Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 6, No.3, July 2024, pp. 02403020-01 ~ 02403020-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v6i3.792

Mathematical Model of Community Participation Levels in Elections in Medan City

Chindy Aulia Putri[1]*, Rina Widyasari[2],

Faculty of Science and Technology, Universitas Islam Negeri Sumatera Utara, Jl. Lapangan Golf , Medan, Indonesia.

chindy0703201019@uinsu.ac.id

Abstract. Political participation is one of the benchmarks of a country's democracy. This can be seen from their involvement in elections. Every general election must have a white group called abstainers who usually consciously do not using their voting rights which may influence individuals not to use their voting rights in general elections. Medan City is the city with the second highest number of abstainers in North Sumatra Province at 33.33%. This study will model the level of public participation in elections in Medan City by comparing the level of public participation in the 2019 and 2024 presidential elections. From the model, two equilibrium points are obtained, namely abstainer and abstainer-free equilibrium points, basic reproduction number and stability analysis of the equilibrium point. The simulation results for 2019 and 2024 showed that for $R_0 > 1$, the abstainer population increases so that the abstainer equilibrium point is asymptotically stable. Then for $R_0 < 1$, the abstainer population will gradually disappear.

Keywords: Election, Mathematical model, Equilibrium point, Stability.

(Received 2024-07-03, Accepted 2024-07-25, Available Online by 2024-07-27)

1. Introduction

Political participation is one of the benchmarks for the functioning of a country's democracy which is related to the fulfillment of citizens' political rights [1]. This can be seen from their involvement in elections, which is one of the means of democracy. Elections are the process of selecting people to fill certain positions [2]. According to constitutional law, elections are a way for the people to express their sovereignty over their own government and country [3]. Political participation is the participation of ordinary citizens in determining all decisions that affect their lives [4]. The higher the political participation of the community shows that most people follow and involve themselves in state activities [5]. Meanwhile, the low political participation of community is reflected in the attitude of the white group in the election process [6].

Every general election must have a white group called abstainers who usually consciously do not use their voting rights for their own reasons. According to KPU data, in the 2019 election, the number of voters who did not use their voting rights reached 18.03%, which is around 34.756.541 million people from 192.770.611 permanent voter list [7]. North Sumatera is an area with a total of 10.355.511 registered voters, with a total of 2.719.285 voters who did not exercise their right to vote 25.26%. Medan city is a district/city with the second highest number of people not using voting rights in North Sumatra Province at 33.33% [8]. The high number of people who do not use their voting rights is caused by internal factors such as distrust of candidates, and the assumption that elections are not important and external factors such as socialization and campaigns and political education [9] [10].

Mathematical modelling is the process of simplifying problems in everyday life that are represented in mathematical models [11]. Mathematical models can be related to problems in engineering, economics, biology, and even politics [12]. One example of applied mathematical modelling that is often used is the epidemic model [13]. An Epidemic model is a model that examine the spread of an epidemic in a population [14]. As in infectious diseases, in the general elections, interactions between people through direct discussion or social media can influence individual choices. One of the effect is to influence individuals not to exercise their right to vote.

There have been many studies related to mathematical models in elections. In research [15],[16], and [17] on mathematical modeling of dynamic with interaction between voters in the presidential election in Indonesia. The results support that interaction between voters plays an important role in the distribution of votes in the presidential election. In addition, in [18] and [19] also discussed the mathematical model of the dynamics of citizens who have the right to register in the voter list and participate in elections with the negative influence of the abstention group. In research [20] developed a model of the level of community participation in elections with the abstainer population is the population that does not use voting rights. Based on this, the level of public participation in the elections in Medan City will be modeled by comparing the level of public participation in the 2019 and 2024 presidential elections. The results of this study are expected to be used by the Medan city government to estimate the level of abstainers so that it can take policies in order to prevent the increasing population of abstainer in future elections.

2. Method

This research was conducted using literature studies by collecting theories and data to identify problems related to mathematical models and the level of public participation in elections. The data used secondary data. The data used was obtained from the General Elrction Commission (KPU) of Medan City. Then the data is analyzed using steps including: Determining initial assumptions, variables and parameters, forming a compartment diagram and mathematical model, determining the equilibrium point and basic reproduction number, carrying out stability analysis of the equilibrium point, carrying out numerical simulations and making conclusions and suggestions.

3. Results and Discussion

3.1 Mathematical Model

The mathematical model of the level of public participation in elections in Medan city consists of three subpopulations, namely individuals who are registered in the DPT but potentially abstain (P), individuals who use voting rights (R), and individuals who do not use voting rights and invalid votes (A). In this model, it is assumed that each compartment also decreases due to natural death. The total population in the population at time (t) can be expressed as $N = P + R + A$. The variables and parameters used in the information of the model can be seen in the following table:

Table 1. Variables and Parameters

Variables	Description
$P(t)$	Population eligible to vote and registered but potentially abstai at t (Number of voters registered in the DPT)
$R(t)$	Population exercising the right to vote at time t
$A(t)$	The population that does not exercise the right to vote and votes are invalid at time t
Λ	The number of new population recruitment
μ	Natural death rate
β	Population rate of individuals entitled to vote and potentially abstaining from exercising their right to vote
α	Population rate eligible to vote and potentially abstain but not exercise their right to vote

γ	The rate of population who exercise their right to vote but become invalid votes

Based on the variables and parameters used, the compartment diagram of the mathematical model of the level of community participation in elections in the city of Medan is depicted as follows

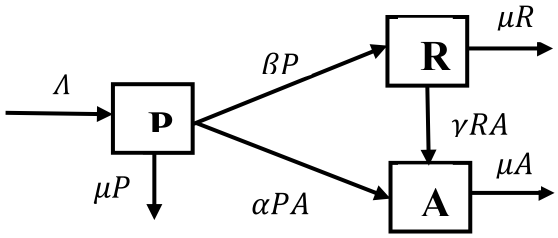

Figure 1. Compartment diagram of a mathematical model of election participation rates

Based on the compartment diagram above, it explains that the recruitment rate in the potential population is Λ. The number of individuals in subpopulation (P) decreases because individuals exercise their right to vote in elections (R) at a rate of β with a rate of βP. Individuals in subpopulation (P) can also be infected with abstention due to contact with subpopulation (A) either through active or passive discussions with a rate of α which results in the number of subpopulation (P) decreasing at a rate of αPA. The subpopulation (P) also decreases due to natural mortality at a rate of μP.

The number of individuals in subpopulation (R) increases when individuals in the subpopulation (P) exercise their right to vote at a rate β with a rate of βP. Subpopulation (R) decreases due to the influence of subpopulation (A) so that it becomes an invalid vote at a rate of γRA. The subpopulation (R) also decreases due to natural mortality at a rate of μR.

The number of individuals in subpopulation (A) increases when individuals in subpopulation (P) interact through active or passive discussions with subpopulation (A) so that they do not want to exercise their voting rights at a rate α with a rate of change of αPA. The subpopulation (A) increases due to the influence of individuals (R) to become invalid votes with a rate of γRA. This subpopulation is also decreasing due to natural mortality at a rate of μA.

Based on the explanation above, the resulting mathematical model of the level of public participation in elections is formed in the form of the following system of differential equations:
The rate of change of subpopulations entitled to vote and registered but potentially abstaining (P),

$$\frac{dP}{dt} = \Lambda - \beta P - \alpha PA - \mu P \tag{1}$$

The rate of change of subpopulations individuals exercise their voting rights (R),

$$\frac{dR}{dt} = \beta P - \gamma RA - \mu R \tag{2}$$

The rate of change of subpopulations of non-voters and invalid voters (A),

$$\frac{dA}{dt} = \alpha PA + \gamma RA - \mu A \tag{3}$$

3.2 Positive Invariant Region

Because equation (1-3) describes interactions between subpopulations, the solution to this equation must be non-negative and finite. By adding all equations (1-3), we obtain $\frac{dN}{dt} = \Lambda - \mu N$. So it is also found that $N(t) = e^{-\mu t}\left(N(0) - \frac{\Lambda}{\mu}\right) + \frac{\Lambda}{\mu}$, when $N(0)$ states the initial value of the population. Therefore $\lim_{t\to\infty} N(t) = \frac{\Lambda}{\mu}$, obtained $0 \le N(t) \le \frac{\Lambda}{\mu}$ which means that

$$\Omega = \left\{(P, R, A) \in \mathbb{R}_+^3 | 0 \le P + R + A \le \frac{\Lambda}{\mu}\right\}$$

is a positive invariant. As a result, equation (1-3) is finite.

3.3 Equilibrium Point

Equation (1-3) has two equilibrium points, namely the abstainer-free equilibrium point and the abstainer equilibrium point.

1. *Abstainer*-free equilibrium point

   The abstainer-free equilibrium point is obtained when there are no abstainers in the population or when $(A = 0)$. The equilibrium point of equation (1-3) is

$$E_0 = \left(\hat{P}, \hat{R}, \hat{A}\right) = \left(\frac{\Lambda}{(\beta+\mu)}, \frac{\beta\Lambda}{\mu(\beta+\mu)}, 0\right) \tag{4}$$

2. *Abstainer* equilibrium point

   The abstainer equilibrium point states the condition where there are abstainer individuals inthe population, $(A \neq 0)$. This abstainer equilibrium point can be expressed by $E_1 = (P^*, R^*, A^*)$. So

$$P^* = \frac{\Lambda}{(\beta + \alpha A^* + \mu)}, \quad R^* = \frac{\Lambda\beta}{(\gamma A^* + \mu)(\beta + \alpha A^* + \mu)} \tag{5}$$

   Next, substitute equation (5) into the equation $(\alpha P^* + \gamma R^* - \mu)A^* = 0$, because the absolute equilibrium point occurs when $A^* > 0$, then

$$\alpha P^* + \gamma R^* - \mu = 0$$
$$\alpha\gamma\Lambda A + \alpha\mu\Lambda + \gamma\beta\Lambda - \gamma\beta\mu A - \alpha\mu\gamma A^2 - \gamma\mu^2 A - \beta\mu^2 - \alpha\mu^2 A - \mu^3 = 0$$
$$(-\alpha\mu\gamma)A^2 + (\alpha\gamma\Lambda - \gamma\beta\mu - \gamma\mu^2 - \alpha\mu^2)A + (\alpha\mu\Lambda + \gamma\beta\Lambda - \beta\mu^2 - \mu^3) = 0$$

   The value A* is written in the positive roots of the quadratic equation as follows:

$$x_1A^2 + x_2A + x_3 = 0 \tag{6}$$

   Where
   $x_1 = -\alpha\mu\gamma$
   $x_2 = \alpha\gamma\Lambda - \gamma\beta\mu - \gamma\mu^2 - \alpha\mu^2$
   $x_3 = \alpha\mu\Lambda + \gamma\beta\Lambda - \beta\mu^2 - \mu^3$

   The condition that there is a single positive root value of the quadratic equation (6) is the discrimination value $D = x_2^2 - 4x_1x_3 > 0$ dan $\frac{x_3}{x_1} < 0$. This is because the parameter is assumed to be positive, so the value of x_1 is always negative and $R_0 > 1$, mark $x_3 > 0$. Therefore for $R_0 > 1$, earned value $= x_2^2 - 4x_1x_3 > 0$ and $\frac{x_3}{x_1} < 0$. So, for $R_0 > 1$ exists with a single abstainer equilibrium point $E_1 = (P^*, R^*, A^*)$.

3.4 Basic Reproduction Number

The basic reproduction number (R_0) in this case is represented as the average number of people affected by the abstainer population so that they do not exercise their right to vote or become invalid votes. The basic reproduction number is obtained with the *Next Generation Matrix*. defined $x = A$, so

$$\dot{x} = \frac{dA}{dt} = [\alpha PA + \gamma RA] - [\mu A]$$
$$= F(x) - V(x)$$

Next we will find F and V with $(P = \hat{P}, R = \hat{R})$ is $F = \left[\alpha\hat{P}A + \gamma\hat{R}A\right]$, $V = [\mu A]$, with the partial derivatives of matrices F and V being $F = \left[\frac{\partial\mathcal{F}}{\partial A}\right] = \left[\alpha\hat{P} + \gamma\hat{R}\right]$, $\quad V = \left[\frac{\partial V}{\partial A}\right] = [\mu]$.

Then we get the inverse of $V^{-1} = \frac{1}{\mu}$, Next, we will look for the next generation matrix and make substitutions for *abstainer*-free equilibrium points $E_0 = \left(\hat{P}, \hat{R}, \hat{A}\right)$ so,

$$R_0 = \frac{\Lambda(\mu\alpha + \gamma\beta)}{\mu^2(\beta + \mu)} \tag{7}$$

3.5 *Equilibrium Point Stability*

The local and global stability of the equilibrium point is given by theorems 1 to 3.

Teorem 1. *The abstainer-free equilibrium point is locally asymptotically stable if* $R_0 < 1$ *and unstable if* $R_0 > 1$.

Proof : Calculations for equilibrium point stability analysis can use the Jacobi matrix which aims to calculate eigenvalues. The Jacobi matrix equation (1) is as follows:

$$J(P,R,A) = \begin{vmatrix} -(\beta - \alpha A - \mu) & 0 & -\alpha P \\ \beta & -(\gamma A - \mu) & -\gamma R \\ \alpha A & \gamma A & (\alpha P + \gamma R - \mu) \end{vmatrix} \tag{8}$$

With an abstainer-free equilibrium point, namely $E_0 = (\hat{P}, \hat{R}, \hat{A})$, then the characteristic equation can be determined, namely as follows:

$$\det(\boldsymbol{J}_0 - \lambda \boldsymbol{I}) = |\boldsymbol{A}|$$

$$|\boldsymbol{A}| = \begin{bmatrix} -(\beta+\mu)-\lambda & 0 & -\alpha\left(\frac{\Lambda}{(\beta+\mu)}\right) \\ \beta & -\mu-\lambda & -\gamma\left(\frac{\beta\Lambda}{\mu(\beta+\mu)}\right) \\ 0 & 0 & \left(\alpha\left(\frac{\Lambda}{(\beta+\mu)}\right) + \gamma\left(\frac{\beta\Lambda}{\mu(\beta+\mu)}\right) - \mu - \lambda\right) \end{bmatrix}$$

To determine the determinant value, you can use the Sarrus method, so that the eigenvalues obtained are as follows:

$$\lambda_1 = -(\beta+\mu), \qquad \lambda_2 = -\mu, \qquad \lambda_3 = \left(\alpha\left(\frac{\Lambda}{(\beta+\mu)}\right) + \gamma\left(\frac{\beta\Lambda}{\mu(\beta+\mu)}\right) - \mu\right) \tag{9}$$

Based on equation (9), it is obtained that for $R_0 < 1$, mark $\lambda_3 < 0$ and to $R_0 > 1$, mark $\lambda_3 > 0$. So it can be concluded that the abstainer-free equilibrium point is locally asymptotically stable if $R_0 < 1$. Next, we will analyze the global stability of the abstainer-free equilibrium point in the following theorem.

Theorem 2. *Abstainer-free equilibrium point is globally asymptotically stable if* $R_0 < 1$ *and unstable if* $R_0 > 1$.

Proof. Defined Lyapunov function

$$Y(A) = \frac{1}{\mu} A \tag{10}$$

If equation (8) is derived with respect to t, we obtain

$$\begin{aligned} \frac{dY}{dt} &= \frac{1}{\mu}\left[\alpha\hat{P} + \gamma\hat{R} - \mu\right]A \\ &\le (R_0 - 1)A \end{aligned} \tag{11}$$

Based on equation (11), the result is that if $R_0 < 1$, so $\frac{dY}{dt} < 0$. This has consequences for $R_0 < 1$, then the abstainer-free equilibrium point is globally asymptotically stable. Next, an analysis of the global stability of the abstainer equilibrium point will be carried out in the following theorem.

Theorem 3. *Abstainer equilibrium point* $E_1 = (P^*, R^*, A^*)$ *globally asymptotically stable if* $R_0 > 1$.

Proof. Defined Lyapunov function

$$Y(P,R,A) = \left(P - P^* - P^* \ln\frac{P}{P^*}\right) + \left(R - R^* - R^* \ln\frac{R}{R^*}\right) + \left(A - A^* - A^* \ln\frac{A}{A^*}\right) \tag{12}$$

The derivative of the function Y is derived with respect to t, using example notation $x = \frac{P}{P^*}$, $y = \frac{R}{R^*}$ and $z = \frac{A}{A^*}$, so

$$\frac{dY}{dt} = \left(1 - \frac{P^*}{P}\right)(\Lambda - \beta P - \alpha PA - \mu P) + \left(1 - \frac{R^*}{R}\right)(\beta P - \gamma RA - \mu R) + \left(1 - \frac{A^*}{A}\right)(\alpha PA + \gamma RA - \mu A)$$

$$\begin{aligned} \frac{dY}{dt} = {} & \beta P^*\left(2 - x - \frac{1}{x}\right) + \alpha P^* A^*\left(2 - \frac{1}{x} - x\right) + \gamma R^* A^*\left(x - \frac{x}{y} - y + 1\right) + \mu P^*\left(2 - \frac{1}{x} - x\right) + \\ & \mu R^*\left(x - \frac{x}{y} - y + 1\right). \end{aligned} \tag{13}$$

From completing the calculation above, it is known that the arithmetic mean value is greater than the geometric mean value, so we get $\left(2 - x - \frac{1}{x}\right) \le 0$ and $\left(x - \frac{x}{y} - y + 1\right) \le 0$. Further, for $\frac{dY}{dt} = 0$

fulfilled for $2 - x - \frac{1}{x} = 0$ and $x - \frac{x}{y} - y + 1 = 0$. This has consequences , $P = P^*, R = R^*$ dan $A = A^*$. So, based on Lasalle's theorem, it is obtained that the abstainer equilibrium point is globally asymptotically stable.

3.6 *Numerical Simulation*

3.6.1 Numerical Simulation 2019

In this numerical simulation, 2 cases will be discussed, namely case $R_0 < 1$ and $R_0 > 1$. According to data from the Medan City KPU in the 2019 election, the number of abstainers in Medan city reached 25.80%, which is 416.624 out of 1.614.673 permanent voter lists with 10.619 invalid votes. Based on these data, the initial population values $P(0) = 1.208.668$, $R(0) = 0$, and $A(0) = 406.005$ were taken. This research was analyzed using the parameter values listed in table 2 below:

Tabel 2. Parameter values

Parameter	$R_0 < 1$	$R_0 > 1$
Λ	0.12	0.12
μ	0.04	0.04
β	0.74	0.74
α	0.0098	0.25
γ	0.009	0.009

Based on **Table 2** which contains parameters, the basic reproduction numbers $R_0 = 1.601923076 > 1$ and $R_0 = 0.0678076923 < 1$ are obtained. The simulation is shown in the following figure

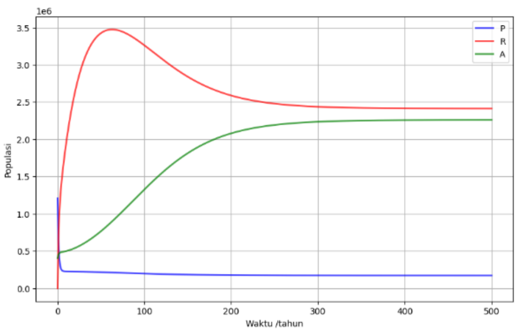

Figure 2. Dynamics Graph $R_0 > 1$

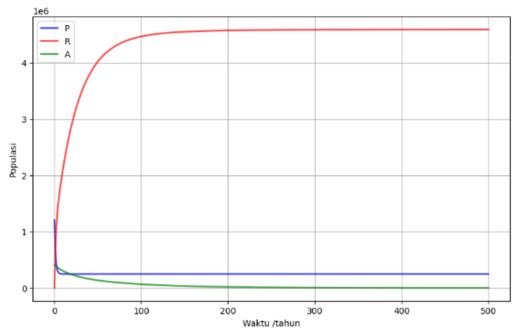

Figure 3. Dynamics Graph $R_0 < 1$

Figure 2 shows that the P population decreased until it stabilized at 171.497 individuals. The R population increased, then decreased until it stabilized at 2.413.153 individuals. The abstainer populations increased until it stabilized at 2.259.359 individuals. So, for $R_0 > 1$, the abstainer equilibrium point is asymptotically stable.

Figure 3 shows that the P population decreased until it stabilized at 248.410 individuals. The population of R increased until it stabilized at 4.595.240 individuals. Then, the abstainer population monotonically decreases and goes to zero. This shows that for $R_0 < 1$, the abstainer-free equilibrium point is asymptotically stable. This means that the abstainer population will disappear.

3.6.2 Numerical Simulation for 2024

According to data from the Medan City KPU in the 2024 election, the number of abstainers in Medan city reached 32.05%, which is 593.995 out of 1.853.458 permanent voter list with 12.983 invalid votes. Based on these data, the initial population values $P(0) = 1.272.446$, $R(0) = 0$, and $A(0) = 581.012$ were taken. This research was analyzed using the parameter values listed in table 3 below:

Table 3. Parameter values

Parameter	$R_0 < 1$	$R_0 > 1$
Λ	0.12	0.12
μ	0.04	0.04
β	0.68	0.68
α	0.0098	0.30
γ	0.010	0.010

Based on **Table 3** which contains parameters, the basic reproduction numbers $R_0 = 1.9583 > 1$ dan $R_0 = 0.74916 < 1$ are obtained. The simulation is shown in the following figure

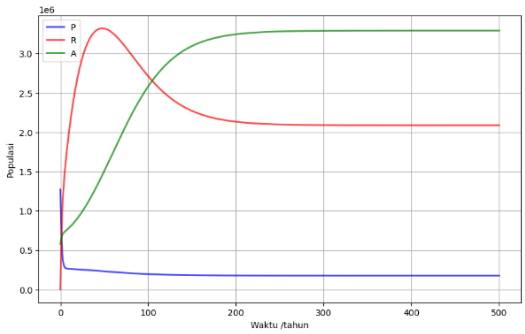

Figure 4. Dynamics Graph $R_0 > 1$

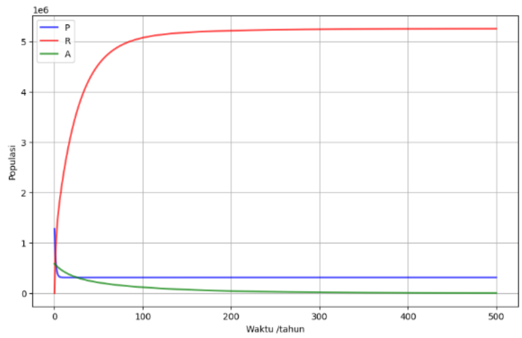

Figure 5. Dynamics Graph $R_0 < 1$

Figure 4 shows that the P population decreased until it stabilized at 177.489 individuals. The R population increased, then decreased until it stabilized at 2.089.170 individuals. The abstainer populations increased until it stabilized at 3.293.713 individuals. So, $R_0 > 1$, the abstainer equilibrium point is asymptotically stable.

Figure 5 shows that the P population decreased until it stabilized at 308.905 individuals. The population of R increased until it stabilized at 5.249.539 individuals. Then, the abstainer population monotonically decreases and goes to zero. This shows, for $R_0 < 1$, the abstainer-free equilibrium point is asymptotically stable. This means that the abstainer population will disappear.

The result of the analysis show that in the 2019 and 2024 simulations, the same results are obtained, namely when $R_0 > 1$, the abstainer equilibrium point is asymptotically stable, which means that the abstainer population has increased. This is in accordance with the data obtained from the KPU of Medan city that abstainer population in the 2019 election to the 2024 election has increased. By minimizing the abstention population rate, $R_0 < 1$, is obtained, this shows that the abstainer population will disappear.

4. Conclusion

In the mathematical model of the level of public participation in elections in Medan city, two equilibrium points are obtained, namely the abstainer-free equilibrium point and the abstainer equilibrium point. The stability analysis results show that the abstainer-free equilibrium point is asymptotically stable if $R_0 < 1$ and the abstainer equilibrium point is asymptotically stable if $R_0 > 1$. Based on the results of numerical simulations for 2019 and 2024, it was found that the 2019 simulation data when $R_0 > 1$ showed that the number of abstainer populations increased until it stabilizes at 2.259.359 individuals. Meanwhile, in 2024 the abstainer populations also increased until it stabilizes at 3.293.713 individuals. This shows that when $R_0 > 1$, the abstention population will remain and continue to increase in future elections. Then for, $R_0 < 1$, the abstainer population will decrease to zero. This shows that the abstainer population will disappear. In future research, researchers are expected to develop the model by adding assumptions, variables and parameters.

Referensi

[1] D. A. Putri, W. Windarto, and C. Alfiniyah, "Analisis Kestabilan dan Kontrol Optimal Model Matematika Partisipasi Pemilih pada Pemilihan Umum dengan Saturated Incidence Rate," *Contemp. Math. Appl.*, vol. 3, no. 1, p. 19, 2021, doi: 10.20473/conmatha.v3i1.26939.

[2] M. Anshar, Faisal, and L. A. Siska, "Model Matematika Penyebaran Konstituen Dalam Pemilihan Umum Presiden dengan Adanya Media Massa," vol. 17, no. 2, pp. 200–209, 2023.

[3] M. Indriany, "Partisipasi Masyarakat Dalam Pemilu 2019 Di Kabupaten Kutai Kartanegara," *eJournal Ilmu Pemerintah.*, vol.8, no. 2, pp. 545–558, 2020, https://ejournal.ip.fisip-unmul.ac.id.

[4] D. Suparto, *Membangun Kesadaran dan Partisipasi Politik Masyarakat*. Bandung: CV Cendikia Press, 2020.

[5] fadjar T. Sakti, *Pengantar Ilmu Politik*. Bandung: Fakultas Ilmu Sosial dan, 2020.

[6] M. A. Iqbal, "Partisipasi Politik Masyarakat Dalam Pemilihan Umum Tahun 2019 Di Kecamatan Tahuna Kabupaten Kepulauan Sangihe," *J. Eksek.*, vol. 1, no. 4, pp. 827–836, 2020.

[7] Badan Pusat Statistik, *Statistik Politik 2019*. Badan Pusat Statistik, 2019. [Online]. Available: https://www.bps.go.id/id/publication/2019/12/17/statistik-politik-2019.html

[8] Badan Pusat Statistik Provinsi Sumatera Utara, *Statistik Politik dan Keamanan Provinsi Sumatera Utara 2019*. [Online]. Available: https://sumut.bps.go.id/publication/2020/11/23.html

[9] A. S. Putri and N. E. Putri, "Faktor-Faktor Yang Mempengaruhi Partisipasi Politik Pemilih Pada Pilkada Serentak Kab 50 Kota Di Kecamatan Guguak," *JISIP (Jurnal Ilmu Sos. dan Pendidikan)*, vol. 6, no. 2, pp. 3747–3756, 2022, doi: 10.58258/jisip.v6i2.2955.

[10] M. . I. H. Rastami and Halking, "Peran Masyarakat dalam Partisipasi Politik Menghadapi Pemilihan Umum tahun 2024," *J. Mhs. Karakter Bangsa*, vol. 2, no. 1, pp. 136–143, 2023.

[11] S. Side, W. Sanusi, and N. K. Rustan, "Model Matematika SIR Sebagai Solusi Kecanduan Penggunaan Media Sosial," *J. Math. Comput. Stat.*, vol. 3, no. 2, p. 126, 2020, doi: 10.35580/jmathcos.v3i2.20124.

[12] B. Yong, "Model dinamika penyebaran pemilih dengan menggunakan pendekatan epidemiologi," pp. 155–160, 2020.

[13] A. Nurkifayah, E. Cahyono, M. Mukhsar, and A. Sani, "Analisis Model Sir Menggunakan Metode Euler Dan Runge-Kutta Orde Empat," *J. Mat. Komputasi dan Stat.*, vol. 2, no. 3, pp. 208–217, 2023, doi: 10.33772/jmks.v2i3.23.

[14] A. Agus, R. Rahmawati, and F. Fardinah, "Model Epidemi SIR Pengguna/Pemain Mobile Games Pada Mahasiswa Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Sulawesi Barat," *J. Math. Theory Appl.*, vol. 2, no. 2, pp. 46–53, 2021, doi: 10.31605/jomta.v2i2.1185.

[15] B. Yong, "A Mathematical Modelling of the Dynamics of Voters Model of Two Political Fanaticism Figures with the Interaction between Voters in Indonesian Presidential Elections," *J. Phys. Conf. Ser.*, vol. 2123, no. 1, 2021, doi: 10.1088/1742-6596/2123/1/012006.

[16] B. Yong and N. A. Samat, "The SIR political fanaticism figure voters model for estimating number of votes in Indonesia presidential elections," *Model Assist. Stat. Appl.*, vol. 13, no. 3, pp. 279–286, 2018, doi: 10.3233/MAS-180434.

[17] B. Yong, "Effect of Undecided and Swing Voters on the Dynamics Voters Model in Presidential Elections," *J. Phys. Conf. Ser.*, vol. 2123, no. 1, 2021, doi: 10.1088/1742-6596/2123/1/012012.

[18] O. Balatif, A. Labzai, and M. Rachik, "A discrete mathematical modeling and optimal control of the electoral behavior with regard to a political party," *Discret. Dyn. Nat. Soc.*, vol. 2018, 2018, doi: 10.1155/2018/9649014.

[19] O. Balatif, B. Khajji, and M. Rachik, *Mathematical Modeling, Analysis, and Optimal Control of Abstinence Behavior of Registration on the Electoral Lists*, vol. 2020, no. January. 2020. doi: 10.1155/2020/9738934.

[20] P. W. Yubelian and N. Y. Megawati, "Model Matematika Tingkat Partisipasi Masyarakat dalam Pemilu di Indonesia," *Limits J. Math. Its Appl.*, vol. 20, no. 3, p. 289, 2023, doi: 10.12962/limits.v20i3.16301.