NSMB
Nigerian Society for Mathematical Biology

8TH ANNUAL INTERNATIONAL WORKSHOP AND CONFERENCE ON MATHEMATICAL MODELLING, SIMULATIONS, MATHEMATICAL ANALYSIS AND OPERATOR THEORY

(IWCMMSMAOT 2025)

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

10TH -16TH, AUGUST 2025

BOOK OF ABSTRACTS

8TH ANNUAL INTERNATIONAL WORKSHOP AND CONFERENCE

OF THE

NIGERIAN SOCIETY FOR MATHEMATICAL BIOLOGY (NSMB)

Theme:
Mathematics in the Age of Complexity and for the Future: Bridging Theory, Data, Dynamics and Real-World Impact

Date: 10TH - 16TH AUGUST, 2025

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

Programme of Events

Day 1 - 3: Monday, 11th - Wednesday, 13th August 2025

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

Day 4: Thursday 14th August 2025

Time		Event
8am	-	Breakfast/Registration
9.00am	-	Arrival of participant, guest and dignitaries
	-	to the Conference opening ceremony
10am	-	Conference opening ceremony commences
	-	at Centre of Excellence in Reproductive Health Innovation Lecture Theatre
10am	-	Introduction of Guests
10.10am	-	National Anthem
10.15am	-	Opening prayer
10.20am	-	Welcoming Address by **Prof E. O. Aiyohuyin**
	-	Dean, Faculty of Physical Sciences, UNIBEN
10.30am	-	NSMB, President Address
	-	**Prof. G. C. E. Mbah**
10.40am	-	Address by the Head, Department of Mathematics, UNIBEN
	-	**Prof. D. U. Okuonghae**
10.50am	-	Address by the Chief Host and Declaration of the Conference open
	-	**Prof. Edoba B. Omoregie, SAN**
		Vice-Chancellor
		University of Benin, Benin City
11.05am - 11.35am	-	Keynote address by **Prof. Abdon Atangana**
		University of the Free State, Bloemfontein, South Africa
11.35am	-	Good will messages from other invited guests
11.50am	-	Closing Remark and Vote of Thanks
	-	**Prof. D. U. Okuonghae (LOC Chairman)**
11.55am	-	Closing prayer
12.00noon	-	National Anthem
12.05pm	-	Group photographs
12.45pm - 01.05pm	-	Plenary lecture 1: **Dr. A. Omame**
		Department of Mathematics and Statistics, York University, Toronto, Canada.
1.15pm - 01.35pm	-	Plenary lecture 2: Local and Global Bifurcation Analysis:
		Implications for Biological and Chemical Modelling pandemic
		Prof. D. U. Okuonghae
		University of Benin, Benin City, Nigeria.
02.10pm	-	Lunch Break
03.00pm	-	Parallel Session 1
06.00pm	-	Dinner
07.00pm	-	Closing for the day

Day 5: Friday 15th August, 2025

Time	Event	
9.00am - 9.20am	-	Plenary lecture 3: **Prof. Promise Mebine** Director/CEO, National Mathematical Centre, Abuja, Nigeria
9.30am	-	Parallel Sessions 2
11.30am	-	Parallel sessions 3
01.00pm	-	Lunch break
02.00pm	-	Parallel session 4
05.00pm	-	AGM
07.00pm	-	Conference Dinner
08.00pm	-	Closing

Saturday 16th August, 2025

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	Departure

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Part I

Contributed Talks

A: Mathematical Epidemiology and related Models

A1: Mathematical Modeling Of Enterohepatic Circulation With Saturation Kinetics Of Bile Delay Effect

Stephen Onome Oyovwevotu, Owin Oghenewaire Olowu, Ignatius Imariabe Ako
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Abstract

Enterohepatic Circulation (EHC) is the process by which bile acid are secreted from the liver into the gallbladder, excreted into the small intestine and then reabsorbed back into the liver. This efflux process is spurred by drug saturation, which is a condition in which the rate of absorption of the drug is limited by the rate of transport to the liver.The influx/efflux process of EHC drugs are captured by nonlinear kinetics due to drug saturation which induces pathological defect as a result of drug toxicity. In order to ascertain the pathological defect and nonlinear kinetics on pharmacokinetic parameters,a physiological base delay differential equation captured by nonlinear kinetics is formulated.The drug toxicity threshold parameter and delay effect accounting for gallbladder and intestine disorder(alter the rate of bile circulation) will be discuss.The model will be rigorously analyzed on Drug Free Equilibria, Toxicity Equilibria and Drug Reabsorption Equilibria. Threshold value for Pathological parameter for which there exist a trans from Hoph bifurcation to periodic system will be discussed. The direction of Stability(super critical and subcritical) will be discussed. Global and Local stabilities will also be investigated.The results from the analysis showed that drug saturation induces toxicity in the absence of pathological defect parameters when Drug Toxicity Number (DTN) is greater than one. Where as in the presence of pathological parameters(Mild Case), Drug Toxicity does not annul the physiological state of the compartments hence cannot effect drug reabsorption, there exist a threshold for pathological parameters for which drug reabsorption occurs, and defect in physiological compartment progresses from mild to acute case when pathological parameters exceed this threshold i.e. $\tau_1 + \tau_2 > \frac{\nu_2+2m_2}{\eta_2}$. Hopf bifurcation analysis on the Drug Free and Drug Saturation Equilibria showed that there exist an upper bound for which the system remains asymptotically stable.Theoretical results obtained from this seminar will form the structure on which Pharmaceutical Policy on EHC are pivoted.

Keywords: Enterohepatic circulation, Toxicity Equlibria, Pathological defect, PACS, Hopf Bifurcation.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A2: Wave Propagation of Pathogen Variants in Epidemiological Models

Daniel Ugochukwu Nnaji and Chinenye Omeh
Department of Mathematics, University of Nigeria, Nsukka, Nigeria

Abstract

This work presents a comprehensive study of the spatio-temporal dynamics of competing pathogen variants in epidemic diseases, utilizing a reaction-diffusion system framework. By extending the classical SIR model to incorporate spatial diffusion and competitive interactions between two pathogen variants, the study aims to model the propagation of infection waves across geographic regions. The objectives include developing a spatio-temporal model that captures two variant dynamics, analyzing the existence and stability of travelling wave solutions, exploring reductions to simpler systems like the generalized Fisher-Kolmogorov-Petrovsky-Piskunov (FKPP) equation, and validating theoretical findings against real-world SARS-CoV-2 data from GISAID sequences. Advanced numerical methods, such as Weighted Essentially Non-Oscillatory (WENO) schemes, will be employed to simulate wave behavior accurately. The expected outcomes include theoretical insights into wave propagation, numerical simulation results, and practical implications for public health interventions. This work bridges the gap in current epidemiological modeling by integrating spatial heterogeneity, variant mutation, and high-resolution numerical analysis, offering a robust framework for predicting and managing epidemic outbreak variants.

Keywords: epidemic model, pathogens, travelling waves, spatial model.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A3: Mathematical Modelling of Taeniasis and Cysticercosis Transmission Dynamics: An Optimal Control Analysis

Onwubuya I. O., Madubueze C. E., Gweryina R. I., Aboiyar T.

Department of Mathematics, Joseph Sarwuan Tarka University, Makurdi, Nigeria

Abstract

We presented a susceptible-exposed-infectious-recovered (SEIR) fractional model of the Ebola virus disease. The EBOV is a zoonotic, infectious, haemorrhagic fever, that is characterized by high fever and bleeding in humans. We considered the process of transmission of the disease in a given human population and formulated the fractional order mathematical model. The basic reproduction number was calculated by the next generation matrix approach. All the disease free and endemic equilibrium points of the model were obtained by setting the derivatives equal to zero. The local and global stability of the disease free equilibria were also obtained. Keywords: Ebola virus, basic reproduction number, disease free equilibrium, endemic equilibrium, stability analysis.

Keywords: Taeniasis, Cysticercosis, Taenia solium, Control reproduction number, Mathematical Analysis, Optimal Control Analysis.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A4: MATHEMATICAL MODELLING FOR THE TRANSMISSION DYNAMICS OF RABIES INCORPORATING BATS POPULATION

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Abstract

Rabies is a zoonotic viral disease transmitted via the saliva of infected animals, typically through bites or scratches. This study presents a mathematical model focusing on bat populations categorized as carriers and non-carriers to analyze rabies transmission dynamics. By simplifying bat epidemiological states, the model investigates the critical role of asymptomatic carrier bats in interspecies transmission to humans and domestic dogs. It calculates the basic reproduction number R 0 , evaluates stability conditions using Jacobian matrices and Lyapunov functions, and explores equilibrium points through Descartes' rule of signs. Results indicate that even with low prevalence, carrier bats sustain endemic transmission. The model suggests that rabies can be eradicated if R 0 lt;1 and carrier bats are removed from the ecosystem. Emphasizing public health strategies, it underscores the importance of pre- and post-exposure prophylaxis in both human and canine populations to curb disease transmission.

Keywords: Differential Equation, Equilibrium points, Rabies and basic reproduction number.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A5: Modeling the Dynamics of Lassa Fever Transmission: Bridging Epidemiological Theory and Public Health Impact

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Abstract

Epidemiological modeling serves as a critical link between theory and actual health system practices. In this regard, a deterministic compartmental model is developed to aptly describe the transmission dynamics of Lassa fever between rodents and humans, while the model is simulated to examine different epidemic scenarios of the disease outbreaks. The model equilibrium solutions are determined, and the associated basic reproduction number (R_0) was derived with contributions from both humans and rodents. Sensitivity analysis reveals that both rodent-related parameters and human health factors significantly impact the R_0. Simulations under different epidemic scenarios, such as baseline, high rodent spread, hospital bottleneck, and improved sanitation, replicate the dynamic responses of each compartment in real life. The findings indicate that both rodent-related factors and human health interventions are critical for effective disease control. Thus, showing how theoretical dynamical systems, when coupled with real-world situations, can help inform sustainable control strategies for Lassa fever and other zoonotic diseases. Therefore, it can be concluded that Mathematical models have the potential to deepen understanding and indeed drive public health actions.

Keywords: Lassa fever, epidemiological modeling, rodent transmission, disease control, compartmental models

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A6: 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.

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

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A7: A Mathematical Model of Tumor Growth and Control Through Virotherapy

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Abstract

Cancer remains a major global public health challenge, with tumor growth being a key contributor to morbidity and mortality. While recent advances in treatments—such as virotherapy, chemotherapy, and radiotherapy—have improved patient outcomes, mathematical modeling offers valuable insights into tumor dynamics and treatment optimization. In this study, we formulate a system of nonlinear differential equations to model tumor growth and assess the effectiveness of virotherapy as a control strategy. The model incorporates the Gompertz growth function to capture the sigmoidal behavior typical of tumor progression and describes interactions among uninfected tumor cells, infected tumor cells, effector T-cells, and virions. A necessary and sufficient condition for a globally stable tumor-free (cure) state is established, while a persistent tumor state is shown to exist when this condition is violated. Bifurcation analysis reveals the presence of a subcritical Hopf bifurcation, characterized by a positive first Lyapunov coefficient. Numerical simulations conducted using MATLAB support the analytical findings, and recommendations are provided based on the observed dynamics.

Keywords: Mathematical modeling; Tumor growth; Virotherapy; Nonlinear differential equations; Gom pertz model; Hopf bifurcation; Stability analysis; Lyapunov coefficient; Cancer dynamics.

AMS 2010 Classification: 34C23, 92D25, 92C50.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

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)

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A9: MATHEMATICAL MODELLING FOR THE CONTROL OF YELLOW FEVER TRANSMISSION DYNAMICS USING WOLBACHIA

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Abstract

In this article, we present a mathematical modelling for the control of yellow fever transmission dynamics using wolbachia. A deterministic ordinary differential equation model for disease transmission dynamics within the human and mosquitoes' populations was formulated, the model is categorized into three populations which include the human populations, wolbachia free and wolbachia infected mosquito populations. Wolbachia are intracellular endosymbiotic bacteria that alter host reproduction. The basic reproduction number $(\mathrm{R}_0) wascomputedusingthemethodofthenextgenerationmatrix(NGM)andnumericalcomputationofthebasicreproductionn$
1 which means that the disease will continue to be prevalent in our society irrespective of the rate of vaccination, as long as the yellow fever infected mosquitoes continue to have unhampered access to humans owing to the fact that, some of the vaccinated humans with weak immune system deftly losses immunity with time, and that the immunity conferred by the available vaccine is not ageless. Numerical simulations of the model equations were carried out using a classical fourth order Runge-Kutta method in MATLAB to illustrate our theoretical analysis.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A10: 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 $R_0 < 1$. 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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A11: LYAPUNOV FUNCTIONAL TECHNIQUES ON THE GLOBAL STABILITY OF SIBR CHOLERA EPIDEMIOLOGICAL MODEL WITH NON – LINEAR INCIDENCE

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[2]Department of Mathematics and Data Science, College of Science And Computing, Wigwe University Isiokpo, Rivers State

Abstract

In this work, we study the global stability of Susceptible $S(t)$, Infectives $I(t)$, Bacteriophage $B(t)$ and Removed $R(t)$, $(SIBR)$ cholera epidemiological model with non – linear incidence. The study used both combine, saturating and mass action incidence rate of the form $\frac{eBS}{K+B} + \beta SI$ due to the complex nature of cholera epidemic modes of transmissions that involves multiple transmission pathways, of human to human and environment to human respectively. The globally asymptotic stability of the cholera free equilibrium is proved by constructing a global Lyapunov function. The study presents the construction of Lyapunov functions for the system using suitable combinations of known functions, common quadratic and volterra – type and of a new function to obtain a suitable Lyapunov functions. Thus, the global stability of the $(SIBR)$ model is hereby established.

Keywords and phrases: Bacteriophage, cholera epidemic, Lyapunov functions, global stability, Incidence rate.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A12: Modelling the Cholera Outbreak with Impact of Treatment and Vaccination: A case study of Lagos, Nigeria

Oyewole, Abimbola Samuel

Abstract

Oyewole! Abimbola Samuel

Cholera remains a considerable public health concern in certain endemic regions due to persistent outbreaks. Thus, the recent outbreak in Lagos is not an exception. Here, a deterministic dynamic model is adopted to capture the Lagos Cholera outbreak scenario with the impacts of implemented treatment and vaccination interventions incorporated. The model equilibrium solutions were obtained with associated basic reproduction number derived. The criteria for stability of each of the equilibrium solutions were established while the model is numerical simulated using model parameter values estimated from the cholera epidemic data. Results from the modeling work show that timely treatment of infected individuals and mass vaccination of residents were particularly effective in reducing transmission rates, bacteria levels, and new cases of the disease, especially when targeted at high-risk areas.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A13: On the Economic Consequence of the Charcoal Industry on the Sustenance of the Natural Biomass

Din Sunday Sarki & Michael Awuya Ali

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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

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A14: Modeling COVID-19 Dynamics: Insights for control, prevention and therapeutic interventions.

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Department of Mathematics, Universty of Nigeria, Nsukka, Nigeria

Abstract

The coronavirus disease 2019 (COVID-19) which was caused by the severe acute respiratory syndrome coronavirus 2 (SARS CoV-.2) which was first reported in Wuhan, China in the later part of December 2019 still remains the present global health problem. In this paper, we developed an epidemic model based on systems of ordinary differential equations by taking into consideration the transmission routes from twelve epidemiological compartments. The basic reproduction number which measures the potential spread of COVID-19 in the population is determined using the next generation operator technique. In addition, a Lyapunov function is constructed to examined the stability of the model around a disease-free equilibrium point. It was found that the model has a globally asymptotically stable disease-free equilibrium if the basic reproduction number of the novel corona virus transmission is less than unity. Sensitivity assessments of the model to changes in its parameters were explored, and safe regions at certain threshold values of the parameters are derived. Furthermore, the Differential Transform Method was used to solve the model equations, and it was observed that there is stability or increase in the number of individuals in the non-transmitting compartments with decrease in the number of individual in the transmitting compartments, which indicates that the population is moving towards the disease-free equilibrium. Also, numerical simulations of the overall system are implemented in MatLab for effective demonstration of the theoretical results.

Keywords: basic reproduction number, COVID-19, disease-free equilibrium, transmitting compartments, effective demonstration of the theoretical results.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A15: Coronavirus Disease: A mathematical Approach to Analyzing its Transmission Dynamics.

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Abstract

The novel Coronavirus Disease (also known as COVID-19) is a highly infectious disease caused by a severe acute respiratory syndrome (SARS-CoV-2) which poses a great risk to public health. In this research, a deterministic approach to mathematical modeling was used to develop a schematic diagram which shows the transmission dynamics of Covid-19, this was then translated into a system of ordinary differential equations comprising equations for susceptible individuals, exposed individuals, infectious individuals, individuals undergoing treatment and recovered individuals. The models validity and epidemiological significance was confirmed. Key metrics, including the epidemic indicator R0 are calculated using the next generation matrix approach and the equilibrium states are identified while the local and global stabilities of disease free equilibrium were investigated using Jacobean matrix approach and Castillo-Chavez criteria respectively. Using normalized forward sensitivity indices, sensitivity analysis was carried out to know the critical parameters influencing Covid-19 transmission. The discovery offers promising strategies in mitigating Covid-19 prevalence.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A16: Influencing Schistosomiasis Dynamics: The Role of Mass Drug Administration, Public Awareness, and Snail Control Efforts.

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Abstract

Schistosomiasis is a disease caused by parasitic flatworms known as schistosomes. Individuals become infected when they come into contact with freshwater contaminated with these parasites. Many people have limited knowledge about how the disease spreads and about mass drug adminis tration strategies. Additionally, some affected communities have not explored environmental modi fications to control the snail populations, which play a significant role in the disease's transmission. This research develops a mathematical model to examine the transmission dynamics of schistoso miasis in human and snail populations. The study examines the effects of mass drug administration, public health education, and snail control measures. It calculates the basic reproduction number and analyses the stability of equilibrium states over time. Additionally, a sensitivity analysis is con ducted to understand how variations in different model parameters impact the basic reproduction number. The numerical simulations are conducted to investigate how changes in parameters affect disease dynamics. The results provide valuable insights that can help decision-makers effectively control schistosomiasis.

Key words: Schistosomiasis, Bifurcation, Basic Reproduction Number, Stability Analysis, Sensitivity Analysis.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A17: THE INFLUENCE OF PUBLIC HEALTH EDUCATION AND BOOSTER DOSE VACCINATION ON THE DYNAMICS OF COVID-19 MODEL

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Abstract

A deterministic COVID-19-based model to deepen investigation and examine the impact of the interplay in the incorporation of saturated nonlinear incidence rate, nonlinear recovery rate, public enlightenment and booster vaccine was developed and analysed. The work proved the existence of Coronavirus-free and endemic equilibrium states. The expression for the effective reproduction number , was derived which was used to ascertain the local and the global asymptotic stability of coronavirus-free equilibrium using Jacobian stability technique and Lyapunov stability criterion respectively. Numerical simulations validated the analytical results and revealed that with vaccination and public enlightenment, coronavirus transmissions can be adequately contained in a society.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A18: Mathematical Modeling of the Effects of Optimized Drainage Systems on Mosquito Dynamics in Prevention of Malaria.

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Abstract

This study develops a six-compartment model combining human-mosquito dynamics with drainage systems, with focus on open drainages (D_o) and closed drainage (D_C). The study uses the Lagrange multiplier technique to optimize the drainage effort aimed at minimize malaria transmission. The analysis shows that effective drainage $_{ODO}+_{CDC} > 1$ stabilizes the mosquito-free state. The basic reproduction number R0 is derived and minimized via optimized drainage. An equal allocation of drainage effort $_{ODO} =_{CDC}$ is most effective. Sensitivity analysis confirms the roles of mosquito reproduction ρ_m and contact rate $beta_2$ in malaria persistence.

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A19: Understanding the Dynamics of Amebiasis Using Mathematical Modelling Approach: Optimal control Strategies and Cost-Effectiveness Analysis.

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Abstract

Amebiasis is a parasitic infection of the intestine caused by amoeba Entamoeba histolytica. It is endemic in tropical countries with poor sanitation and hygiene practices and spreads when a susceptible individual ingests cysts through food or water. It can also spread through fecal-oral means or anal sex, or oral and anal sex. A mathematical model that incorporates the treatment class in the human population and the concentration of amebiasis pathogen in the environment, to investigate the dynamics of amebiasis and effective control interventions is formulated. The steady states, stability and the basic reproduction number were computed. Global sensitivity analysis was conducted to determine most significant parameters responsible for the spread of the disease. Subsequently, optimal control model with four time-dependent controls namely; hygiene practices and awareness campaign, the effective and efficient screening of some infected humans, efficient and effective treatment, and disinfection/sterilization of the environment is formed. This was analyzed and simulated based on four categories (A-D) to investigate the impact of these controls. Thereafter, the cost-effectiveness analysis using incremental cost-effectiveness ratio (ICER) method was computed, in which the outcomes provide useful understanding that will assist the policy makers to effective and efficiently control the disease with limited available resources.

Keywords: Amebiasis, mathematical model, global sensitivity analysis, optimal control, cost-effectiveness analysis

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

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

[1]Tertsegha Tivde, [1]Christopher Zamber & [2]Nguavese Tertsegha Tivde

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.

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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 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

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 Ro, 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 sjort and long term dybamics of the disease wirhin 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 F2. 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.

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

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 F2. 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.

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A28: A Deterministic Model to Assess the Influence of *Wolbachia* in Controlling the Transmission Dynamics of Dengue Fever.

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Abstract

In this work, a deterministic model to assess the influence of *Wolbachia* in controlling the transmission dynamics of dengue fever was formulated. The model involves two populations; the human population N_h which is further subdivided into six compartments and the vector population N_v which is further subdivided into five compartments, three of which are non-Wolbachia (wild) mosquito and two compartments of Wolbachia mosquito. The research work established and analyzed two equilibria states: the Disease Free Equilibrium (DFE) and the Endemic Equilibrium (EE). The effective reproduction number R_c for the model was computed and the result generated shows Locally Asymptotically Stable (LAS) at disease free equilibrium when $R_c < 1$ as well as Globally Asymptotically Stable (GAS) when $R_c \leq 1$ at dengue free equilibrium and otherwise unstable whenever $R_c > 1$. Preliminary numerical simulations were made using Maple 16 software and some results were analyzed graphically.

Keywords: Dengue, Wolbachia, population, equilibria, stability.

MSC Classification: Biomathematics (Mathematical Epidemiology) .

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

A29: A Deterministic Model of Dengue Fever Transmission Dynamics with Mild and Severe Compartments Incorporating the Impact of Booster Vaccine.

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Abstract

In this work, a deterministic model of dengue fever transmission dynamics with mild and severe compartments was formulated, incorporating the impact of booster vaccine. The model considered the human population N_h and the vector population N_v, which were further subdivided into eight classes. The model possesses two equilibria states: the Disease Free Equilibrium (DFE) and the Endemic Equilibrium (EE), which were obtained and analyzed for stability. The effective reproduction number R_c for the model was computed and the result

shows Locally Asymptotically Stable (LAS) when $R_c < 1$ and Globally Asymptotically Stable (GAS) when $R_c \leq 1$ at dengue free equilibrium, otherwise unstable whenever $R_c > 1$. Preliminary numerical simulations were made using Maple 16 software and some results were analyzed graphically.

Keywords: Dengue, basic reproduction number, vaccine, equilibria, stability.

MSC Classification: Biomathematics (Mathematical Epidemiology) .

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

B: Non Epidemiological and Fluid Dynamics models and other applied Mathematics

B1: Temporal Transferability of Land Cover–Bird Abundance Models: Insights from Long-Term Survey Data

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Abstract

Assessing the durability of ecological models over time is crucial for reliable biodiversity forecasting and sustainable management of natural systems. This study investigates the temporal transferability of bird abundance models built from land cover variables, using data from the U.S. Breeding Bird Survey and land classifications provided by the USGS National Land Cover Database (NLCD). For each of 42 bird species, negative binomial generalized linear models were trained on 2001 abundance data using 14 land cover types measured at six spatial scales (ranging from 200 to 3000 meters). An exhaustive model selection process using AIC produced over 3,000 candidate models per species. Land cover models outperformed null models for 28 species in both the training and test sets, with gains in predictive accuracy ranging between 3Model performance showed little variation across the test years (2004–2019), indicating strong temporal generalizability. Some species, such as the American Robin and Least Flycatcher, maintained consistently low prediction errors across years, whereas others, including the Sora and Bald Eagle, exhibited persistently poor model fit. These results highlight the need to assess predictive stability when applying ecological models for biodiversity monitoring.

Keywords: Ecological modelling, Land cover, Bird abundance, Temporal transferability, Ecological Prediction

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

NKUTURUM C. and OLAWUYI O. M.

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 amplitudeas 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 beta1, beta2, beta3 and beta4 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$_x, E_y), foundationproperties(K_0, G_0), andribthickness(h).Resultsshowsy$
$relatedcalcificationorincreasedribcomplianceinosteoporoticsubjects.Thesefindingsholdpracticalvalueforbiomedicalengin$
$protectiongeardesign, surgicalplanning, andimplantdevelopment, offeringinsightsintoribmechanicalbehaviorunderphysi$

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

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

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

Paper read at the 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

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 an 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 8th International Workshop and Conference of the Nigerian Society for Mathematical Biology (NSMB) held at the University of Benin, Benin City 10 - 16 August 2025

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 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 to together with the flow rate from to 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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B11: ON THE MATHEMATICAL STUDY OF STEADY BLOOD FLOW IN THE STRAIGHT PART OF MAXILLARY ARTERY

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Abstract

This project presents a novel and simple mathematical model of blood flow. Assuming blood is a Newtonian fluid which is governed by the Navier-Stokes equations together with continuity. This led to the formulation of blood flow model called the circulatory system equation. The logical assumptions on the blood flow dynamics model were applied yielding the general mathematical model of the normal blood flow rate in the straight part of the maxillary artery. The circulatory system equation was also used to develop a model for blood pressure using Poiseuille's equation. These two models are then analyzed against surface, pressure gradient and the vessel39;s length with the help of MATLAB.

Keywords: Mathematical model, blood flow, Navier-Stokes, Poiseuille, Newtonian.

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B12: SHALLOW WATER FLOW MODEL AND ITS IMPACT ON THE MAKURDI AXIS OF THE UPPER BENUE TROUGH

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Abstract

The work examined shallow water flow model and its impact on the Benue Trough by formulating a shallow water flow model which was solved using the Lax-Wendroff and Homotopy Perturbation Methods. The model was analysed and reduced to a family of ordinary differential equations whose solutions were characteristic curves. Both the flow velocity and pressure variation in the flow were considered. The model, considered water as an incompressible fluid: the flow as non-steady and uniform. We derived an equation for the nonuniform bottom topography (flow depth) and substituted into the governing equation for shallow water flow with nonuniform bottom topography. The results were simulated and we found out that, the higher depth, the lower the pressure within the flow and the lower the velocity and the higher the pressure, because there is going to be a pressure build-up under this condition. We also found that the higher the flow height (H) the higher the pressure. The study inferred that the flow in the region was super-critical at the region.

Keywords: Shallow water, mathematical model, Benue, Trough, flow depth, Lax-Wendroff and Homotopy, Perturbation

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B13: Mathematical Modelling of Microbial–Nutrient Kinetics in Biochar-Amended Soils for Sustainable Agricultural Development in Nigeria

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Abstract

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This study formulated a mathematical model describing the temporal interplay between microbial biomass, soil organic carbon, nitrogen, phosphorus, biochar levels, available nutrients, and crop yield. The model uses Monod-type kinetics to describe microbial growth, modified by the presence of biochar. Nutrient uptake is coupled to microbial growth, while soil health is modeled as a cumulative function of microbial activity, biochar content, and nutrient availability. Sensitivity analysis of the model was accessed using both the Morris and Sobol methods to identify key parameters influencing crop yield. The Morris method revealed that microbial carrying capacity and crop growth efficiency exert direct effects on yield, as indicated by high mean elementary effects . Meanwhile, the Sobol analysis confirmed as the most influential parameter via its high first-order index , while the total-order index highlighted and crop decay rate as critical drivers through their interaction effects . The convergence of both methods on as the primary determinant reinforces its central role in regulating microbial biomass and productivity. Discrepancies, such as low but high , underscore the importance of considering parameter interactions. These findings demonstrate the value of integrating elementary effect and variance-based methods to enhance model simplification and inform targeted agricultural decision-making. **Keywords:** Biochar, Morris Screening Method, Sobol Variance-Based Method, Crop Yield.

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B14: Computational Analysis of Magnetohydrodynamic (MHD) Nanofluid Flow and Heat Transfer using the Finite Volume Method.

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Abstract

This study presents a numerical investigation of unsteady magnetohydrodynamic (MHD) nanofluid flow with coupled heat and mass transfer over a vertical surface. The physical model incorporates the effects of Brownian motion, thermophoresis, and an applied transverse magnetic field. Governing equations for mass, momentum, energy, and nanoparticle concentration are formulated using nanofluid-specific thermophysical properties and transformed into a dimensionless form. The resulting system of nonlinear partial differential equations is discretized using an explicit finite volume method, employing a combination of upwind and central-difference schemes. Generalized algebraic expressions are developed for the velocity, temperature, and concentration fields. The numerical scheme conserves mass, momentum, and energy, and is implemented under appropriate initial and boundary conditions. Parametric effects of key non-dimensional numbers including the Hartmann number, Prandtl number, Eckert number, and thermophoresis parameter are systematically examined to characterize their influence on flow and transport behaviour. It is found that higher value of nanoparticle volume fraction parameter improves thermal conductivity, enhancing heat dissipation and reducing wall temperatures. While increasing the Eckert number strengthens viscous dissipation effects, leading to accelerated flow in the boundary layer region of Cu–water nanofluids. These results are useful in the area of thermal flow behaviour of magnetic nanomaterials, as the current simulations are applicable to chemical and metallurgical processing industries.

Keywords: Nanofluid, Heat and Mass Transfer, Magnetohydrodynamics, Numerical Simulation, Finite Volume Method.

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B15: SIMULATING CURRENT DENSITY AND HEAT DISTRIBUTION OF MAGNETO- VISCOELASTIC HYBRIDIZED NANOFLUIDS SOLAR ENERGY ABSORBER: A PEROVSKITE-CONCENTRATED SOLAR POWER REVIEW

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Abstract

The rising demand for industrial expansion and optimization of energy and cost has stimulated this study to consider practical usages of solar radiation and nanomaterials. The functional properties of a hybridized nanomaterial offer high applications in nanotechnology advancement and efficient industrial output. This study, which will examine the dynamic of nonlinear solar radiation absorbers, thermal dissipation of magneto-viscoelastic hybridized nanomaterials and current density for perovskite concentrated solar power, is a truly interdisciplinary endeavour, drawing on principles from physics, engineering, and material sciences. A mathematical model for the viscoelastic nanocomposite materials will be formulated and non-dimensionalized to portray physical applications in engineering and industry. The available work destruction that affects the effectiveness of technology devices and industrial engines or machines will be investigated and reported. Also, the wall shear stress friction and wall temperature gradient that assist the engineers in accurately predicting their activities and developing technological equipment will be examined. All these investigations are essential to improve the efficiency of hybrid nanomaterials for the optimization of perovskite-concentrated solar power and its industrial and technological usage. A particular mathematical software or package (Maple) will be used for the analysis. A perovskite-concentrated solar power works in the presence of or without sunlight. Findings from the study shall be reported in tables, graphs and pictures.

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Abstract
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B16: A MATHEMATICAL APPROACH ON THE DYNAMICS OF KIDNAPPING WITH APPREHENDED KIDNAPPERS

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Abstract

In this work, we develop a mathematical model on kidnapping by incorporating the concept of apprehended kidnappers in a system of ordinary differential equations describing the evolution and propagation of kidnapping as a crime in human society. It accounts for the interaction between kidnappers and vulnerable humans leading to their abduction for the main purpose of ransom payment. We establish the crime propagation number, CP_N, in which a $CP_N < 1$ guarantees a kidnaping free state. The analysis and the numerical simulations of the model suggests that, increasing the apprehension rate of kidnappers by Security agents is a better and more effective way of ensuring a kidnapping free society.

Keyword: Kidnapping, Quick-money, Apprehension, Crime Propagation Number, Terrorism.

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C: Differential Equations Operator Theory and other pure mathematics

C1: THE CONCEPT OF DIFFERENTIATION AND INTEGRATION OF PARALETRIX, A GENERALIZATION OF RHOTRIX.

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Abstract

The idea of matrix-tertions and matrix- noittrets was discussed by many authors, where the objective was to offer exercises in mathematical enrichment with objects that are in some ways between two-dimensional vectors and two by two –dimensional matrices. This was followed by the idea of rhotrices proposed by many authors, looking at objects that are in some ways between two by two and three by three-dimensional matrices. Heart oriented and row –column multiplications of rhotrices with equal number of rows and columns are well known and a number of results based on these multiplications were also established. With the existence of rectangular and square matrices, a structure called paraletrix was introduced, which is a generalization of rhotrix whose number of rows and columns are not necessarily the same. In this paper, we introduced the concept of differentiation and integration of paraletrix with respect to an independent variable that is present in a function.

Keywords: Paraletrix, Rhotrix, Differentiation and Integration.

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C2: On the robust stability analysis for nonlinear impulsive Caputo fractional order derivative with weakly singular kernel

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Abstract

This paper examines the stability of the trivial solution for a nonlinear Impulsive Caputo fractional order derivative using the vector Lyapunov functions which is generalized by a class of piecewise continuous Lyapunov functions. Together with comparison results, sufficient conditions for the stability of the trivial solution for the impulsive fractional order systems are presented. Example given extends and improves on the existing results.

Key words: Stability, Caputo derivative, impulse, vector Lyapunov functions, fractional derivatives, singular kernel.

MSC: 34A08; 34A12; 34A37; 34D20

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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.

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D: statistic, computer science and other Sciences

D1: IMPACT OF EXPERIMENTAL TIME OF MANGROVE FOREST RELATIVE ABUNDANCE IN THE ABSENCE OF ARTISANAL HYDROCARBON EFFECT

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Abstract

An impact study of experimental time of mangrove forest relative abundance in the absence of artisanal hydrocarbon effect has been investigated. The analytical solutions of tree growth models were derived and used to predict the impact of experimental time of mangrove forest relative abundance through computational method using MATLAB ODE45.Three different mangrove sites in the Niger delta and considered as natural mangrove forest vegetation sites in the absence of artisanal hydrocarbon. It is observed that on the based day of our experimental time called the initial condition, the relative abundance of the three sites was recorded as 0.01 units, same values each. Furthermore, from the tenth month up to the one hundred and twentieth month, the data base result shows a monotonic increasing pattern in the relative abundance of the three coordinates as 0.0246 units on the tenth month to a saturating value of 0.2427 units on the one hundred and twentieth months. These observations show a strong increase in the numerical strength of the relative abundance of the second coordinate followed by the first coordinate with a slow increase in numerical strength and a strong increase pattern in the third coordinate which converges earlier to its saturated value.

Keywords: Relative abundance, artisanal hydrocarbon, experimental time, computational method, mangrove forest.

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D2: APPLICATION OF SENSITIVITY ANALYSIS TO A LINEAR PROGRAMMING PROFIT OPTIMIZATION OF A BAKERY COMPANY

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Abstract

Linear programming is an optimization technique used to allocate limited resources to production services in order to make an optimal profit and at the same time achieve some other peculiar goals. In linear programming, a real life problem is formulated as mathematical model which comprises an objective function subject to linear inequality or equality constraints. The objective function marks the target to be achieved while the constraints are the limiting factors to such achievement. The objective of this study is to carry out a sensitivity analysis on a linear programming profit optimization of a bakery company. This company produces four sizes of cake, of which the sizes are denoted by X1, X2, X3 and X4. The data used for this study were collected on the profit that is being made from each size of the cake, the various measurements of the needed resources and the quantity of each resource available in the store for each size of the cake. The profits made from the various cake sizes form the objective function coefficients; the measurements of the various resources for the different sizes of the cake form the coefficients of the variables in the constraint equations while the total available resource quantities form the right hand sides (RHS) of the constraint equations. The resultant linear programming problem was solved using simplex algorithm so as to know the various quantities of the cake sizes that should be produced so as to make a maximum profit. A sensitivity analysis was carried out to know how the optimal solution changes due to any possible changes in the cost coefficients of the objective function and the resource constraints.

Keywords: Linear Programming, Bakery Company, Objective function, Maximum profit, Resource constraints and Optimal solution.

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D3: FAE'S INDEXED NUMBERS' CONCEPT'S APPROACH TO SOLVING EXISTING INDICES' PROBLEMS

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Abstract

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Globally, many concepts have been introduced and applied in various fields of endeavor which seem familiar and known. One notices that even though these introduced concepts are familiar and known by people all over the world, the easy applications to make learning and achievable is not available within or among learners and teachers/tutors and learners today. This FAEI's Indexed Numbers' Concepts entail methods that would help mathematics and/or science inclined students and teachers/tutors to conquer such goliath or mountain-like challenge(s) by simply applying patterns or procedures which will be enumerated hereafter.

Keywords: Index (indices), Indexed numbers, FAE's Indexed Numbers' Concepts, Positive next immediate indexed i number, Negative next immediate indexed i number, Addition for next immediate indexed i number and Subtraction for next immediate indexed i number.

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