, making them suitable for industrial material design and optimisation.

Key words: emotional artificial neural network, genetic algorithm-based emotional artificial neural network (GEANN), signal-to-noise ratio (SNR), Statistical Metrics.

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D13: Tropical Bi-Objective Pseudolinear Optimization and Parametric Mean-Payoff Games

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Abstract

We extend the parametric mean-payoff game framework of Parsons, Sergeev and Wang to bi-objective tropical pseudolinear optimization with general two-sided constraints. The problem is to simultaneously minimize two tropical pseudolinear objectives over the feasible set of a two-sided system $U \otimes x \otimes b \leq V \otimes x \oplus d$; we characterize the Pareto front via a parametric mean-payoff game in two parameters (1, 2) simultaneously. The feasibility region R in parameter space is convex, and the Pareto front $\mathcal{P}$ is a convex piecewise-linear curve with finitely many breakpoints; for integer data every breakpoint has half-integer coordinates, extending the denominator bound of Parsons, Sergeev and Wang to the bi-objective setting. Optimality and infeasibility certificates are given in terms of the cycle structure of the parametric game. Two algorithms are developed: a directional bisection algorithm computing Pareto-optimal triples in $O(\log M)$ iterations for data bounded by M , and a Newton scheme tracing the complete Pareto front in at most $|S|$ steps, independent of M , where S is the set of Max strategies. Numerical experiments on random instances confirm both complexity bounds.

Key words: Tropical algebra; bi-objective optimization; mean-payoff games; Pareto front; parametric optimization; piecewise-linear convexity.

AMS Classifications: 15A80; 90C26; 90C29; 91A46.

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D14: Mathematics in a Data-Driven World: Dynamical Modelling and Sustainable Control of Crimean-Congo Hemorrhagic Fever Virus (CCHFV).

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Abstract

The increasing availability of epidemiological and environmental data has strengthened the role of mathematics in understanding and controlling infectious diseases. In a data-driven world, mathematical modelling provides essential tools for studying the transmission dynamics of zoonotic diseases such as Crimean-Congo Hemorrhagic Fever. This study highlights how data-driven dynamical models can be used to analyze the spread of CCHFV among humans, livestock, and tick vectors, and to evaluate the impact of intervention strategies. By integrating epidemiological data, environmental factors, and computational techniques, mathematical models can improve outbreak prediction, estimate transmission risks, and support evidence-based public health policies. Such approaches also help identify critical drivers of disease spread, including vector abundance, human-animal interactions, and ecological conditions. The application of data science and dynamical systems modelling therefore provides valuable insights for designing effective surveillance, prevention, and control strategies. Ultimately, data-driven mathematical frameworks contribute to innovative and sustainable solutions for managing emerging zoonotic diseases in a changing global environment.

Key words: CCHFV; Mathematical Modelling; Data Science.

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D15: STATISTICAL ANALYSIS OF SWIMMING POOLS WATER QUALITY INDEX IN NASSARAWA LOCAL GOVERNMENT KANO, NIGERIA.

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Abstract

This study assesses the water quality of swimming pools used for recreational purposes in both public and private residences within Kano metropolis. A total of 20 water samples were collected and analyzed for key physicochemical and microbiological parameters, including temperature, pH, electrical conductivity, chloride, phosphate, nitrate, total dissolved solids (TDS), *Escherichia coli*, and *Shigella*, using standard methods prescribed by the American Public Health Association (APHA). The Water Quality Index (WQI) was determined using the Weighted Arithmetic Water Quality Index (WAWQI) method, while a Likert scale was employed to rank the quality status of each swimming pool. The Swimming Pool Water Quality Index (SPWQI) results indicate that all public swimming pools were unsuitable for recreational use, particularly during the wet season as the water quality was generally poor. In the dry season, approximately 25% of both public and private swimming pools were classified as unsuitable for recreational purposes. Furthermore, the findings reveal that none of the sampled pools complied with the recommended standards of the World Health Organization (WHO) and the Environmental Protection Agency (EPA), particularly with respect to chlorine concentration and the presence of pathogenic microorganisms. Notably, elevated contamination levels were observed in selected private swimming pools (S4 and S5). The study underscores the urgent need for proper water treatment and monitoring to reduce excessive chlorine levels and microbial contamination, thereby minimizing the risk of waterborne diseases and health conditions such as asthma, skin irritation, and eye infections.

Key words: Key words: Water quality, Recreation, Swimming pools, Index, Unsuitable.

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