Dynamical Analysis of Mathematical Model of Social Behavior with Law Enforcement and Religious Approaches

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ABSTRAK

Model matematika dapat digunakan untuk menggambarkan berbagai macam fenomena, salah satunya adalah fenomena sosial. Salah satu fenomena sosial yang menarik untuk dikaji adalah tentang tindak kriminal. Dengan membagi total populasi menjadi beberapa bagian berdasarkan status perilaku sosialnya, dapat dibangun model matematika untuk menggambarkan dinamika sosial. Dinamika sosial tersebut diketahui dengan melakukan analisis dinamik dan simulasi numerik. Dalam penelitian ini dilakukan simulasi numerik menggunakan software Maple 2022 dan metode Runge-Kutta. Berdasarkan hasil analisis dinamik dan simulasi numerik, diketahui bahwa dengan menerapkan penegakan hukum dan pendekatan keagamaan, tindak kriminal dalam suatu populasi dapat dikurangi bahkan dihilangkan.

Kata kunci: Model matematika; perilaku sosial; tindak kriminal; penegakan hukum; pendekatan keagamaan.

ABSTRACT

Mathematical models could be used to describe various phenomena, one of which is social phenomena. One of the interesting social phenomena to study is criminal behavior. By dividing the total population into several compartments based on their social behavior status, a mathematical model could be constructed to depict social dynamics. These social dynamics could be understood through dynamical analysis and numerical simulation. In this study, numerical simulations were conducted using Maple 2022 software and the Runge-Kutta method. Based on the results of dynamical analysis and numerical simulations, it is known that by implementing law enforcement and religious approaches, criminal activities within a population could be reduced or even eliminated.

Keywords: *Criminal behavior; law enforcement; mathematical model; religious approaches; social behavior.*

INTRODUCTION

According to the Oxford Language Dictionary, crime means an act or omission that constitutes a punishable offense under the law, or can also be interpreted as illegal activity, or an action or activity that, although not illegal, is considered morally wrong, shameful, or incorrect [1]. Meanwhile, according to the Oxford Dictionary of Sociology, crime is considered as a violation that extends beyond personal and public realms, breaking rules or laws that are prohibited, subject to legitimate punishment or sanctions, and requiring intervention by public authorities (state or local bodies). Ideally, institutions execute a formal system to handle crimes and employ representative officers (such as the police) to act on behalf of these institutions. In terms of law and jurisprudence, being guilty of a criminal act typically involves malicious intent or deliberate negligence, although there are exceptions in law. If conscious intent is proven absent (such as in cases involving children or the mentally ill), the offense is not considered a crime and may not incur regular punishment (though some forms of detention or therapeutic care may follow) [2].

Criminal behavior, broadly speaking, is a deviant behavior. Such behavior certainly disrupts social order. Therefore, law enforcement is necessary to prevent and overcome it. From a mathematical perspective, social behaviors could be modeled. Former researches that discuss mathematical model of criminal behavior includes: Misra (2014), who developed a model examining the impact of police strength in controlling crime within a population of varying sizes [3]; Abbas et al. (2017), who constructed a simpler model to depict the dynamics between two factions, where law enforcement is a factor in reducing the criminal population [4]. This model was further developed in subsequent research. González-Parra et al. (2018) considered the law enforcement process in more detail [5], Tripathi et al. (2021) incorporated Holling type II response function into their model [6], Kumar and Abbas (2023) explored age structure [7], and Arora et al. (2023) utilized a fractional-order model to describe the dynamics of criminal activity spread [8].

In addition to law enforcement, prevention of criminal acts can be achieved through religious approaches. In practice, one of the functions of religion in society is as a form of social control [9]. The religious approaches play a crucial role, both directly and indirectly, in preventing criminal behavior [10]. Considering that religious activities are expected to prevent individuals from committing evil and wrongful acts. A study mentioned that religious activities significantly influence social behavior due to the inherent values of goodness they promote [11].

In this study, we discuss a mathematical model of social behavior with law enforcement and religious approaches. The model is constructed by modifying previous mathematical models of social behavior in former research. Besides model modification, we also discuss dynamical analysis and numerical simulations of the modified model.

METHOD

There are six steps undertaken in this study, the steps are shown in Figure 1. The first step is literature review. In this step, data supporting and related to criminal behavior are collected, including the influence of law enforcement and religious approaches on such behavior. The literature review also identifies the mathematical model that be used as a reference for constructing the mathematical model of social behavior with law enforcement and religious approaches. The second step is modifying the mathematical model obtained from the first step. In the second step, new state variables and parameters are constructed to depict the mathematical model of social behavior with law enforcement and religious approaches. The third step is dynamical analysis of the modified model. This step aims to determine equilibrium points and eigenvalues of the system describing the model. The Routh-Hurwitz criterion is used to assess the stability characteristics of the obtained equilibrium points. The fourth step is numerical simulation. In numerical simulations, calculations are performed using Maple 2022 to verify the analytical results obtained in the previous steps, including equilibrium points, eigenvalues, and stability characteristics. The fourth-order Runge-Kutta method is used in numerical simulations to plot population dynamics graphs in the model of social behavior with law enforcement and religious approaches. The fifth step is drawing conclusions from the results obtained.

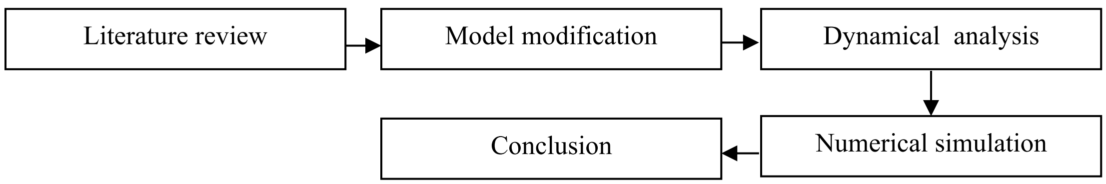


Figure 1. Research flow diagram

RESULT AND DISCUSSION

The mathematical model of social behavior with law enforcement and religious approaches builds upon the model developed by Abbas et al. [4]. In addition to the non-criminal population (N_p) and criminal population (C_p), another compartment is considered, namely the religious population denoted as R_p. Interactions between individuals from the criminal population and the religious population cause the criminal-minded individuals to change their status to be included in the non-criminal population. While, interactions between individuals from the non-criminal population and the religious population cause the non-criminal individuals to change their status to be included in the religious population. This is illustrated by the compartment diagram in Figure 2.

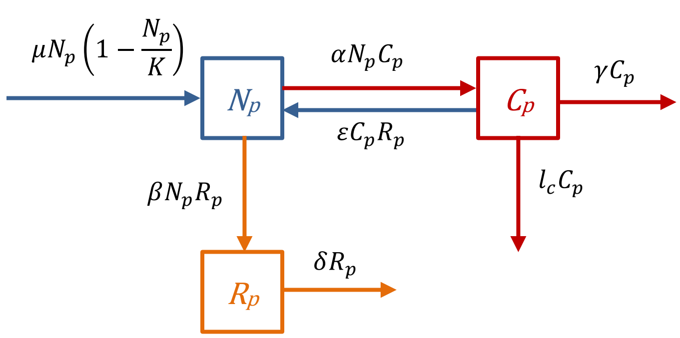


Figure 2. Compartment diagram of the mathematical model of social behavior with law enforcement and religious approaches

The compartment diagram in Figure 2 illustrates that the dynamics of the three populations in the model are affected by:

1. The growth of the non-criminal population is based on the logistic model $\mu N_p\ (1 - \frac{N_p}{K})$. Additionally, the non-criminal population increases due to interactions between the criminal population and the religious population, $\varepsilon C_p R_p$. Conversely, interactions between the non-criminal population and the criminal population decrease the non-criminal population by $\alpha N_p C_p$. Similarly, interactions between the non-criminal population and the religious population decrease the non-criminal population by $\beta N_p R_p$.
2. The growth of the criminal population is influenced by interactions between the non-criminal population and the criminal population, which increases the criminal population by $\alpha N_p C_p$. Conversely, it decreases due to interactions between the criminal population and the religious population, $\varepsilon C_p R_p$. The criminal population also decreases due to law enforcement measures $l_c C_p$ and natural deaths denoted by γC_p.
3. The growth of the religious population is influenced by interactions between the non-criminal population and the religious population, which increases it by $\beta N_p R_p$. Conversely, it decreases due to natural deaths in the religious population, denoted by δR_p.

The compartment diagram in Figure 2 could be mathematically expressed by the system of ordinary differential equations (1)-(3).

$$\frac{dN_p}{dt} = \mu N_p \left(1 - \frac{N_p}{K}\right) - \alpha N_p C_p - \beta N_p\, R_p \tag{1}$$

$$\frac{dC_p}{dt} = -\gamma C_p + \alpha N_p C_p - l_c C_p - \varepsilon C_p R_p \tag{2}$$

$$\frac{dR_p}{dt} = \beta N_p R_p - \delta R_p \tag{3}$$

Where μ is the natural growth rate, K is the carrying capacity of the environment, α is the criminality rate, β is the rate of interaction between the non-criminal population and the religious population, ε is the rate of interaction between the criminal population and the religious population, γ is the death rate of the criminal population, l_c is the law enforcement rate, and δ is the death rate of the religious population.

By solving $\frac{dN_p}{dt} = 0, \frac{dC_p}{dt} = 0, \frac{dR_p}{dt} = 0$, equilibrium points of the system (1)-(3) are obtained. There are five equilibrium points: the trivial equilibrium point $E_1 = (0,0,0)$, equilibrium points with no criminal community $E_2 = (K, 0,0)$ and $E_4 = \left(\frac{\delta}{\beta}, 0, \frac{\mu(\beta K - \delta)}{\beta^2 K}\right)$, equilibrium points with no religious community $E_3 = \left(\frac{\gamma + l_c}{\alpha}, \frac{\mu(\alpha K - \gamma - l_c)}{\alpha^2 K}, 0\right)$, and equilibrium point $E_5 = \left(\frac{\delta}{\beta}, \frac{\delta(\mu\beta K\varepsilon - \mu\delta\varepsilon + \gamma\beta^2 K - \alpha\beta\delta K + \beta^2 l_c K)}{\beta^2 K\varepsilon(\gamma + l_c)}, \frac{-\gamma\beta + \alpha\delta - \beta l_c}{\varepsilon\beta}\right)$. Using The Next Generation method to determine the basic reproduction number, R_0 is obtained as $R_0 = \frac{\alpha\delta\beta K + \varepsilon\mu\delta}{\beta K(\gamma\beta + l_c\beta + \varepsilon\mu)}$.

The Jacobian matrix of the system is

$$J = \begin{bmatrix} \mu - \frac{2\mu N_p}{K} - \alpha C_p - \beta R_p & -\alpha N_p + \varepsilon R_p & -\beta N_p + \varepsilon C_p \\ \alpha C_p & -\gamma + \alpha N_p - l_c - \varepsilon R_p & -\varepsilon C_p \\ \beta R_p & 0 & \beta N_p - \delta \end{bmatrix}. \quad (4)$$

By substituting equilibrium points into the Jacobian matrix and solving $|J_{E_i} - \lambda I| = 0$ for $i = 1,2,3,4,5$, the characteristic equations of each equilibrium point are determined. For equilibrium points E_1, E_2, E_3, and E_4, eigenvalues and stability properties could be obtained. However, for equilibrium point E_5, due to the algebraically length characteristic equation, stability is determined using the Routh-Hurwitz criterion. The results, shown in Table 1, with parameters a, b, c, and d are as follows.

$$a = \mu^2\gamma^2 + \mu^2 l_c^2 + 2\mu^2\gamma l_c + 4\alpha\mu K\gamma^2 + 4\alpha\mu K l_c^2 + 8\alpha\mu K\gamma l_c - 4\mu\alpha^2 K^2\gamma - 4\mu\alpha^2 K^2 l_c. \quad (5)$$

$$b = \mu\varepsilon\beta^2\gamma K + \mu\varepsilon\beta^2 l_c K - 2\mu\delta\varepsilon\beta\gamma - 2\mu\delta\varepsilon\beta l_c - \alpha\mu\delta\varepsilon\beta K + \alpha\mu\delta^2\varepsilon - \alpha\delta\gamma\beta^2 K + \alpha^2\delta^2\beta K - \alpha\delta l_c\beta^2 K + \gamma^2\beta^3 K + \gamma l_c\beta^3 K - \alpha\delta\beta^2\gamma K - \alpha\delta\beta^2 l_c K + \beta^3\gamma l_c K + \beta^3 l_c^2 K. \quad (6)$$

$$c = \frac{-bc_1(\gamma + l_c) + bc_2\left(\frac{-\beta\gamma + \alpha\delta - \beta l_c}{\varepsilon}\right) - c_3(\gamma + l_c)\frac{-\beta\gamma + \alpha\delta - \beta l_c}{\varepsilon}}{b}. \quad (7)$$

$$c_1 = \frac{\alpha\varepsilon\mu\delta\beta K - \alpha\varepsilon\mu\delta^2 + \alpha\delta\gamma\beta^2 K - \alpha^2\delta^2\beta K + \alpha\delta l_c\beta^2 K}{\varepsilon\beta^2(\gamma + l_c)K}. \quad (8)$$

$$c_2 = \frac{-\delta\beta^2\gamma K - \delta\beta^2 l_c K + \varepsilon\mu\delta\beta K - \varepsilon\mu\delta^2 + \delta\gamma\beta^2 K - \alpha\delta^2\beta K + \delta l_c\beta^2 K}{\beta^2(\gamma + l_c)K}. \quad (9)$$

$$c_3 = \frac{-\varepsilon\mu\delta\beta K + \varepsilon\mu\delta^2 - \delta\gamma\beta^2 K + \alpha\delta^2\beta K - \beta^2\delta l_c K}{\beta^2(\gamma + l_c)K}. \quad (10)$$

$$d = -c_3(\gamma + l_c)\frac{-\beta\gamma + \alpha\delta - \beta l_c}{\varepsilon}. \quad (11)$$

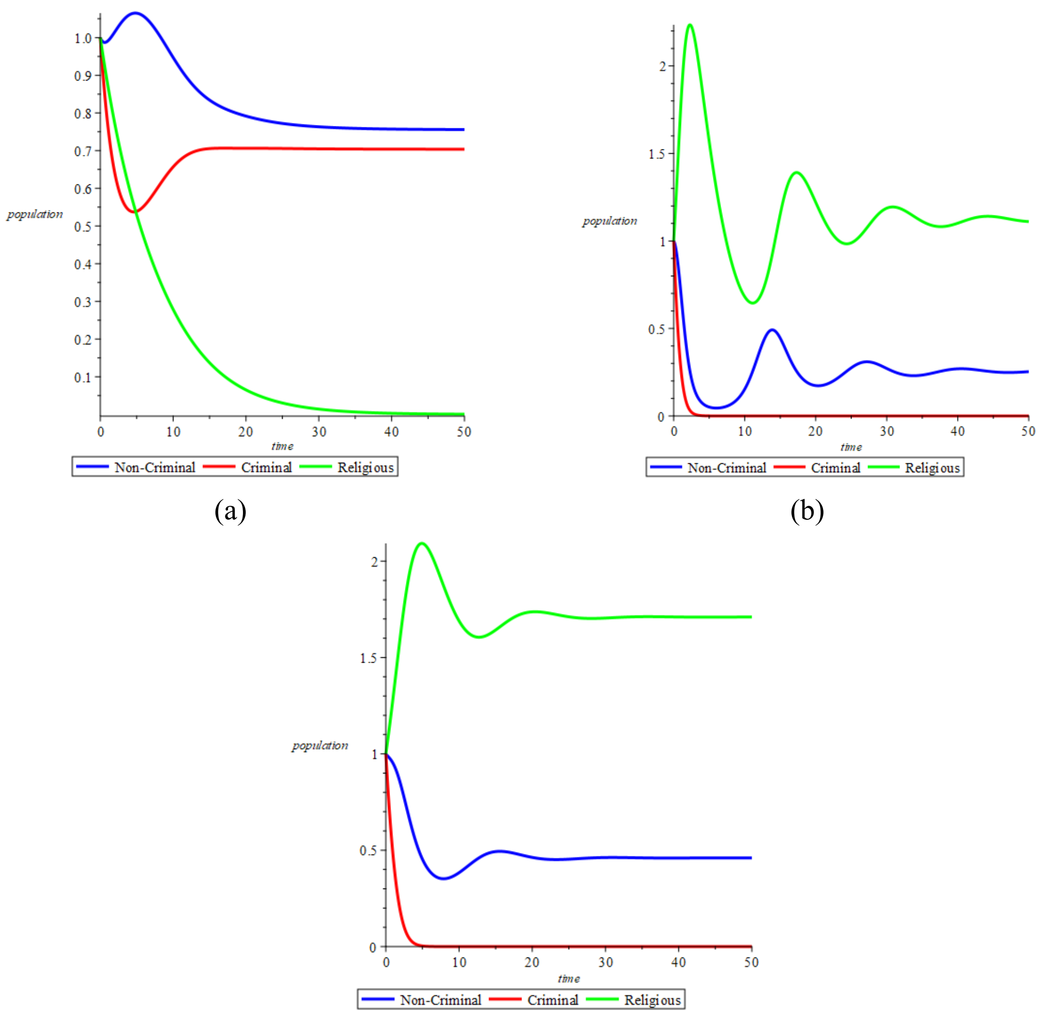
Table 1. Eigen value and stability of the equilibriums

Equilibrium	Eigen value	Stability
E_1	$\lambda_1 = \mu, \lambda_2 = -\gamma - l_c, \lambda_3 = -\delta.$	Unstable for all $K > 0$.
E_2	$\lambda_1 = -\mu, \lambda_2 = \alpha K - \gamma - l_c, \lambda_3 = \beta K - \delta.$	Stable if $\alpha K < \gamma + l_c$ and $\beta K < \delta$.
E_3	$\lambda_1 = \frac{\beta(\gamma + l_c)}{\alpha} - \delta, \lambda_2 = \frac{-\mu\gamma - \mu l_c + \sqrt{a}}{2\alpha K},$ $\lambda_3 = \frac{-\mu\gamma - \mu l_c - \sqrt{a}}{2\alpha K}.$	Stable if $\frac{\beta(\gamma + l_c)}{\alpha} < \delta$ and $\gamma + l_c < \alpha K$.
E_4	$\lambda_1 = \frac{\alpha\delta\beta K - \varepsilon\mu\beta K - \gamma\beta^2 K - l_c\beta^2 K + \varepsilon\mu\delta}{\beta^2 K},$ $\lambda_2 = \frac{-\mu\delta + \sqrt{\mu^2\delta^2 - 4\beta^2\delta\mu K^2 + 4\beta\delta^2\mu K}}{2\beta K},$ $\lambda_3 = \frac{-\mu\delta - \sqrt{\mu^2\delta^2 - 4\beta^2\delta\mu K^2 + 4\beta\delta^2\mu K}}{2\beta K}.$	Stable if $R_0 < 1$ and $\beta K > \delta$.
E_5	Not analyzed.	Stable if $b < 0$, $c < 0$, and $d < 0$.

In numerical simulations to depict population dynamics over time, parameter values used are $\mu = 1.2$, $\gamma = 0.23$, $l_c = 0.45$ [6], $\varepsilon = 0.5$, and $\delta = 0.23$. Meanwhile, for parameters α, β, and K, various values are employed to observe their effects on the system's solutions. Numerical simulations are conducted with three different cases: Case A where $\alpha > \beta$, Case B where $\alpha < \beta$, and Case C where $\alpha = \beta$. Each case is simulated with three different values of K, i.e. $K = 1.6$, $K = 16$, and $K = 160$. The comparison of values obtained from numerical simulations is presented in Tables 2, 3, and 4. The behavior of the system's solutions is illustrated in Figure 3, Figure 4, and Figure 5.

Table 2. The results of numerical simulation I ($K = 1.6$)

Parameter	Case A	Case B	Case C
α	0.9	0.1	0.5
β	0.1	0.9	0.5
Feasible equilibrium(s)	E_1, E_2, E_3	E_1, E_2, E_4	E_1, E_2, E_3, E_4
R_0	1.601	0.098	0.306
Stable equilibrium(s)	$E_3(0.756,0.704,0)$	$E_4(0.256,0,1.120)$	$E_4(0.460,0,1.710)$



(a) (b)

(c)

Figure 3. Population dynamics in the mathematical model of social behavior with law enforcement and religious approaches with $K = 1.6$, (a) $\alpha = 0.9, \beta = 0.1$, (b) $\alpha = 0.1, \beta = 0.9$, (c) $\alpha = 0.5, \beta = 0.5$

In numerical simulation I, the value $K = 1.6$ is used. In Table 2, it is observed that when $\alpha = 0.9 > \beta = 0.1$, the basic reproduction number $R_0 > 1$, and the numerical solution converges to equilibrium point E_3. When $\alpha = 0.1 < \beta = 0.9$, and $\alpha = \beta = 0.5$, the basic reproduction number $R_0 < 1$, and the numerical solution converges to equilibrium point E_4. With initial values $N_p(0) = 1$, $C_p(0) = 1$, and $R_p(0) = 1$, the behavior of the numerical solution in Figure 3 is obtained. Figure 3.a shows that over time, the numerical solution converges to E_3(0.756, 0.704, 0). This indicates that when the criminality rate is greater than the interaction rate between the non-criminal population and the religious population, over time, the system that initially with $N_p = C_p = R_p = 1$ evolves to $N_p = 0.756$, $C_p = 0.704$, and $R_p = 0$. In this case, eventually, the religious population becomes extinct, and criminal activities persist in the system.

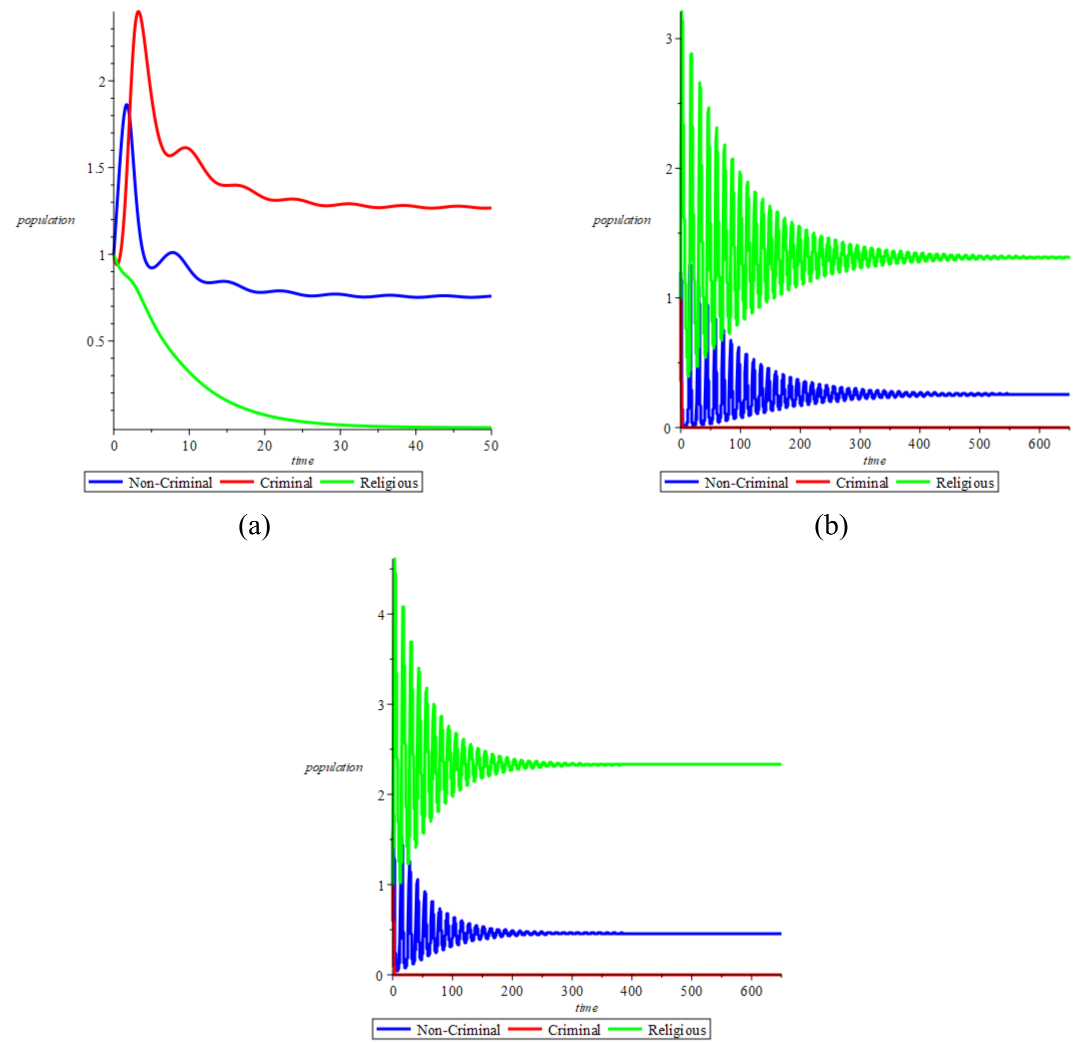
Figure 3.b shows that the numerical solution converges to E_4(0.256, 0, 1.120). This means that when the rate of interaction between the non-criminal population and the religious population is greater than the criminality rate, over time, the criminal population will eventually become extinct. Meanwhile, Figure 3.c demonstrates that the numerical solution converges to E_4(0.460, 0, 1.710). This indicates a similar outcome to Figure 3.b, with the difference lying in the time required to reach the equilibrium point free from criminal activities, E_4. Figure 3.b takes longer to converge compared to Figure 3.c. Based on the comparison of Case A, Case B, and Case C in numerical simulation I, it is evident that the ratio between α (criminality rate) and β (rate of interaction between the non-criminal population and the religious population) influences the dynamics occurring within the system.

In numerical simulation II and III, the carrying capacity values were increased compared to numerical simulation I, specifically to $K = 16$ and $K = 160$. The results obtained in simulations II and III are similar. The difference lies in the fact that with larger values of K compared to before, it is known from the results shown in Tables 3 and 4 that equilibrium points E_4 and E_5 are feasible in Case A, and equilibrium point E_3 is feasible in Case B. In Case A, it is found that E_3 and E_4 are locally stable. To observe this, the differences in the graphs shown in Figure 4 and Figure 5 can be noted.

Table 3. The results of numerical simulation II ($K = 16$)

Parameter	Case A	Case B	Case C
α	0.9	0.1	0.5
β	0.1	0.9	0.5
Feasible equilibrium(s)	E_1, E_2, E_3, E_4, E_5	E_1, E_2, E_3, E_4	E_1, E_2, E_3, E_4
R_0	0.439	0.027	0.141
Stable equilibrium(s)	E_3(0.756,1.270,0) and E_4(2.3,0,10.275)	E_4(0.256,0,1.312)	E_4(0.460,0,2.331)

In Figure 4.a, with $K = 16$, it can be seen that if the initial values are $N_p(0) = C_p(0) = R_p(0) = 1$, over time, the numerical solution in Case A converges to equilibrium point E_3(0.756, 1.270, 0). This means that the religious population will become extinct while the criminal population persists in the system. However, if the initial values are taken as $N_p(0) = C_p(0) = 1$, $R_p(0) = 3$, in Case A (see Figure 5.a), the numerical solution converges to equilibrium point E_4(2.3, 0, 10.275). This indicates that the criminal population becomes extinct, while the religious population remains. This shows that if the initial values are sufficiently close to equilibrium point E_3, the numerical solution will converge to E_3, whereas if the initial values are sufficiently close to equilibrium point E_4, the numerical solution will converge to E_4.



(a) (b)

(c)

Figure 4. Population dynamics in the model with $K = 16$, $N_p(0) = C_p(0) = R_p(0) = 1$ (a) $\alpha = 0.9$, $\beta = 0.1$, (b) $\alpha = 0.1$, $\beta = 0.9$, (c) $\alpha = 0.5$, $\beta = 0.5$

In other words, when the environmental capacity is increased, with the criminality rate greater than the rate of interaction between the non-criminal population and the religious population, the initial amount of the religious population plays a role in determining the behavior of the numerical solution. Meanwhile, in Figure 4.b and Figure 5.b, both show that the numerical solution converges to $E_4(0.256, 0, 1.312)$. Similarly, in Figure 4.c and Figure 5.c, both converge to $E_4(0.460, 0, 2.331)$. Similar results are obtained when $K = 160$ (see Table 4).

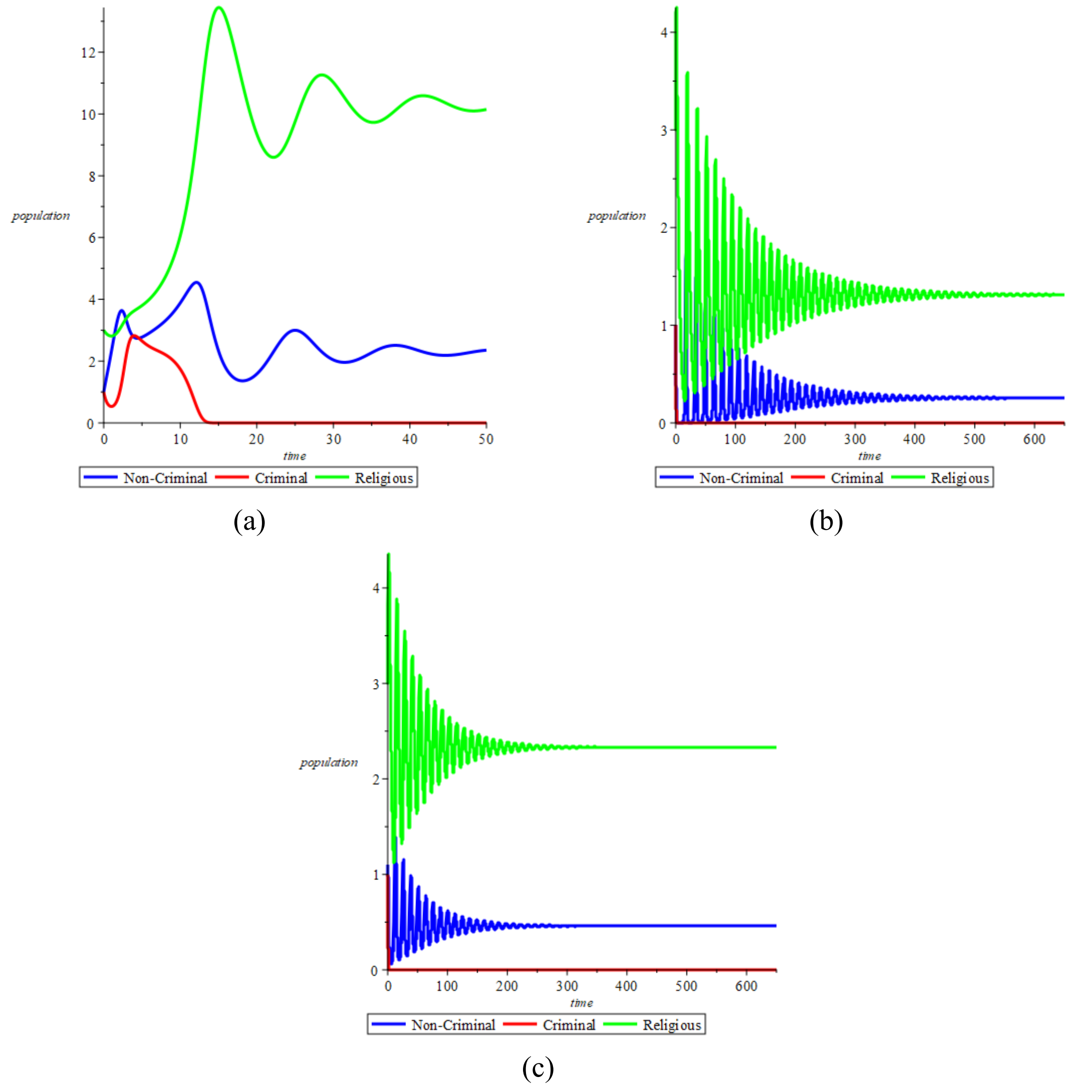


Figure 5. Population dynamics in the model with $K = 16$, $N_p(0) = C_p(0) = 1$, $R_p(0) = 3$ (a) $\alpha = 0.9$, $\beta = 0.1$, (b) $\alpha = 0.1$, $\beta = 0.9$, (c) $\alpha = 0.5$, $\beta = 0.5$

Table 4. The results of numerical simulation III ($K = 160$)

Parameter	Case A	Case B	Case C
α	0.9	0.1	0.5
β	0.1	0.9	0.5
Feasible equilibrium(s)	E_1, E_2, E_3, E_4, E_5	E_1, E_2, E_3, E_4	E_1, E_2, E_3, E_4
R_0	0.323	0.019	0.124
Stable equilibrium(s)	$E_3(1.327,0.756,0)$ and $E_4(2.3,0,11.828)$	$E_4(0.256,0,1.331)$	$E_4(0.460,0,2.393)$

CONCLUSION

Based on the results and discussion, two conclusions can be drawn. First, the value of the criminality rate and the rate of interaction between the non-criminal population and the religious population influence the dynamics within the system. If the criminality rate is greater than the rate of interaction with the religious population, the religious population may face extinction. Conversely, if the interaction rate with the religious population is greater than the criminality rate, then the criminal population may become extinct. Second, there are changes in the behavior of the solution of dynamic system as shown in the numerical simulations when the carrying capacity is increased. The changes of the solution's behavior as a parameter value varies indicate bifurcation in the system. However, bifurcation is not discussed in this study. Further studies could explore bifurcation occurring in models of social interaction between criminal and non-criminal behavior. In addition, a study mentioned the correlation of criminal acts with factors such as age, gender, and level of education [12]. This can certainly be used as the basis for developing models in future research.

REFERENCE

[1] Google Dictionary, "Crime Dictionary Definition," 06 December 2023. [Online]. Available: https://languages.oup.com/google-dictionary-en/. [Accessed 06 December 2023].

[2] J. Scott, "A Dictionary of Sociology," 06 December 2023. [Online]. Available: https://www.oxfordreference.com/display/10.1093/acref/9780199683581.001.0001/acref-9780199683581-e-441. [Accessed 06 December 2023].

[3] A. K. Misra, "Modeling the effect of police deterrence on the prevalence of crime in the society," *Applied Mathematics and Computation*, vol. 237, pp. 531-545, 2014.

[4] S. Abbas, J. P. Tripathi and A. A. Neha, "Dynamical analysis of a model of social behaviour: Criminal vs non-criminal population," *Chaos, Solitons and Fractals*, vol. 98, pp. 121-129, 2017.

[5] G. González-Parra, B. Chen-Charpentier and H. V. Kojouharov, "Mathematical modeling of crime as a social epidemic," *Journal of Interdisciplinary Mathematics*, vol. 21, no. 3, pp. 623-643, 2018.

[6] J. P. Tripathi, S. Bugalia, K. Burdak and S. Abbas, "Dynamical analysis and effect of law enforcement in a social interarction model," *Physica A*, vol. 567, p. 125725, 2021.

[7] M. Kumar and S. Abbas, "Modelling and prevention of crime using age-structure and law enforcement," *Journal of Mathematical Analysis and Applications*, vol. 519, no. 2, p. 126849, 2023.

[8] S. Arora, T. Mathur and K. Tiwari, "A fractional-order model to study the dynamics of the spread of crime," *Journal of Computational and Applied Mathematics*, vol. 426, p. 115102, 2023.

[9] Mulyadi, "Agama dan Pengaruhnya dalam Kehidupan," *Jurnal Tarbiyah Al-Awlad*, vol. 6, no. 2, pp. 556-564, 2016.

[10] K. Ihsan, "Faktor Penyebab Anak Melakukan Tindakan Kriminal (Studi Kasus Lembaga Pemasyarakatan Pekanbaru Kelas II B)," *JOM FISIP*, vol. 3, no. 2, pp. 1-15, 2016.

[11] A. S. Latifi, Suklani and Suteja, "Pengaruh Aktivitas Keagamaan Terhadap Perilaku Sosial Remaja Usia 13-18 Tahun di Blok 1 Desa Gembongan Induk Kecamatan Babakan Kabupaten Cirebon," *Al-Tarbawi Al-Haditsah: Jurnal Pendidikan Islam*, vol. 3, no. 1, pp. 154-169, 2018.

[12] W. Pramesti, "Analisis Korespondensi Untuk Mengetahui Keterkaitan Tindak Pidana Dengan Usia, Jenis Kelamin, Tingkat Pendidikan, Pekerjaan Dan Alasan Melakukan Tindak Pidana," *J-Statistika,* vol. 4, no. 2, pp. 41-54, 2012.