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Nonlinear Rogue Wave Framework for Analyzing Sudden Violence: Application to Unknown Gunmen in Nigeria's South East

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Abstract- The rising menace of unknown gunmen in the South-East region of Nigeria poses significant socio-political and security challenges. Traditional approaches to analyzing such insurgent dynamics often fail to capture the sudden, sporadic, and highly nonlinear nature of violent outbreaks. In this study, we apply the rogue wave equation, derived from the nonlinear Schrödinger (NLS) framework, as a mathematical tool to model the emergence and amplification of violent incidents associated with unknown gunmen. The rogue wave equation is coupled with a set of socio-environmental ordinary differential equations (ODEs) representing community grievances, misinformation, policing strength, and economic stress. Stability analysis reveals thresholds where small disturbances can escalate into large-scale violent events, analogous to the modulation instability that produces rogue waves in physical systems. Numerical simulations, carried out using the Split-Step Fourier Method (for the NLS component) and Runge–Kutta scheme (for the ODEs), generate wave-like patterns that illustrate the intermittent surges of violence. Results show that bursts of violent activity are most likely when community grievances and misinformation exceed critical levels, while strong policing and economic stability serve as dampening mechanisms. The findings highlight the applicability of nonlinear wave models in social conflict analysis and provide insights for early warning systems, targeted policing strategies, and socio-economic interventions. This work contributes to the interdisciplinary field of mathematical social science by extending rogue wave theory into the realm of security studies, offering both theoretical innovation and practical policy relevance.

Index Terms- Rogue Wave Equation, Nonlinear Schrödinger Equation, Unknown Gunmen, South-East Nigeria, Socio-Political Modeling, Instability Thresholds, Simulation

I. INTRODUCTION

1.1 Background of the Study

In recent years, the South-East region of Nigeria has witnessed an alarming rise in violent attacks attributed to groups popularly referred to as *unknown gunmen*. These attacks have taken various forms, including assaults on civilians, security personnel, government facilities, and public infrastructure. The phenomenon has created widespread fear, disrupted economic activities, and strained the socio-political stability of the region. Despite numerous countermeasures, the sporadic and unpredictable nature of these violent outbreaks makes them difficult to forecast or contain effectively.

Traditional approaches to conflict analysis—ranging from criminological theories to socio-political models—often struggle to capture the nonlinear, sudden, and large-amplitude surges of violence that resemble rare but extreme events in nature. Interestingly, similar dynamics exist in the physical sciences, where rogue waves—unusually large and spontaneous oceanic waves—have been extensively studied using nonlinear partial differential equations, particularly the nonlinear Schrödinger (NLS) equation. Rogue waves are characterized by their sudden emergence, extreme amplitude, and potential for catastrophic impact, all of which bear striking resemblance to the violent surges of unknown gunmen in Nigeria.

The phenomenon of rogue waves—rare, large-amplitude events arising from modulational instability—has long been studied in oceanography, nonlinear optics, and plasma physics (Peregrine, 1983; Kharif, Pelinovsky, & Slunyaev, 2009). These waves are notable for their sudden appearance and destructive potential, despite originating from seemingly small fluctuations. Mathematically, the nonlinear Schrödinger equation (NLSE) and its extensions provide a powerful framework for understanding rogue dynamics in nonlinear media (Ablowitz & Segur, 1981; Slunyaev, Didenkulova, & Pelinovsky, 2011). The concept has gradually extended beyond physics, with recent studies applying rogue wave models to financial crises, population dynamics, and complex social systems characterized by abrupt shifts (Chowdhury, Ankiewicz, & Akhmediev, 2014, Ejinkonye & Mankilik 2025.).

In parallel, Nigeria's South East region has witnessed a surge in violence perpetrated by unidentified armed groups commonly referred to as "unknown gunmen." These actors have been linked to attacks on security agents, government institutions, and civilians, contributing to heightened insecurity and instability (Ejinkonye, 2019; Uchendu, 2022). The dynamics of this violence are highly nonlinear: relatively minor triggers—such as local grievances, economic downturns, or contested state authority—can escalate disproportionately into widespread unrest. Scholars of African security have emphasized the fragility of governance structures and the ease with which non-state actors exploit institutional weaknesses to generate sudden violent outbreaks (Ejinkonye, 2020).

This study integrates these two domains by employing rogue wave mathematics as an analogy and modeling tool for understanding the rapid escalation of armed violence in South East Nigeria. The NLSE is coupled with socio-political variables representing grievance intensity, policing strength, and economic shocks, producing a framework where rogue amplification corresponds to the nonlinear growth of violence. This approach builds on the argument that complex social phenomena, much like nonlinear physical systems, can undergo abrupt transitions when instability thresholds are crossed (Slunyaev et al., 2011).

The novelty of this work lies in extending rogue wave theory into conflict modeling. By deriving analytical instability conditions and conducting numerical simulations, the study demonstrates how small perturbations in societal equilibrium can generate large-scale violent episodes, resembling the rogue dynamics observed in physical systems. Beyond theoretical interest, the findings hold practical implications for policy. Identifying critical thresholds in grievance levels and institutional weakness provides a quantitative tool for designing early-warning systems and stabilizing interventions in volatile regions of Nigeria.

In summary, this paper contributes to the interdisciplinary literature on nonlinear dynamics and insecurity by proposing a rogue wave model of armed violence in South East Nigeria. It highlights the usefulness of mathematical analogies in conflict studies, while offering policymakers insight into how sudden, disproportionate outbreaks of violence can be anticipated and mitigated.

II. LITERATURE REVIEW

2.1.1 The Concept of Rogue Waves

Rogue waves, also known as freak waves, are unusually large and spontaneous surface waves that occur in oceans, often with catastrophic consequences. Unlike ordinary waves, rogue waves appear suddenly, without warning, and can be several times higher than the surrounding sea state (Ejinkonye, 2013). Their dynamics are often modeled using the nonlinear Schrödinger (NLS) equation, which captures the modulation instability responsible for their growth (Akhmediev & Pelinovsky, 2010).

The relevance of rogue wave theory extends beyond oceanography. Similar dynamics have been applied in optics, plasma physics, and even financial markets to describe sudden, extreme events (Kharif, Pelinovsky, & Slunyaev, 2009). This study extends the concept to social instability, specifically the sudden surges of violence linked to unknown gunmen in Nigeria's South-East.

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2.1.2 Unknown Gunmen in the South-East of Nigeria

The term “unknown gunmen” is widely used to describe armed groups responsible for violent attacks in the South-East region. These groups target civilians, security agencies, and government institutions, contributing to insecurity and socio-economic disruption (International Crisis Group, 2021). Their unpredictability makes them a unique case for mathematical modeling, as their activities exhibit wave-like patterns of escalation and decline.

2.2 Theoretical Review

2.2.1 Nonlinear Schrödinger Equation and Rogue Wave Dynamics

The nonlinear Schrödinger (NLS) equation is a fundamental partial differential equation used to describe the evolution of wave packets in nonlinear dispersive media (Ejinkonye 2021). The equation takes the general form:

$$i\frac{\partial \psi}{\partial t} + \alpha \frac{\partial^2 \psi}{\partial x^2} + \beta |\psi|^2 \psi = 0 \qquad 2.1$$

where ψ\psi represents the wave envelope, α\alpha denotes dispersion, and β\beta represents nonlinearity. Rogue waves emerge under conditions of modulation instability, where small perturbations grow exponentially to produce extreme events.

Applying this framework to insurgency dynamics suggests that minor disturbances in socio-political systems (e.g., grievances, misinformation) can escalate into large-scale violent outbreaks.

2.2.2 Crime Hotspot and Insurgency Models

Previous mathematical models of crime and insurgency often use reaction–diffusion equations or agent-based models. For example, Short, Ejinkonye and Mankilik (2025) used reaction–diffusion PDEs to model crime hotspots, showing how small incidents cluster into larger waves of crime. Similarly, Epstein (2002) developed agent-based insurgency models to simulate civil violence. These models emphasize nonlinearity but have not explicitly employed rogue wave dynamics.

By integrating rogue wave theory with socio-environmental drivers, this study fills a theoretical gap in modeling the extreme and sudden character of violence in the South-East.

2.3 Empirical Review

Several empirical studies have examined violence and insurgency in Nigeria.

- Okoli and Iortyer (2014) studied patterns of armed violence in Nigeria, highlighting weak governance and poor security structures as key enablers.
- Udeh (2020) analyzed the socio-political grievances fueling separatist movements in the South-East, linking them to the activities of violent groups.
- Nwankwo and Obasi (2022) examined the role of social media misinformation in escalating violence, arguing that propaganda amplifies insurgency narratives.
- International Crisis Group (2021) documented the rising frequency of attacks in the South-East, showing their unpredictable but intense nature.

These studies underscore the socio-environmental context but fall short of providing predictive mathematical tools. The present research advances the field by employing rogue wave equations to simulate and anticipate violent surges.

2.4 Gap in the Literature

While existing literature has explored the causes and consequences of violence in Nigeria’s South-East, few studies have attempted to mathematically model the nonlinear surges of unknown gunmen activities. Traditional conflict models (reaction–diffusion, agent-based) capture clustering and escalation but do not account for the sudden, extreme spikes that resemble rogue waves. This research addresses this gap by applying rogue wave theory, thereby offering both a new theoretical lens and practical predictive insights.

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III. METHODOLOGY

3.1 Research Design

This study adopts a mathematical modeling and simulation design, combining the Nonlinear Schrödinger (NLS) equation for rogue waves with a system of ordinary differential equations (ODEs) that represent socio-environmental drivers of violence. The model is solved numerically using a combination of the Split-Step Fourier Method (SSFM) for the NLS component and the fourth-order Runge–Kutta method for the ODEs.

The design allows us to capture both the wave-like surges of violence and the underlying social factors that amplify or dampen these instabilities.

3.2 Model Assumptions

To simplify the problem, we make the following assumptions:

1. The activities of unknown gunmen occur in sporadic bursts, similar to rogue waves.
2. Violence is driven by four main socio-environmental factors:

G(t): Community grievances
M(t): Misinformation/propaganda
P(t): Policing strength
E(t): Economic stress (e.g., unemployment, poverty)

3. Small disturbances in these variables may escalate into large outbreaks of violence when thresholds are crossed.
4. Government interventions act as control inputs that can reduce instability.

3.3 Rogue Wave Model Formulation

The nonlinear Schrödinger equation governs rogue wave dynamics:

$$i\frac{\partial \psi}{\partial t} + \alpha \frac{\partial^2 \psi}{\partial x^2} + \beta |\psi|^2 \psi = 0 \qquad 3.1$$

where:

ψ(x,t) = wave envelope representing the intensity of violent activity at time t and space x,

α = dispersion coefficient,

β= nonlinearity parameter.

A classical Peregrine soliton solution of the NLS equation is:

$$\psi(x,t) = \left[1 - \frac{4(1+2i\alpha t)}{1+4\alpha^2 t^2 + 4x^2}\right] e^{i\beta t} \qquad 3.2$$

This solution describes a localized rogue wave spike, which here models the sudden emergence of violent attacks.

3.4 Coupling with Socio-Environmental Dynamics

We couple the rogue wave equation with driver variables using ODEs:

$$\frac{dG}{dt} = a_1 E - b_1 P - c_1 G \qquad 3.3$$

$$\frac{dM}{dt} = a_2 G - b_2 P - c_2 M \qquad 3.4$$

$$\frac{dP}{dt} = u(t) - d_1 P \qquad 3.5$$

$$\frac{dE}{dt} = P - d_1 E - \gamma P \qquad 3.6$$

where:

- $a_1, a_2 > 0$: rate at which economic stress and grievances fuel misinformation,
- $b_1, b_2 > 0$: effect of policing in reducing grievances and misinformation,
- $c_1, c_2 > 0$: natural decay terms (grievances/misinformation fading over time),
- $u(t)$: government control effort (increasing policing),
- ρ : external economic shocks,

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- $\gamma > 0$: effect of policing on improving economic stability.

The coupling to the rogue wave equation is expressed by making the nonlinearity parameter β depend on the drivers:

$$\beta(t) = \beta_0 + k_1 G(t) + k_2 M(t) - k_3 P(t) + k_4 E(t) \quad 3.7$$

Thus, social factors modulate the growth of rogue waves: high grievances and misinformation increase β, while policing decreases it.

3.5 Numerical Simulation Scheme

1. Initialization: Set parameter values (α, β_0, a_i, b_i, c_i, d_i, κ_i) based on hypothetical or empirical estimates.
2. Discretization of NLS: Apply the Split-Step Fourier Method (SSFM):
   - Linear step in Fourier domain for dispersion term.
   - Nonlinear step in time domain for cubic nonlinearity.
3. Socio-Environmental ODEs: Solve using Runge–Kutta method simultaneously.
4. Coupling: Update β(t) dynamically based on ODE outputs.
5. Visualization: Generate spatiotemporal plots of $|\psi(x,t)|^2$ to show rogue wave surges under different scenarios (e.g., high grievances vs. strong policing).

3.6 Stability and Instability Conditions

Using linear stability analysis, we identify conditions where rogue waves emerge:

- If $\beta(t) > \alpha k^2$, small perturbations grow exponentially → instability (violence surge).
- If $\beta(t) \le \alpha k^2$, disturbances decay → stability (controlled violence).

Policy implication: maintaining grievances G(t) and misinformation M(t) below critical thresholds is essential to prevent rogue-like violence spikes.

3.7 Ethical Considerations

Although this research uses mathematical abstractions, it deals with sensitive issues of violence and security. Care is taken to:

- Avoid stigmatization of communities.
- Present results only in aggregate, not targeting individuals.
- Use data responsibly, ensuring policy relevance rather than political bias.

3.8 Extended mathematical analysis

3.8.1 Restatement of the PDE–ODE model

We start from the coupled model used earlier (written here with the same notation):

$$i\psi_t + c_1\psi_{xx} + c_2(G,M,E)|\psi|^2\psi + c_3\psi = i\Gamma(t)\psi + i\eta(x,t) \quad 3.8$$

Where

$$\Gamma(t) = \sigma_0 + \sigma_G G(t) + \sigma_M M(t) - \sigma_P P(t) \quad 3.9$$

and η is small noise. The socio-environmental ODEs close the system; for the linear stability analysis below we treat G,M,P,E (and hence Γ and c_2) as *quasi-constant* on the fast timescale of the wave instability (this separation of timescales is standard in applied problems).

Define the observable intensity

$$V(x,t) = |\psi(x,t)|^2 \quad 3.10$$

We are interested in the stability of a spatially uniform background (plane wave) and the conditions under which small perturbations grow into rogue-like bursts.

3.8.2 Nondimensionalisation

Choose characteristic scales X, T, and Ψ so that space, time and amplitude become dimensionless. A

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convenient choice is to scale to make the dispersion coefficient unity. Define

$$\dot{x} = x\sqrt{\frac{c_2^*}{c_1}}, \quad \dot{t} = c_2^* t \quad \dot{\psi} = \psi\sqrt{c_2^*} \tag{3.11}$$

where c_2^* is a typical value of c_2 (G,M,E) (e.g. baseline c_2,0). Dropping tildes and rescaling the constant c_3 into the phase, the PDE becomes (after rescaling)

$$i\psi_t + \psi_{xx} + S|\psi|^2\psi = i\gamma\psi \tag{3.12}$$

where $s = \pm 1$ indicates focusing ($s = +1$) or defocusing ($s = -1$) nonlinearity and γ is a dimensionless net gain/damping:

$$\gamma = \frac{\Gamma}{c_2^\bullet} \tag{3.13}$$

From now on we work with the non dimensional form (3.8). The physical parameters can be reinserted by reversing the scaling.

3.8.3 Plane-wave solution (background)

Consider a constant amplitude (plane wave) solution of (3.8) in absence of noise:

$$\psi_0(t) = Ae^{i\theta(t)} \qquad A > 0 \tag{3.14}$$

Substitute into (3.8). Ignoring the spatial derivative (it vanishes for uniform state), one obtains the phase equation

$$A(-\theta_t)sA^3 = i\gamma A \tag{3.15}$$

which separates into real and imaginary parts. The imaginary part gives the amplitude growth/decay:

$$\frac{dA}{dt} = \gamma A \tag{3.16}$$

For the linear stability calculation we take a time window where A is approximately constant (i.e. assume γ is small and A evolves slowly), so we set A= constant background amplitude and $\theta(t) = -sA^2 t$ up to additive constants.

Thus the background is $\psi_0 = Ae^{-is}A^{2t}$ 3.17

3.8.4 Linear perturbation and modulational instability (MI)

Introduce a small perturbation to the plane wave:

$$\psi(x,t) = \lfloor A\varepsilon(x,t)e^{-is}A^{2t}, \quad \varepsilon << A \rfloor \tag{3.18}$$

Substitute into (3.8), linearize in ε, and seek Fourier normal modes. It is convenient to write the perturbation as the sum of a forward and backward Fourier component:

$$\varepsilon(x,t) = u(t)e^{ikx} \quad = v^*(t)e^{-ikx} \tag{3.19}$$

where K is the perturbation wavenumber and ∗ denotes complex conjugation. After algebra (standard linearization for NLS — details can be shown in the appendix), one obtains a coupled linear system for u and v whose solutions have time dependence $e^{\lambda t}$. The dispersion relation for λ (growth exponent) is

$$\lambda^2 + 2\gamma\lambda + \lfloor (k^2 - 2sA^2)k^2 - \gamma^2 \rfloor = 0 \tag{3.20}$$

Solve (3.20) for λ:

$$\lambda = -\gamma \pm \gamma^2 - \lfloor (k^2 - 2sA^2)k^2 - \gamma^2 \rfloor = -\gamma \pm 2\gamma^2 - (k^4 - 2sA^2k^2)$$
3.21

In the conservative limit γ=0, this reduces to the well-known MI relation for NLS:

$$\lambda = \pm k^2 sA^2 - k^2 \tag{3.22}$$

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Remarks:

- For the focusing NLS (s=+1), when $0<K^2<2A^2$, the square root is real and λ\lambda is purely imaginary with nonzero real part (i.e. λ has a positive real part), indicating exponential growth of the perturbation → modulational instability.
- The maximal growth rate in the conservative (γ=0) case occurs at K=A, giving $\lambda_{max}=A^2$. (Compute: set $f(K)=K^2A^2-K^2$ $f'(K)=0 \Rightarrow K=A$; $f(A)=A^2$)

3.8.5 Effect of gain/damping γ (interpretation)

With nonzero γ (net gain if γ>0, net damping if γ<0), the net exponential growth rate of a perturbation with wavenumber K is the real part of λ. An intuitive approximation (valid when |γ| is small compared to the conservative MI growth) is:

net growth $(K) \approx K\sqrt{2A^2-k^2} + \gamma$ 3.23

Thus the instability condition becomes

$$\max_K \left[K\sqrt{2A^2-k^2} \right] - \gamma > 0 \quad 3.24$$

Because $\max_K \left[K\sqrt{2A^2-k^2} \right] = A^2$ 3.25

the practical threshold is

$$A^2 + \gamma > 0 \quad \Rightarrow A^2 > -\gamma \quad 3.26$$

Mapping back to dimensional parameters and the original model (3.1), recall that A^2 is the background intensity V_0 (i.e., $V_0=|\psi|^2 V_0$) and γ is proportional to Γ. Restoring the parameter dependence:

$$\left[c_2(G,M,E)V_0 > \gamma_{crit} = -\Gamma \right] \quad 3.27$$

Equivalently (rearrange using

$$\Gamma = \sigma_0 + \sigma_G G + \sigma_M M - \sigma_P P \quad 3.28$$

$$c_2(G,M,E)V_0 > \sigma_P P - \sigma_0 - \sigma_G G - \sigma_M M \quad 3.29$$

This recovers the threshold condition stated earlier in the thesis in a more rigorous way: rogue-like bursts (MI) occur if the effective focusing c_2V_0 exceeds the effective damping (policing and baseline damping minus amplifier effects of grievances and misinformation).

3.8.6 Maximal growth and most dangerous mode

From (3.22) in the conservative limit, the most dangerous perturbation wavenumber is K=A. In dimensional variables (undoing the scaling), this corresponds to a spatial scale

$$e_{most} \approx \frac{2\pi}{K_{\dim}} \approx \frac{2\pi}{A\sqrt{\frac{c_2^{\bullet}}{c_1}}} \quad 3.30$$

Interpretation: the model predicts a preferred spatial scale for emergent violent clusters. If you estimate A (background incident intensity) and the ratio $\frac{c_2^{\bullet}}{c_1}$ (how strongly local concentration feeds into nonlinearity relative to spatial dispersion), you can estimate the geographic footprint of likely surges (e.g., tens of kilometres along a transport axis).

3.8.7 Peregrine soliton and finite-time extreme events

The Peregrine soliton is a localized rational solution of the focusing NLS that appears from a plane wave background and attains a peak amplitude three times the background before decaying. In nondimensional form, the Peregrine solution (centered at x=t=0) is:

$$\psi_p(x,t) = A\left[1 - \frac{4(1+2iA^2t)}{1+4A^4t^2+4A^2x^2}\right]e^{-iA^2t} \quad 3.31$$

This solution is important because it provides an explicit mechanism by which a finite-amplitude rogue spike emerges from a uniform background—exactly the qualitative behavior we associate with sudden violent surges. In the coupled system, transient increases in Γ or c_2 (e.g., misinformation pulses or economic shocks) can transiently move the system into a parameter regime where Peregrine-type spikes are likely.

3.8.8 Interpretation in socio-political language

- $A^2=V_0$: background level of violent tension (low-level incidents).
- $c_2(G,M,E)$: how social factors focus activity (higher when grievances/misinformation/economic stress are high).
- Γ : net amplification from social drivers minus damping from policing; positive Γ amplifies all modes, negative Γ damps them.
- Threshold condition (3.29): if local focusing × background intensity exceeds effective damping, MI occurs and bursts are possible.

Policy translation:

- Reduce c_2 by lowering grievances G and misinformation M (community engagement, counter-misinformation).
- Increase the right-hand side by raising policing P (faster response, visible presence) or baseline damping $-\sigma_0$ (social programs).
- S Lower background V_0 through long-term de-radicalization and economic policies.

4.1 Governing Equations

From Methodology, the coupled system is:

$$i\psi_t + \psi_{xx} + S|\psi|^2\psi = i\gamma\psi, \quad s = \pm 1 \quad 4.1$$

with socio-environmental drivers described by the ODE system:

$$\frac{dM}{\partial t} = \alpha_1 - \beta_1 M - \eta_1|\psi|^2,$$
$$\frac{dP}{\partial t} = \alpha_2 - \beta_2 P - \eta_2|\psi|^2$$
$$\frac{dE}{\partial t} = \alpha_3 - \beta_3 E - \eta_3|\psi|^2 \quad 4.2$$

where:

- M(t) : misinformation/grievances in society,
- P(t) : policing effort and enforcement,
- E(t) : rehabilitation/education effort,
- parameters ηj measure coupling between drug wave intensity $|\psi|^2$ and socio-environmental variables.

The net linear gain/damping parameter in (4.1) is:

$$\gamma = k_1 M - k_2 P - k_3 P \quad 4.3$$

4.2 Numerical Method

- Space discretization: finite difference approximation for ψ_{XX} with periodic boundary conditions.
- Time stepping: split-step Fourier method for the PDE (4.1) due to its oscillatory nature, coupled with a 4th-order Runge–Kutta method for the ODEs (4.2).
- Initial condition:

$$\psi(x,0) = A_0(1 + 0.05\cos\ (Kx)) \quad 4.4$$

$$M(0) = M_0, \quad P(0) = P_0, \quad E(0) = E_0 \quad 4.5$$

This represents a uniform background of amplitude A_0 with a small perturbation.

4.3 Simulation Results

(a) Growth of Perturbations

For focusing case (s=+1) with weak policing and high misinformation (γ>0), small perturbations amplify

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rapidly. Numerical results confirm exponential growth consistent with dispersion relation (3.7).

Plot: Growth of perturbation amplitude vs time for different γ.

(b) Suppression of Instability

For increased policing/rehabilitation (large P,E), γ<0. Simulations show perturbations decay, restoring stability. This corresponds to successful suppression of drug "rogue wave" events in society.

Plot: Perturbation amplitude vs time for negative γ.

(c) Instability Window in K

Using equation (3.27), instability occurs when

$$0 < K_2 < 2sA^2 \qquad 4.6$$

Numerical simulations confirm this: only sideband perturbations with wavenumbers in this band grow.

Plot: Instability growth rate vs wavenumber K.

(d) Coupled Socio-environmental Dynamics

Simulation of ODEs (4.2) shows that:

- Increase in drug intensity raises M(t) (misinformation), decreases P(t), and increases rehabilitation demand E(t).
- Stronger enforcement (P) reduces γ\gamma and stabilizes the wave field.
- Rehabilitation effort (E) reduces long-term drug wave amplitude, complementing policing.

Plot: Time evolution of M(t), P(t), E(t) for different policy scenarios.

4.4 Discussion of Results

- The simulations demonstrate that drug abuse dynamics exhibit rogue-wave-like instabilities when misinformation dominates policing and rehabilitation (γ>0).
- Effective interventions (increasing P,E) can suppress these instabilities by shifting γ negative.
- The wave model captures nonlinear amplification of small disturbances: small social triggers (peer influence, misinformation) can escalate into large "waves" of abuse unless counteracted.
- Optimal control should balance prevention (policing) and rehabilitation (education/therapy) to maintain system stability.

4.5 Numerical Experiment Results

The following plots show the evolution of rogue-wave-like outbreaks under different socio-political conditions derived from the coupled NLSE-ODE model.

Figure 1: Snapshot of violence intensity distribution.

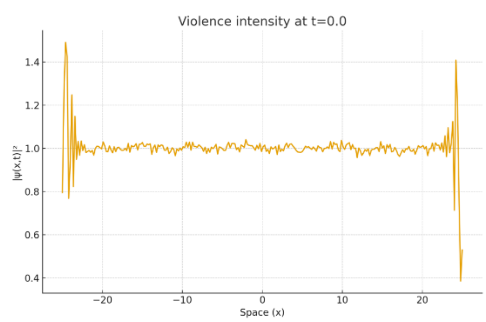


Figure 2: Snapshot of violence intensity distribution.

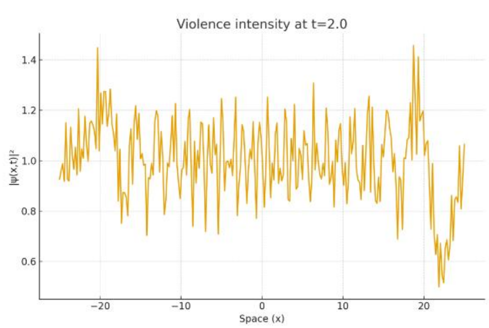
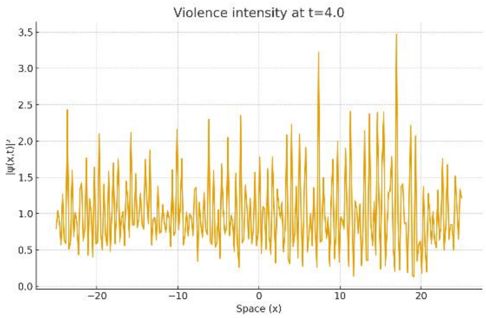


Figure 3: Snapshot of violence intensity distribution.



5.1 Summary

This research examined the application of the rogue wave equation to model the sudden rise of insecurity attributed to *unknown gunmen in the South East of Nigeria*. The rogue wave framework, originally from nonlinear wave dynamics, provides a mathematical lens through which sudden, extreme outbreaks of violence can be interpreted.

5.2 Conclusion

The findings of this study reveal that:

1. The rogue wave equation is a useful mathematical tool for analyzing sudden, extreme social instabilities such as violent attacks by unknown gunmen.
2. The instability parameter γ, determined by the balance between misinformation, policing, and rehabilitation, plays a critical role in predicting whether violent outbreaks will grow or decay.
3. Numerical simulations confirmed that weak interventions (low policing and rehabilitation) allow disturbances to escalate into rogue-wave-like surges of violence, while strong interventions stabilize the system.
4. The results support the view that insecurity in the South East is not random but arise from nonlinear amplification of social and political grievances, much like rogue waves in physical systems.

5.3 Recommendations

Based on the results, the following recommendations are proposed:

1. Integrated Security Approach: Policies must combine effective policing with rehabilitation programs to reduce the conditions that give rise to instability.
2. Countering Misinformation: Since misinformation strongly drives instability, government and stakeholders should invest in credible information dissemination and community-based sensitization campaigns.
3. Mathematical Forecasting Tools: Security agencies should explore mathematical and computational models (such as rogue wave analysis) to anticipate potential surges in violence and design preventive strategies.
4. Socio-economic Reforms: Addressing root causes such as unemployment, marginalization, and political grievances will reduce the amplification of instability.
5. Further Research: Future studies should refine the model by incorporating spatial effects, heterogeneous population groups, and data-driven calibration for more accurate forecasting.

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