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ANALYSIS OF VOTER BEHAVIOR IN THE 2024 ACEH GOVERNOR ELECTION: SAIFR EPIDEMIOLOGICAL MODEL APPROACH

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Abstract. *This article proposes a SAIFR (Susceptible–Apathetic-Independent–Figurative–Resolved) epidemiological model to analyze voter behavior in the 2024 Aceh Governor Election. The model classifies voters into five compartments: susceptible voters (S), apathetic voters (A), independent voters (I), voters influenced by the political figure of Muzakir Manaf, the former commander of the Free Aceh Movement (GAM) (F), and resolved voters (R). This model is developed within a non-contagion framework, where transitions between compartments are determined by rate parameters representing the influence of campaigns, political figures, and individual decisions, without assuming interactions between voters. Pre-election survey data and official vote recapitulations were used to calibrate the model parameters. Simulation results indicate that the majority of voters ultimately accumulate in compartment R (resolved), with the dominant transition path proceeding from susceptible to figurative and then to resolved (S to F to R). Sensitivity analysis identified parameters β (susceptible to apathetic), σ (susceptible to resolved), and φ (figurative to resolved) as key factors determining the final turnout. These findings confirm that the attractiveness of local political figures and campaign effectiveness play a more important role than horizontal interactions between voters in determining turnout patterns.*

Keywords: *Aceh Governor Election; Epidemiological Model; Political Figure; Voter Behavior.*

1. INTRODUCTION

The election of local political leaders is essentially identical to the election of regional heads in Indonesia, which is formally regulated in Law No. 10 of 2016 concerning regional head elections, namely the direct election of executive officials at the provincial and district/city levels by the people. Regional head elections are the main instrument of local democracy that reflects the will of the people in determining the direction of leadership at the regional level. According to (Winengan, 2018), policies regarding regional election mechanisms must be practically based on political life, social dynamics, the development and progress of national democracy, as well as applicable laws and regulations. Regional head elections in Indonesia are carried out directly by every citizen in the region. According to (Cikusin, 2020), the normative application of a direct election system in the recruitment of local political leaders aims, among other things, to produce local political leaders who are more politically motivated. Aceh Province, whose political dynamics are characterized by its status as a former conflict region with special autonomy, has unique characteristics. In the 2024 Aceh Governor Election, a political contestation occurred that involved not only a contest of programs and ideas, but also a contest for influence over certain figures. One of the central figures in the 2024 Aceh Governor Election is Muzakir Manaf, a former commander of the Free Aceh Movement (GAM) and a powerful symbol of local political representation. In this context, many voters make decisions not based solely on rational information, but rather on emotional, historical, and symbolic ties to certain figures. This phenomenon creates a pattern of political support distribution that resembles the spread of an infectious disease, known as contagious political behavior.

The study of voter behavior has become an important part of political science and political sociology, particularly in understanding the dynamics of public participation and political choice. With the development of interdisciplinary approaches, mathematical modeling has begun to be widely used to represent social dynamics, including voter behavior in elections. One prominent approach is mathematical epidemiology, originally developed in the health sciences but successfully adapted to describe the distribution of opinions, political attitudes, and voting tendencies in society. In this context, a number of researchers have previously developed models based on the SEIR (*Susceptible–Exposed–Infected–Recovered*) structure or modifications thereof to study voter behavior. This model positions voters as entities that can be "infected" by political influences, whether through the media, campaigns, or social interactions. To gain a comprehensive understanding of the development and limitations of these previous models, a review of relevant primary literature was conducted. This review covers the research context, the compartmental structure used, the analytical focus of each model, and any identified weaknesses or research gaps. Previous models were used to understand voter behavior by adapting the compartment-based social epidemiology approach SIR (*Susceptible–Infected–Recovered*) and its variants. This model was originally proposed by (Kermack & Mckendrick, 1927), who proposed the SIR epidemic model. The first example can be seen in the work of (Calderon et al., 2005), they use the SEIR compartment model with a focus on the spread of opinion through social interaction. Their model inspires the basic structure of the transition model. Then (Ambrose et al., 2007) uses the SIR compartment model with a focus on voter participation and abstention. Their model provides a general framework for grouping voters. (Romero et al., 2009) uses the SEIR compartment model with a focus on the spread of third party ideology. Their model serves as a comparison with the ideological approach. (Kaufman & Kaufman, 2011) uses the SIR compartment model with a focus on campaign dynamics and media effects. Their model provides a reference for media influence, but is not yet relevant to the Indonesian context, especially Aceh. (Misra, 2012) uses the SIAR compartment model with a focus on voter apathy and choice in developing countries. Their model provides a structure for apathetic voters but is incomplete. (Nyabadza et al., 2016) uses the Misra SIR compartment model, focusing on participation in post-conflict elections in South Africa. Their model is socio-politically relevant but needs adjustment in the Indonesian context. (Sooknanan & Comissiong, 2018) explores the phenomenon of the spread of socio-political attitudes deterministically. (Yong & Samat, 2018) uses the SIR compartment model, focusing on vote estimation in the Indonesian Presidential Election. Their model is relevant in the context of regional electoral systems. (Banuelos et al., 2019) used the SIAR compartment model, focusing on the distribution of abstention and rational choice in the case of elections in Spain. Their model reinforces the importance of separating apathetic and independent compartments. (Macansantos, 2020) used the poaching model, which focuses on political party elites, not voters. They included the term "cadre theft" in the model. Their model reinforces the basis of elite-induced support transitions. Finally, (Balatif et al., 2020) also used the SIAR compartment model, focusing on culturally based models of voter behavior in Arab and African countries.

Of the several literatures mentioned above, none of them specifically model the influence of local political figures in regional head elections, and no research explicitly distinguishes between independent voters and voters influenced by political figures in an epidemiology-based mathematical model. Therefore, this study makes an original contribution by developing a more contextual SAIFR model for the socio-political context of Aceh, specifically in explaining the influence of figures on voting decisions. This model is called the SAIFR model with the aim of representing voter transitions between compartments based on social interactions and the influence of certain political figures. The compartments in this model consist of: S(t) (*Susceptible*): voters who have not yet decided their attitude (susceptible to political influence); A(t) (*Apathetic*): voters who are apathetic and have no intention of voting; I(t) (*Independent*):

voters who make their choice independently without external influence; F(t) (*Figurative*): voters who are influenced by political figures, especially Muzakir Manaf as the former GAM Commander and a symbol of local power; and R(t) (*Resolved*): voters who have completed the election process (both those who have voted and those who have not voted).

2. LITERATURE REVIEW OF EPIDEMIOLOGICAL MODEL OF VOTER BEHAVIOR

The study of voter behavior has become an important part of political science and political sociology, particularly in understanding the dynamics of public participa-tion and political choices. With the development of interdisciplinary approaches, mathematical modeling has begun to be widely used to represent social dynamics, including voting behavior in elections. One prominent approach is mathematical epidemiology, originally developed in the health sciences but has been successfully adapted to describe the distribution of opinions, political attitudes, and voting tendencies in society. In this context, a number of previous researchers have devel-oped models based on the SEIR (Susceptible–Exposed–Infected–Recovered) struc-ture or modifications thereof to study voter behavior. These models position voters as entities that can be "infected" by political influences, whether through the media, campaigns, or social interactions. Some models add compartments such as apathetic voters or undecided voters, but most still do not accommodate other, more contextu-al determinants, such as political figure, which is often found in elec-toral contests in developing countries, including Aceh. In this section, we review some of the relevant primary literature in the landscape of epidemiological models of voter behavior. For example, (Calderon et al., 2005) used the SEIR model with a focus on the spread of third party opinion through social interaction; (Ambrose et al., 2007) used the SIR model with a focus on the voter participation and abstention; (Romero et al., 2009) used the SEIR model with a focus on spread of third party ideology; (Kaufman & Kaufman, 2011) used the SIR model with a focus on campaign dynamics and media effect; (Misra, 2012) used the SIAR model to determine the behavior of apathetic voters; (Nyabadza et al., 2016) used the SIS and SIRS models to analyze the dynamics of competition between two political parties with defections; (Yong & Samat, 2018) used the SIR model to estimate the number of votes in the presidential election in Indonesia; (Banuelos et al., 2019) used the SIAR model to analyze the spread of abstention voters and rational choices in a three-party political system; (Balatif et al., 2020) used the SIAR model and applied optimal control to analyze abstention behavior in registration on the voter list. None of these models explicitly include the political figures compartment as a compartment that can influence voter decisions in the General Election. This study aims to develop the SAIFR model, namely an epidemiological model with five compartments: S(t) (Susceptible): voters who have not yet decided their attitude (susceptible to political influence); A(t) (Apathetic): voters who are apathetic and have no intention of voting; I(t) (Independent): voters who make their choice independently without external influence; F(t) (Figurative): voters who are influenced by political figures, especially Muzakir Manaf as the former GAM Commander and a symbol of local power; and R(t) (Resolved): voters who have completed the election process (both those who have voted and those who have not voted);, and apply it to the case of the 2024 Aceh Governor Election. The development of a more complex model by adjusting the compartmental structure in epidemiology but in accordance with the local context in this study, is expected to represent socio-political dynamics more comprehensively and contextually.

3. RESEARCH METHODS

This research is theoretical research focused on developing a mathematical model and analyzing its behavior. The study does not involve individual or respondent data as the approach used is mathematical modelling. The model developed in this study is a modification of the classic SEIR model used in infectious disease epidemiology, with adjustments to the context of voter behavior in the 2024 Aceh Governor Election. This model is called the SAIFR model, and aims to represent the transition of voters between compartments based on social interactions and the influence of certain political figures. The compartments in this model consist of: S(t) (*Susceptible*): voters who have not yet decided their attitude (susceptible to political influence); A(t) (*Apathetic*): voters who are apathetic and have no intention of voting; I(t) (*Independent*): voters who make their choice independently without external influence; F(t) (*Figurative*): voters who are influenced by political figures, especially Muzakir Manaf as the former GAM Commander and a symbol of local power; and R(t) (*Resolved*): voters who have completed the election process (both those who have voted and those who have not voted). The transition flow between compartments in the voter behavior SAIFR model can be seen in **Figure 1**.

Figure 1. Transition Flow Between Compartments in the SAIFR Voter Behavior Model

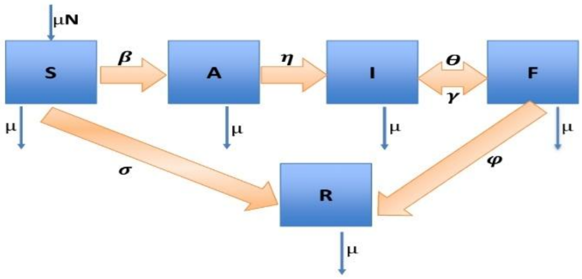


Figure 1 can be interpreted as follows: Compartment *S (Susceptible Voters*) are voters who have not yet decided their political stance. They are still open to being influenced, whether by campaigns, public figures, or political discourse. From S there are three possible paths: a) switching to *A (Apathetic Voters*) at a rate of β, if they eventually lose interest or choose to be passive, b) directly entering R (*Resolved Voters*) at a rate of σ, if they immediately decide their choice quickly without going through a long phase, and c) remaining in S if there is no change. Compartment *A (Apathetic Voters*) are voters who are indifferent or hesitant to participate. However, some of them can change to *I (Independent Voters)* at a rate of η, for example due to obtaining new information or environmental pressure. Compartment *I (Independent Voters*) are voters who make their choices independently based on personal beliefs. From I, there is a possibility that they move to compartment *F (Figurative Voters)* with a rate γ, when they are more influenced by political figures or identity symbols. Compartment *F (Figurative Voters)* are voters who are influenced by certain figures, in the context of the 2024 Aceh Governor Election, specifically Muzakir Manaf as a central figure. From F there are two transition directions: a) back to I with a rate ϑ, if the influence of the figure weakens and they choose to return to an independent stance, and b) to R with a rate ϕ, if the influence of the figure succeeds in forming a firm final decision. Compartment R is voters who have made a final decision (either have voted or decided not to vote). This compartment R is terminal - there is no outflow. Each compartment experiences an outflow rate μ (for example, voters die, move domicile, or are invalid in the DPT). As compensation, there is an input μN to S, which represents the constant recruitment of new voters (e.g., first-time voters or in-migration). The model branches into two main pathways: the apathetic pathway (*S to A to I to F to R* or *S to A to I to R*), which describes voters who are initially susceptible and then go through a phase of hesitation before finally participating, and the figurative pathway (*S to F to R*), which describes voters who are directly influenced by political figures. The presence of the return arrow *F to I* (θ) indicates that the influence of figures is not always permanent, some voters may revert to an independent attitude. R as the final compartment reflects the nature of elections: eventually all voters (active and passive) arrive at a final decision that does not change anymore. It is assumed that the total size of the voting population is constant; that is, $N = S + A + I + F + R$.

The SAIFR model used in this study is a system of ordinary differential equations that describes changes between compartments continuously (from day to day, not only during major campaigns) with respect to time t, with adjustments based on the assumption that political figures are run by external parties from the candidate pair or success team, not as a social transmission process between voters:

$$\frac{dS(t)}{dt} = \mu N - (\beta + \sigma + \mu)S \qquad (1)$$
$$\frac{dA(t)}{dt} = \beta S - (\eta + \mu)A \qquad (2)$$
$$\frac{dI(t)}{dt} = \eta A + \theta F - (\gamma + \mu)I \qquad (3)$$
$$\frac{dF(t)}{dt} = \gamma I - (\theta + \varphi + \mu)F \qquad (4)$$
$$\frac{dR(t)}{dt} = \sigma S + \varphi F - \mu R \qquad (5)$$

The systematic steps in the analysis of epidemiological compartmental models (such as SIR, SEIR) generally involve several main, sequential and interrelated steps, including: 1) identifying the compartments and the relevant underlying assumptions of the formulated model; 2) formulating a mathematical model using a system of differential equations that describes the movement of individuals between compartments; 3) conducting model analysis, including stability analysis, numerical simulations, and exploration of intervention scenarios (Bernardi et al., 2025). For the identification and estimation stage of the formulated model parameters, this can be done using epidemiological data available through various methods, see (Beira & Sebastião, 2021; Ferrández et al., 2023; Li et al., 2024; Schiassi et al., 2021). However, in this article, to calibrate the SAIFR model, we use two sources: a) Pre-election preference survey (LSI, 5–12 November 2024) to determine the initial conditions for voter allocation to compartments S, A, I, F, and R; and official KPU recapitulation data (DPT), and b) Voter turnout/participation/number (valid votes per candidate pair and invalid votes) as the final target on election day. The initial conditions are defined as: S_0 = proportion of undecided survey participants; A_0 = proportion of undecided/absentees; I_0 = proportion of independent participants; F_0 = proportion influenced by family/figures; dan R_0 = remainder. We simulate the SAIFR model's system of ordinary differential equations from the survey date to election day (15 days) with μ = 0 (short period, no demographic data). The parameters (β, σ, η, γ, ϑ, φ) are estimated by solving a constrained least squares problem, minimizing the relative deviation between: a) Modeled turnout/participation/turnout vs. observed turnout/participation/turnout, b) Modeled vote counts per candidate vs. observed vote counts per candidate. To reduce identification problems, some parameters were given reasonable constraints and some were initialized using survey information; the accuracy and robustness of the solution were tested through bootstrapping and sensitivity analysis.

In developing this SAIFR model, two mathematical approaches are commonly used in the epidemiological literature: the contagion version (based on mass action interactions between susceptible and independent voters) and the non-contagion version (based on linear transition rates without interaction terms). In the context of the 2024 Aceh Governor Election, the contagion assumption is less relevant because changes in voter behavior do not occur primarily through individual contact, but are influenced by external factors such as media campaigns, elite mobilization, and the appeal of political figures. Therefore, this study adopts a non-contagion framework, in which the transition rate of each compartment (e.g., from susceptible voters to apathetic, independent, figurative, or established voters) is modeled as a proportional function of the number of individuals in that compartment, with a fixed transition rate parameter. The non-contagion approach allows for analysis that is more in line with survey data and election recapitulation results, because each transition flow can be directly linked to the proportion of voters in a particular category without requiring the assumption of interactions between individuals. Thus, the focus of the methodological analysis is directed at finding the equilibrium point of the system, the rate of convergence to a steady state, and the sensitivity of the results to parameter variations. Meanwhile, the contagion framework is still noted as an alternative approach and is presented in the appendix for conceptual comparison, in particular to show that even though opinions are assumed to spread among voters, the basic reproduction number (R_0) remains below the threshold of one, so that the spread process is not sustainable.

4. RESULTS AND DISCUSSION

The SAIFR model developed in this study requires several initial parameters estimated from empirical data from the 2024 Aceh Governor Election recapitulation, combined with survey results from the Indonesian Statistics Institute (LSI). Initial compartment parameter estimation was conducted to ensure it aligns with reality and is valid for epidemiological model simulations. The available data indicate (Tabel 1):

Tabel 1. Recapitulation of Voting Results for the 2024 Aceh Governor Election

Parameters	Component	Total Number	Percentage (%)
β	Number of registered voters (DPT)	3.764.944	100%
γ	Total number of votes cast	2.927.814	77,77%
δ	Number of valid votes	2.802.221	95,71%
α	Number of invalid votes	125.593	4,29%
μ	Number of Votes for Candidate Pair 02 Muzakir Manaf – Fadhlullah	1.492.846	53,27%
N	Number of Votes for Candidate Pair 01 Bustami Hamzah – Fadhil Rahmi	1.309.375	46,73%

Source: KPU Aceh, 2024.

Based on the data in Table 1, the number of registered voters (DPT) in the 2024 Aceh Governor Election was 3,764,944, with a turnout of 77.7% (2,927,814 votes). Of the total votes cast, 2,802,221 were declared valid, and 125,593 were declared invalid. The distribution of valid votes shows that the Muzakir Manaf-Fadhlullah ticket obtained 53.3% (1,492,846 votes), while the Bustami Hamzah-Fadhil Rahmi ticket obtained 46.7% (1,309,375 votes). This data was then mapped into the SAIFR model compartments to describe the structure of the voter population at the endpoint (post-election). To obtain the initial conditions for the simulation, we also used pre-election survey data (LSI, November 2024), which showed that approximately 24.3% of voters were still undecided (referred to as S), 7% were apathetic, 29.2% were independent, and 37.5% were influenced by political figures. Thus, a comparison of the initial proportion (based on the survey) and the final proportion (based on the recapitulation) for each compartment in the SAIFR model can be seen in **Table 2**.

Table 2. Comparison of Values S_0, A_0, I_0, F_0, R_0 (beginning vs end)

Parameters	Component	Total Number
S (Susceptible)	24,3% (≈ 915.000)	0%
A (Apathetic)	7,0% (≈ 264.000)	22,3% (≈ 837.000 abstain+ 126.000 invalid)
I (Independent)	29,2% (≈ 1.100.000)	-
F (Figurative)	37,5% (≈ 1.410.000)	39,6% (≈ 1.493.000, Candidate pair 02)
R (Resolved)	2,0% (≈ 75.000, very strong voters)	100% (2.927.814 total turnout)

Table 2 shows a significant shift from the S compartment in the pre-election survey to the *R* compartment in the post-election survey. The *A* compartment also saw an increase, from 7% to over 22% in the final results, reflecting a group of voters who were absent or cast invalid ballots. In contrast, the *F* compartment remained relatively consistent between the surveys and the results, with a slight increase for candidate pair 02. This comparison served as the basis for calibrating the parameters of the SAIFR model, specifically the transition rates from *S to R* and from *I to F* leading up to election day.

The results of the SAIFR model equilibrium calculation show that the system has a unique steady state point that can be expressed explicitly for each compartment (*S*, A*, I*, F*, R**). Using the estimated parameters, it is found that the value of *S** is relatively small compared to the total population, while *R** dominates at the final state, which is consistent with the fact that the majority of voters eventually reach the final decision.

From the system of differential equations (1) – (5), to find the equilibrium point *X* = (S*, A*, I*, F*, R**), with $\frac{dX(t)}{dt} = 0$; positive abbreviations can be defined: $k_S = \beta + \sigma + \mu$, $k_A = \eta + \mu$, $k_I = \gamma + \mu$, $k_F = \theta + \phi + \mu$.

From $\frac{dS(t)}{dt} = 0$, obtained:

$$\boldsymbol{S}^* = \frac{\mu \boldsymbol{N}}{\boldsymbol{k_S}};\text{ under the condition } R_0 > 1.$$

From $\frac{dA(t)}{dt} = 0$, obtained:

$$\boldsymbol{A}^* = \frac{\boldsymbol{\beta}}{\boldsymbol{k_A}}\boldsymbol{S}^*.$$

From $\frac{dF(t)}{dt} = 0$, obtained:

$$\boldsymbol{F}^* = \frac{\boldsymbol{\gamma}}{\boldsymbol{k_F}}\boldsymbol{I}^*.$$

From $\frac{dI(t)}{dt} = 0$, substitution of A* and F*: $0 = \eta A^* + \theta F^* - k_I = \eta A^* + \theta \frac{\gamma}{k_F} I^* - k_I I^*$; by collecting terms containing I*, then:

$$\left(k_I - \frac{\theta\gamma}{k_F}\right) I^* = \eta A^*.$$

Next, define the denominator, $D = k_I k_F - \theta\gamma$. With D > 0, we get:

$$\boldsymbol{I}^* = \frac{\boldsymbol{\eta A^* k_F}}{\boldsymbol{D}} = \frac{\boldsymbol{\beta\eta k_F}}{\boldsymbol{k_A D}}\boldsymbol{S}^*.$$

Then, from $F^* = (\frac{\gamma}{k_F})I^*$ give $F^* = \frac{\beta\eta\gamma}{k_A D}S^*$.

And finally, from $\frac{dR(t)}{dt} = 0$, 0 = σS* + ϕF* −μR*, then obtained:

$$\boldsymbol{R}^* = \frac{\boldsymbol{\sigma S^* + \varphi F^*}}{\boldsymbol{\mu}}.$$

Because $S^* = \frac{\mu N}{k_S}$; All components *A*, I*, F*, R** can be written explicitly as functions of the parameters and N (see direct substitution if desired). Physical existence condition (positivity): it is required that all parameters > 0 dan D > 0 (i.e., $k_I k_F > \vartheta_\gamma$) so that the denominator is positive, and all I*, F* are finite and non-negative. In usual practice of positive parameters, *D > 0* will be satisfied unless the combination is extreme. In conclusion, the existence and uniqueness of the equilibrium are guaranteed by the condition $k_I k_F > \vartheta_\gamma$, so that the solution remains positive and meaningful.

Furthermore, the numerical results of the final distribution of the voter population in each compartment can be seen in Table 3. The numerical results were obtained from the SAIFR model simulation with the most appropriate parameters from the calibration results against the 2024 Aceh Governor Election data.

Table 3. The Final Distribution of The Voter Population in Each Compartment

Compartment	**Description**	**Final value (sum)**	**Proportion to DPT (%)**
S*	Susceptible voter	195.287	5,2%
A*	Apathetic voter	289.054	7,7%
I*	Independent voter	424.707	11,3%
F*	Figurative voter	691.980	18,4%
R*	Resolved voter	2.163.916	57,5%
Total	Number of voters (DPT)	**3.764.944**	**100%**

Numerical simulations of the system of differential equations (1)–(5) show that all compartments move towards equilibrium rapidly. The trajectories of S(t), A(t), I(t), F(t) exhibit an exponential decreasing pattern towards zero or a small steady-state value, while R(t) increases until it dominates the population. Jacobian analysis confirms local stability since all eigenvalues are negative (except for the case μ = 0 which yields one zero eigenvalue due to population conservation).

The Jacobian J (the order of the variables (S, A, I, F, R) - since the system is linear - is constant and the same at all points:

$$J = \begin{pmatrix} -k_s & 0 & 0 & 0 & 0 \\ \beta & -k_i & 0 & 0 & 0 \\ 0 & \eta & -k_a & 0 & 0 \\ 0 & 0 & \gamma & -k_f & 0 \\ \sigma & 0 & 0 & \varphi & -\mu \end{pmatrix}$$

Since J is almost lower-triangular, its eigenvalues are its diagonal elements: $\lambda_1 = -k_S$, $\lambda_2 = -k_A$, $\lambda_3 = -k_I$, $\lambda_4 = -k_F$, $\lambda_5 = -\mu$; all of k*, μ > 0 ⇒ all eigenvalues are negative.

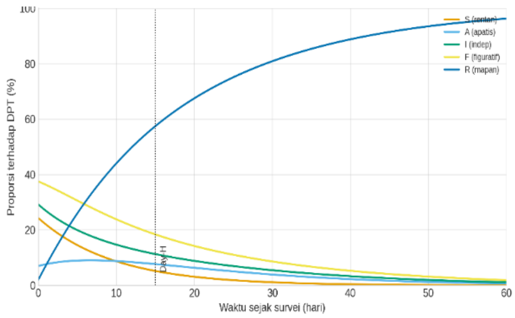
Since all eigen values < 0 (untuk μ > 0 dan parameter > 0), the equilibrium point X* is linearly asymptotically stable (or locally asymptotically stable). Since the system is linear with constant coefficients, linear stability ⇒ global asymptotic stability: the solution under any realistic initial conditions will converge to X*. Case μ = 0 (no demographics, often used for short campaign periods). If μ = 0, then: $k_S = \beta + \sigma$, $k_A = \eta$, $k_I = \gamma$, $k_F = \theta + \phi$.

Equilibrium solution $\frac{dX(t)}{dt} = 0$ → S* = 0, A* = 0, I* = 0, F* = 0, R* = N. (All mass is ultimately at R). The diagonal entries of the Jacobian become: $-k_S$, $-k_A$, $-k_I$, $-k_F$, *0*.

We have four negative eigenvalues and one eigenvalue 0 (because the total is conserved and R acts as an accumulator). The system remains interesting: S, A, I, F → 0 is exponential while *R* → *N*. So the equilibrium with μ = 0 is also asymptotically stable in the physical domain (non-hyperbolic due to zero eigenvalue from conservation), and the explicit solution we have derived shows global convergence to that condition.

In summary, there is a unique physical equilibrium X* (for μ > 0) which is calculated explicitly above. This is a global attractor in the non-negative population domain. The critical parameter: $D = k_I k_F - \vartheta_\gamma$ must be positive I*, F* to be finite - as D approaches zero, the stock of *I*, F** can become very large (an indicator of resonance between the I ↔ F flows). For a model without demography (μ = 0), the trivial equilibrium R* = N, S* = A* = I* = F* = 0 exists and is also physically global. This indicates that the system is always converging towards a steady state without cycles or oscillations. Figure 2 shows a simulation curve that confirms this convergence dynamic.

Figure 2. Dynamics of the SAIFR Model



The sensitivity analysis results indicate that certain transition parameters have a more dominant influence on the final distribution of voters. Variations in the levels of β (*S to A*) and σ (*S to R*) produce significant proportional changes in R*, while the parameters γ (I to F) and ϕ (*F to R*) have a strong influence on the magnitude of F* and the rate of accumulation to R*. In contrast, the parameter θ (*F to I*) has only a small impact. Table 4 displays the elasticity values calculated for each parameter with respect to the final outcome compartment, allowing the identification of the most important transition paths in determining the election outcome. Elasticity values are calculated relative to R* using the best-fit parameters; a positive sign indicates that an increase in the parameter increases the number of resolved/established voters, while a negative sign indicates a decrease.

Table 4. The Final Distribution of The Voter Population in Each Compartment

Paramet er	Interpretation	Fittest value	Elasticity	Policy Impact (1% change)
β	S → A	0.0495	+0.84	1% ↑β → R* ↑ 0,84%
σ	S → R	0.0534	+0.91	1% ↑σ → R* ↑ 0,91%
η	A → I	0.0669	−0.22	1% ↑η → R* ↓ 0,22%
γ	I → F	0.1258	−0.47	1% ↑γ → R* ↓ 0,47%
θ	F → I	0.0184	−0.05	Very little impact
ϕ	F → R	0.1107	+0.55	1% ↑ϕ → R* ↑ 0,55%

The results of the SAIFR model analysis highlight that the non-contagion transition structure better fits the 2024 Aceh Governor Election data than the contagion approach. Voters switched not because of "contagion" between individuals, but because of exposure to campaigns and political figures, particularly the central figure, Muzakir Manaf. Simulations show that the R compartment is the final destination with the largest proportion, consistent with the high election turnout data. The rate of convergence to a steady state is rapid, reflecting the intense dynamics leading up to election day. Sensitivity analysis shows that the parameters β and σ directly influence the size of the voter mass that reaches a final decision, while ϕ determines the speed of figurative voters in completing their choices. In contrast, the parameter θ (*F to I*) has a relatively small influence. This confirms that the dominant pathway to participation is through political figures, rather than through independent dynamics. Substantially, these findings suggest that figure-based campaign strategies and symbolic narratives are more effective in mobilizing voters than rational-independent approaches. In line with (Chilachava & Sulava, 2018), this modeling can be a useful tool in understanding micro-political behavior that is difficult to measure directly. The dynamics of this model also have strategic implications: a campaign approach that relies too heavily on political figures may not guarantee sustained support. Meanwhile, strengthening independent voters (I) through political education can be a long-term strategy for building a rational and loyal voter base.

CONCLUSION

This study develops a SAIFR (Susceptible–Apathetic–Independent–Figurative–Resolved) epidemiological model to map the dynamics of voter behavior in the 2024 Aceh Governor Election, focusing on the influence of the political figure of the former Free Aceh Movement (GAM) commander, Muzakir Manaf. This study shows that the SAIFR model, within a non-contagion framework, is able to describe the dynamics of voter behavior consistently with survey data and the results of the 2024 Aceh Governor Election. The equilibrium point achieved indicates a stable voter dominance (R^*), while a sensitivity analysis identifies the main transition pathways that determine the level of participation. The main finding is that the influence of political figures and elite mobilization have a greater impact than horizontal interactions between voters, making the symbolic role of local figures a determinant in the formation of preferences. Thus, this study not only provides a methodological contribution through the formulation of a new mathematical model, but also provides substantive insights into the dynamics of political participation in Aceh Province.

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