International Journal of Engineering & Technology, 7 (3) (2018) 1962-1969

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i3.16547
Research paper

Population prediction of purwanegara village, Indonesia using modified logistic model with migration factor

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Abstract

Population growth model is a widely been used model to do an estimation and forecasting towards the population of peoples, animals, bac-teria and even in economics growth. Many studies have been carried out on population growth model concerning the factors of birth, death and carrying capacity in order to predict the number of population at certain area. From these studies there is only one study involved the constant value factor of migration as an input in the logistic model. Therefore contradicting with the above modified logistic model, in this study logistic model is modified by adding a migration factor as a function of population. This function takes into account the migration and the interaction between peoples that is limited to the carrying capacity of the environment. This model can be solved qualitatively using the analysis of equilibrium point and quantitatively using the separable variables method. This modified logistic model with migration factor has been applied in the population prediction of Purwanegara village in Central Java Province, Indonesia. Throughout the results, the modified logistic model with migration factor as a function of population gives a better result for population prediction of Purwanegara village in Central Java Province, Indonesia compared with logistic model.

Keywords: *Logistic Model; Migration; Intrinsic Growth; Carrying Capacity of Environment; Population.*

1. Introduction

According to a recent report by the Population Reference Bureau [1], the population of the world will be able to achieve 9.9 billion by 2050. Currently, the estimated world inhabited by 7.6 billion people. When we use mathematics, the global population is now 33 percent larger than the previous 35 years. Prediction is larger than the latest estimates reported by the United Nations (UN). As it turned out, nowadays people live longer than in other history. It is caused by the presence of health care, nutrition, and access to food. The UN report also added that a lot of people who survive at reproductive age and the increasing migration of the more developed into many areas. Rapid population growth will likely be a challenge for future generations, including competition from sources such as clean water, food and size area [1].

According to the Statistics of Central Java Province (2016), the populations of Indonesia are all residents of the entire territory of Indonesia who have stayed for six months or longer, and those who intended to stay more than six months even though their length of stay is less than six months. In addition, population is one of the important assets for development since the population is the subject and object of development [2]. Therefore, it means the population acts as a development activist who aims for the benefit of the population. For example, if the immigrant population increased then ability to speak in a foreign language can be an asset as well as the ability to interact or mingle with different ethnic groups. In the development, the population quality can speed up the development process. However, the population lacking in quality will burden the development oppositely. The population growth for a country can be both strength and a burden. It depends on how the quality of the population. For Indonesia, the high population growth is the development burden because the population of Indonesia is quite large but the quality of life (prosperity) is still low. If the population growth is still high, the quality of life (prosperity) will decrease. According to Mantra [3], the development plan is necessary for the formulation of policies. For the planning of development it requires a prediction about the population.

2. Population prediction

Generally, the mathematical model that can be used to predict the population is population growth model (PGM) which can be written as

$$P'(t) = RP(t) + M \tag{1}$$

Where t is time, R is the intrinsic rate coefficient, P (t) represents number of population (NP) at time t and M is migration rate (MR) or factor which can be written as $M = \alpha - \beta$. Where α and β are immigration and emigration rates respectively. The migration factors can also take a constant value or as a function that depends on the population P (t) or time t . However, in this paper, considered R = R (P, t) and M = M (P, t) [4].

PGM consists of simple and complex models of population growth. The simple models are Malthus model (MM) and logistic model (LM). The Malthusian principle of explosive growth of human populations has become one of the classic laws of popula-

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tion change [4]. Formulas to be considered in MM are natural birth rate (m) and natural death rates (n), where intrinsic growth rate (r) is m – n [5]. If M = 0 and R (= r) is a positive constant, then (1) becomes

$$P'(t) = rP(t) \tag{2}$$

Where its solution is given by

$$P(t) = P_0 e^{rt} \text{ and } P_0 = P(t=0)$$

MM is a PGM that will keep increasing indefinitely for long term behavior [4]. LM is the extension of Malthus model with M = 0 and R (see (1.1)) has the form r – bP (t) where r and b are positive constants [4]. A negative coefficient b represents a restraint on the growth rate, whereas b positive would lead to accelerated growth. Thus, (1) becomes

$$P'(t) = (r - bP(t))P(t) \tag{3}$$

It is normal to write the coefficient rate of differential equation (3) by the coefficient rate

$$r\left(1 - \frac{P(t)}{K}\right);\ K = \frac{r}{b} \neq 0$$

Where r and K are positive constants. Thus, the LM with initial condition (IC) can be defined as

$$P'(t) = r\left(1 - \frac{P(t)}{K}\right)P(t);\ P(0) = P_0. \tag{4}$$

P = 0 and P = K are the solutions of (4) where K is called as the carrying capacity of the environment (CCE). In other words, LM assumes that for long term behavior the population will not keep increasing indefinitely but will be limited to the value of CCE [5]. Thus, LM is more realistic than MM to predict the population in the future.

3. Several studies of modified logistic model

Several studies have revealed the usefulness of logistic equations in estimating the events in the field of biology [6], economics [7] and demography [8]. In 2007, Peleg et al. have described the logistic equation based on the notion that the momentary growth rate of a given population introduced into a virgin environment is proportional to the momentary population's size and to the remaining material resources in the habitat that are still available for exploitation. Expressed mathematically:

$$N'(t) = k\left(1 - \frac{N(t)}{NA}\right)N(t) \tag{5}$$

Where N'(t) is the momentary rate, k is a proportionality constant, N(t) is the momentary (instantaneous) number of organisms and NA is the habitat's carrying capacity, quantified as the number of organisms that it can support. The proportionality constant k and to a lesser extent NA are temperature dependent but their magnitude is also affected by any other environmental factors that might influence the growth rate, notably the pH, water activity, the concentration of salts and so forth. In 2013, Ramos described logistic model for explaining and forecasting different areas in business and economics such as product diffusion and market acceptance, inflation rate of goods, purchasing power of peso, and employment and unemployment in the Philippines [9]. Expressed mathematically:

$$P'(t) = (a - bP(t))P(t) \tag{6}$$

Where P (t) is the number of Philippine mobile cellular telephone subscribers and a - bP(t) is the inflation rate function derived using the least square linear regression analysis. In 2014, Sari described logistic model to predict the population in Purwanegara village, Indonesia [10]. Equation (4), where P(t) is the number of population in Purwanegara village, r is intrinsic growth rate (birth minus death rate) in Purwanegara village and K is the used carrying capacity in Purwanegara village.

The complex population growth model of MM and LM are modified by considering many factors that affect the growth of population. Since the population is not only affected by birth and death factors, it can also be affected by migration factor so LM can be modified by taking into account the M factor [4]. In 1999, Meyer and Ausubel has modified (4) by replacing the constant K in (4) with a function K (t) as follows [11]:

$$P'(t) = r\left(1 - \frac{P(t)}{K(t)}\right)P(t),\ K'(t) = r_K\left(1 - \frac{K(t)}{K_K}\right)K(t) \tag{7}$$

In 2012, Laham et al. have modified the LM with periodic harvesting [12].

$$P'(t) = r\left(1 - \frac{P(t)}{K}\right)P(t) - H(t) \tag{8}$$

Modified logistic model with a constant migration factor (MLMCM) has been discussed by Rakhim [13],

$$P'(t) = r\left(1 - \frac{P(t)}{K}\right)P(t) + q \tag{9}$$

Where q is a constant value of migration factor.

In 2018, Wang et al have modified logistic model for heterogeneous populations [17]. Then, Sun et al have classified mixed logistic model prediction for clustered binary data [18].

According to the data supplied by local authority that Purwanegara village (refer as Village) is one of the important villages in subdistrict of the North Purwokerto, Banyumas regency, Central Java Province, Indonesia. Since the Village has a good economy growth and the location near the central of city with many universities, the Village allows to be a temporary location to live. A population prediction (PP) in the Village has been studied by Sari [10] using the LM and Rakhim [13] using the MLMCM.

Since the migration factor can be either a constant value or a specific function (a function of time or a function of population) [4]. In this paper, we propose an extension of MLMCM to form a new logistic model called MLMPP (Modified Logistic Model for Population Prediction) of the Village.

4. Research methodology

Methodologies for this research are extension of the MLMCM, application of the MLMPP and simulation of the MLMPP. Then, the results will be compared to LM. The MLMPP can be solved either by quantitative method (separate variables method (SVM)) or qualitative method (analysis equilibrium point method (AEPM)).

In order to apply the model used in this research, the data of the Village is used (Table 1). To apply MLMPP, the graph method (GM) and AEPM method are used. Data in December, 2011 (t = 0) is used as IC (P (0)), data in January, 2012 (t =1) until October, 2016 (t = 58) are used for determining the averages of intrinsic growth rate (IGR) and migration rate (MR) and data in November, 2016 (t = 59) is used to validate the MLMPP.

In the first step, we apply MLMPP with GM by computing the IGR, MR and CCE. According to Campbell and Reece (2005), suppose that B (t) and D (t) are the number of birth and death at time t respectively [14], and P (t) is the NP at t, then IGR at t is

Table 1: Population Data of the Village

t	Month, Year	The Number of			$r = r(t)$	The Number of		$M = M(t)$
		$P(t)$	$B(t)$	$D(t)$		$I(t)$	$E(t)$	
0	December, 2011	8042	19	9	0.00124347	28	20	0.00099477
1	January, 2012	8043	14	3	0.00136764	7	17	-0.00124331
2	February, 2012	8043	9	8	0.00012433	24	25	-0.00012433
3	March, 2012	8029	9	6	0.00037364	12	29	-0.00211732
4	April, 2012	8047	10	8	0.00024853	36	20	0.00198831
5	May, 2012	8046	10	3	0.00086999	21	29	-0.00099428
6	June, 2012	8061	11	3	0.00099243	25	18	0.00086837
7	July, 2012	8057	11	5	0.00074469	7	17	-0.00124115
8	August, 2012	8064	9	2	0.00086805	4	4	0.00000000
9	September, 2012	8056	5	7	-0.00024826	14	20	-0.00074478
10	October, 2012	8055	14	4	0.00124146	8	19	-0.00136561
11	November, 2012	8038	9	10	-0.00012440	5	21	-0.00199054
12	December, 2012	8044	12	6	0.00074589	10	10	0.00000000
13	January, 2013	8062	11	7	0.00049154	17	3	0.00173654
14	February, 2013	8057	7	11	-0.00049646	19	20	-0.00012411
15	March, 2013	8077	10	5	0.00061904	28	13	0.00185712
16	April, 2013	8090	14	7	0.00086526	11	5	0.00074165
17	May, 2013	8110	17	6	0.00135635	15	6	0.00110974
18	June, 2013	8124	17	4	0.00160019	18	17	0.00012309
19	July, 2013	8141	13	4	0.00110551	13	5	0.00098268
20	August, 2013	8154	10	1	0.00110375	15	11	0.00049055
21	September, 2013	8159	11	1	0.00122564	15	20	-0.00061282
22	October, 2013	8162	6	2	0.00049007	5	6	-0.00012251
23	November, 2013	8161	14	4	0.00122534	12	23	-0.00134787
24	December, 2014	8160	6	4	0.00024509	13	16	-0.00036764
25	January, 2014	8168	7	5	0.00024485	30	24	0.00077457
26	February, 2014	8163	4	5	-0.00012250	12	16	-0.00049001
27	March, 2014	8149	11	9	0.00024542	6	22	-0.00196343
28	April, 2014	8155	8	2	0.00073574	10	10	0.00000000
29	May, 2014	8159	5	2	0.00036769	16	15	0.00012256
30	June, 2014	8156	7	6	0.00012260	4	8	-0.00049043
31	July, 2014	8168	10	1	0.00110186	14	11	0.00036728
32	August, 2014	8174	13	5	0.00097871	18	20	-0.00024467
33	September, 2014	8162	13	3	0.00122518	13	35	-0.00269541
34	October, 2014	8173	13	3	0.00122354	9	8	0.00012235
35	November, 2014	8153	6	5	0.00012265	9	30	-0.0025757
36	December, 2014	8144	5	8	-0.00036836	9	15	-0.00073673
37	January, 2015	8155	8	5	0.00036787	32	24	0.00098099
38	February, 2015	8155	10	5	0.00061312	13	18	-0.00061312
39	March, 2015	8159	5	9	-0.00049025	11	13	-0.00024512
40	April, 2015	8157	11	4	0.00085815	10	18	-0.00098075
41	May, 2015	8161	18	8	0.00098027	12	18	-0.0007352
42	June, 2015	8164	10	7	0.00036746	14	14	0.00000000
43	July, 2015	8166	10	3	0.00085721	12	17	-0.00061229
44	August, 2015	8163	11	3	0.00098003	8	19	-0.00134754
45	September, 2015	8163	11	5	0.00073502	17	23	-0.00073502
46	October, 2015	8174	9	5	0.00048935	15	8	0.00085637
47	November, 2015	8154	5	9	-0.00049055	2	18	-0.00196222
48	December, 2015	8160	15	6	0.00110294	21	24	-0.00036764
49	January, 2016	8146	10	6	0.00049103	5	23	-0.00220967
50	February, 2016	8138	7	8	-0.00012288	12	19	-0.00086016
51	March, 2016	8139	10	4	0.00073719	18	23	-0.00061432
52	April, 2016	8137	12	8	0.00049158	13	19	-0.00073737
53	May, 2016	8154	7	1	0.00073583	18	7	0.00134903
54	June, 2016	8141	8	3	0.00061417	13	31	-0.00221103
55	July, 2016	8140	12	2	0.00122850	12	23	-0.00135135
56	August, 2016	8134	14	4	0.00122940	8	24	-0.00196705
57	September, 2016	8101	13	8	0.00061720	13	51	-0.00469077
58	October, 2016	8085	7	4	0.00037105	5	24	-0.00235003
59	November, 2016	8079	14	3	0.00136155	7	24	-0.00210422

$$r(t) = \frac{B(t)}{P(t)} - \frac{D(t)}{P(t)} \tag{10}$$

Suppose, I (t) and E(t) are the number of immigration and emigration at t respectively, then MR at t can be written by [15]

$$M(t) = (\alpha - \beta)(t) = \frac{I(t)}{P(t)} - \frac{E(t)}{P(t)} \tag{11}$$

In this study, it is assumed that CCE is landmass that can be populated divided by minimum floor area for 1 person.

In the second step, we apply MLMPP with GM by predicting the population of the Village in January, 2012 (t = 1) until October, 2016 (t = 58). The population prediction in the Village is performed by substituting the value of P (0), r, M(t), or (α - β) (t), K and t = 1…58 into specific solution of MLMPP. If r - (α - β) > 0, then specific solution of the MLMPP for Case 1, is used. If r - (α - β) < 0, then specific solution of the MLMPP for Case 2 is used. If the absoulte error of percentage (ARP) of population prediction is a small value (less than 5%) [16], then specific solution of the MLMPP can be employed to predict the population of the Village. Furthermore, the formula to find the ARP ($\varepsilon t\%$) is

$$\varepsilon t\% = \left|\frac{P(t)-G(t)}{P(t)}\right| \times 100\% \quad (12)$$

With G(t) is an estimated population (EP) at t [16].
In the third step, we apply MLMPP with growth rate (GR) for validating the model by using the data in November, 2016.
Validation model is a step to verify whether the obtained solution from the model can be used to predict the population in the future or not. If the validation model results show the ARP less than 5% [16], then the solution of the model can be used to predict the population in the future.
Furthermore, we apply MLMPP with AEPM in the Village. The value of r, (α - β) and K are used to compute the formula of asymptotically stable point where the detail will be given in the next section. If r - (α - β) > 0, then asymptotical stable point of the Case 1 is used. If r - (α - β) < 0, then asymptotically stable point of the Case [2] is used.
In this study, the simulation is operated by using Microsoft Visual Basic software (MVBS). The simulation of the MLMPP involves two steps. First step, simulate MLMPP by employing the input variables (K and P (0)) from the data of the Village and the other input variables (t, α - β) and r) are made as random values. Meanwhile, for the second step is to analyze the output in the model. In this research, model of [4] random data from the output will be analyzed. Then, in order to verify the result of the MLMPP, the results yielded from the quantitative and qualitative methods are compared with the output of the MLMPP.

5. Results and discussion

5.1. Extension of the model

The number of migration in population for long term behavior could be limited cause of CCE. In addition, the change of rate is directly proportional to the number of migration. The interactions between the individual in a population of push and pull factors cause the individual to perform the migration. Suppose, the dense population in a region led to interaction between individual that encourage them for the migration. Therefore, the number of migration is directly proportional to the interaction among the individual in the population. Thus, in this research, the function of population to be taken into account in the migration factor (M (P)), is

$$M(P) = \frac{(\alpha-\beta)(P(t))^2}{K} \quad (13)$$

If (13) is substituted into (1), we have MLMPP given by

$$\frac{dP(t)}{dt} = rP(t)\left(1-\frac{UP(t)}{rK}\right); U = r-(\alpha-\beta) > 0 \quad (14)$$

$$\frac{dP(t)}{dt} = rP(t)\left(1+\frac{UP(t)}{rK}\right); U = r-(\alpha-\beta) < 0 \quad (15)$$

In addition, MM if r = q, several cases to be considered as follows.
Case 1: r - (α - β) > 0 for this case, (14) can be solved to yield

$$P(t) = \frac{P_0 K}{\left(\frac{UP_0(1-e^{r(t_0-t)})}{r} + Ke^{r(t_0-t)}\right)} \quad (16)$$

And an asymptotically stable point

$$P(t) = \frac{Kr}{U} \quad (17)$$

By using Maple 13 software we have Fig. 1. Fig 1 shows the graph of solution MLMPP for Case 1.
Case 2: r - (α - β) < 0: For this case, (15) can be solved to yield

$$P(t) = \frac{P_0 K}{\left(\frac{-UP_0(1-e^{r(t_0-t)})}{r} + Ke^{r(t_0-t)}\right)} \quad (18)$$

And an asymptotically stable point

$$P(t) = -\frac{Kr}{U} \quad (19)$$

By using software Maple 13 software we have Fig. 2. Fig 2 shows the graph of solution MLMPP for Case 2.

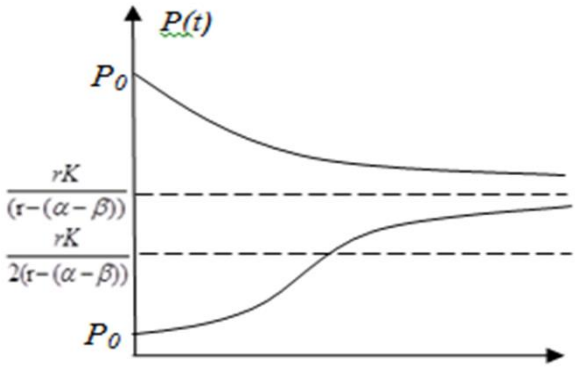


Fig. 1: Graph of Solution MLMPP for Case 1.

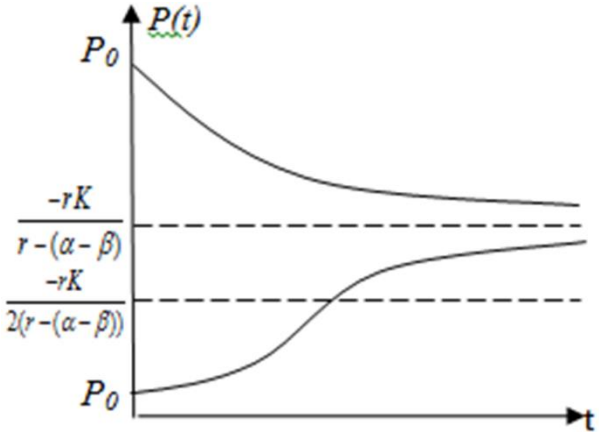


Fig. 2: Graph of Solution MLMPP for Case 2.

5.2. Application of the model

5.2.1. Graph method

According to Table 1, using the data from January, 2012 (t = 1) until October, 2016 (t = 58), and based on the equation (10), the average of IGR (r_a) can be computed as

$r_a(t) = \frac{1}{58}\sum_{t=1}^{58}\frac{B(t)-D(t)}{P(t)} = 0.00061941$ and by (11) the average of MR (α - β)a is given by

$$(\alpha-\beta)_a(t) = \frac{1}{58}\sum_{t=1}^{58}\frac{I(t)-E(t)}{P(t)} = -0.00054752$$

The area of Village is 1,727,100 m2. However, 1,290,400 m2 only can be populated (Statistics of Banyumas Regency, 2016). One indication of healthy home is a home which has minimum 10 m2 floor area per capita for 1 person (Statistics of Banyumas Regency, 2016). Suppose K is CCE in the Village, then

$$K = 1{,}290{,}400m^2 x\frac{1person}{10m^2} = 129{,}040person \quad (20)$$

Since ra > (α - β) a, Eq (16) is used to predict the population in the Village which is the specific solution of MLMPP for the Case 1. The estimated population (EP) in the Village can be obtained by substituting P (0) = 8042, ra = 0.0006194, (α - β)a, = -0.00054752, K = 129040 and t = 1…58 into Eq (16) (Table 2). For example to estimate the population in January, 2012 (t = 1), by using (16) with P (0) = 8042, ra = 0.0006194, (α - β)a, = -0.00054752, K = 129040 and t = 1…58 and (t = 1), the estimation of P(t) in January, 2012 (G(1)) as follows.

$$G(1)=\frac{8042x129040}{15149.658252(1-e^{0.00061941(-1)})+129,040e^{0.0006941(-1)}}\approx 8046$$

The ARP of (G (1)) is

$$\varepsilon t\%=\left|\frac{8043-8346}{8043}\right|\times 100\%=0.037\%$$

The average ARP for estimating the NP in the Village is 0.613 % (Table 2). Since the ARP of the estimated NP in the Village is a small value (less than 5%) [16], then Eq (16) can be used to predict NP in the Village.

Validation of the MLMPP can be done by examining the data of population November, 2016 (t = 59)) as shown in Table 4. By using Eq (16) with P(0) = 8042, r_a = 0.0006194, $(\alpha - \beta)_a$, = -0.00054752, K = 129040 and t = 59, the prediction of P(t) in November, 2016 (G(59)) is as follows

$$G(59)=\frac{8042x129040}{15149.658252(1-e^{0.00061941(-59)})+129,040e^{0.0006941(-59)}}\approx 8305$$

The ARP of (G (59)) is

$$\varepsilon t\%=\left|\frac{8079-8305}{8079}\right|\times 100\%=2.797\%$$

The result showed that the ARP of data in November, 2016 by using Eq (16) which is 2.797 % (less than 5%). Thus, Eq (16) can be used to predict P(t) in the future. The results for predicting the NP in December, 2016 until December, 2018 are given in Table 3. According to Table 3, P(t) increases every month.

Through Eq (16) with P(0) = 8042, r_a = 0.0006194, $(\alpha - \beta)_a$, = -0.00054752, K = 129040 and t = 20000, the graph of population prediction for long term behavior by using Maple 13 software is shown in Fig. 3. Also, in the Village increases every month (t) and will approach a constant value, 68495. In other words, P(t) in the Village for long term behavior time will rise every month but limited to 68495 (see Table 4).

5.2.2. Analysis on equilibrium point method

Since the Village's average intrinsic growth rate is greater than the average migration rate, we refer the Case : r - (α - β) > 0. Therefore, the average value of asymptotically stable point can be computed through the formula $r_aK\div(r_a-(\alpha-\beta)_a)$ as given in Table 5. Clear that, from Table 5 that P(t) in the Village for long term behavior will approach to 68495 which is no growth in population.

5.2.3. Logistic model to predict the population in village

In order to predict the NP of Village in January, 2012 (t = 1) until October, 2016 (t = 58) with LM, it can be obtained through Eq (4), when P (0) = 8042, r_a =0.00061941, and K = 129040 (Table 6).

The average ARP of the estimated NP of Village is 0.695 %. Since the ARP of predicted NP of Village is a small value (less than 5%), then Eq (4) can be employed to predict the NP of Village. According to the ARP of the estimated NP of Village, the MLMPP (0.613 %) is less than LM (0.695 %). So, MLMPP is better than LM to predict the NP of Village.

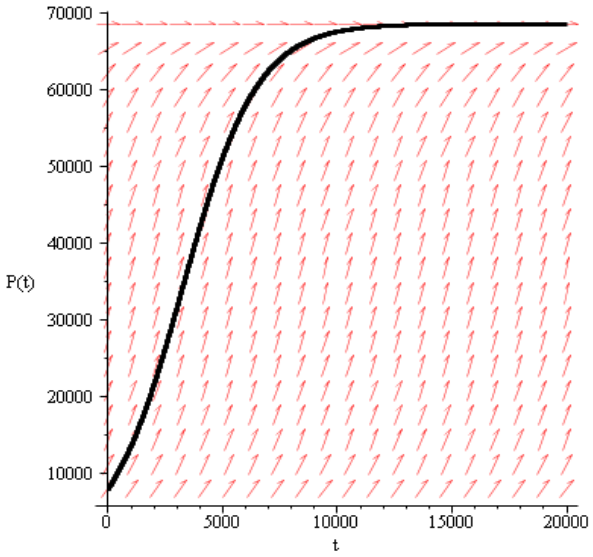


Fig. 3: Graph for Estimating the NP in the Village for Long Term Behavior.

Validation of the model can be done by examining the data of NP of Village in November, 2016 (t = 59)). By using Eq (4) with P(0) = 8042, r_a =0.00061941, K = 129040 and t = 59, the predicted NP of Village in November, 2016 (G (59)) with LM is 8322 (Table 7). The ARP of estimated NP of Village in November, 2016 with through the LM is 3.00%. The result shows that the ARP of data November, 2016 by using Eq (4) which is 3.00 % (less than 5%). Thus, Eq (4) can be used to predict NP of Village in the future. According to the validation model, by using data of NP of Village in November, 2016, the ARP of LM is 3.00 % but the ARP of MLMPP is 2.79 %. In other words, MLMPP is better than LM for predicting the NP of Village in the future.

5.3. Simulation of the model

By using the constant value of CCE (K = 129040) and IC (P(0) = 8042) from the data of Village and random value of IGR and MR with the simulation work that using Microsoft Visual Basic software, the simulation of the MLMPP is obtained. Random value of IGR and MR are used for analyzing the effects of IGR and MR in each case, (i) r - (α - β) > 0 and (ii) r - (α - β) < 0 of the MLMPP. In this study 4 random values were taken from the outputs of the simulation to be used in analysis. Simulation 1: According to the output by using P (0) = 8042, r =0.00001175, K = 129040, and α – β = -0.00021130 and t = 12553, the NP $=7846$ is obtained. In other words, Simulation 1 is the case 1 r - (α - β) > 0. By using Maple 13 software we have graph of simulation 1 is given in Fig. 4. From the Fig. 4, if P (0) = 8042 then P (t) = 7846. Hence, both of NP results from the Simulation 1 and GM gives the same result, which is 7846. The graph of simulation 1 decreases since P(0) = 8042 > 6802 the asymptotically equilibrium point (6802). It gives the same result with the Case 1: r - (α - β) > 0 as shown in Fig. 4 where $P(0)>\frac{rK}{r-(\alpha-\beta)}$.

Simulation 2: According to the output by using P(0) = 8042, r = 0.00140354, K = 129040, and α – β = -0.000220631 and t = 2809, the NP $=112434$ is obtained. In other words, Simulation 2 is the Case 1: r - (α - β) > 0. By using Maple 13 software we have graph of simulation 2 is given in Fig. 5. From the Fig. 5, if P (0) = 8042 then P(t) = 112434. Hence, both of the NP results from Simulation 2 and GM gives the same result which is 112434. The graph of Simulation 2 increases since P(0) = 8042 < 151277 the asymptotically equilibrium point (151277). It gives the same result with the Case 1: r - (α - β) > 0 as shown in Fig. 5 where $P(0)<\frac{rK}{r-(\alpha-\beta)}$.

Table 2: The EP and ARP (= $\varepsilon t\%$) by Using MLMPP

t	Month, Year	NP	EP	$\varepsilon t\%$	t	Month, Year	NP	EP	$\varepsilon t\%$
1	January, 2012	8043	8046	0.037	30	June, 2014	8156	8175	0.232
2	February, 2012	8043	8051	0.099	31	July, 2014	8168	8179	0.134
3	March, 2012	8029	8055	0.323	32	August, 2014	8174	8184	0.122
4	April, 2012	8047	8060	0.161	33	September, 2014	8162	8188	0.318
5	May, 2012	8046	8064	0.223	34	October, 2014	8173	8193	0.244
6	June, 2012	8061	8068	0.086	35	November, 2014	8153	8197	0.539
7	July, 2012	8057	8073	0.198	36	December, 2014	8144	8202	0.712
8	August, 2012	8064	8077	0.161	37	January, 2015	8155	8206	0.625
9	September, 2012	8056	8082	0.322	38	February, 2015	8155	8211	0.686
10	October, 2012	8055	8086	0.384	39	March, 2015	8159	8215	0.686
11	November, 2012	8038	8090	0.646	40	April, 2015	8157	8220	0.772
12	December, 2012	8044	8095	0.634	41	May, 2015	8161	8224	0.771
13	January, 2013	8062	8099	0.458	42	June, 2015	8164	8229	0.796
14	February, 2013	8057	8104	0.583	43	July, 2015	8166	8233	0.820
15	March, 2013	8077	8108	0.383	44	August, 2015	8163	8237	0.906
16	April, 2013	8090	8113	0.284	45	September, 2015	8163	8242	0.967
17	May, 2013	8110	8117	0.086	46	October, 2015	8174	8246	0.880
18	June, 2013	8124	8121	0.369	47	November, 2015	8154	8251	1.189
19	July, 2013	8141	8126	0.184	48	December, 2015	8160	8255	1.164
20	August, 2013	8154	8130	0.294	49	January, 2016	8146	8260	1.399
21	September, 2013	8159	8135	0.294	50	February, 2016	8138	8264	0.319
22	October, 2013	8162	8139	0.281	51	March, 2016	8139	8269	0.368
23	November, 2013	8161	8144	0.208	52	April, 2016	8137	8273	1.671
24	December, 2014	8160	8148	0.147	53	May, 2016	8154	8278	1.520
25	January, 2014	8168	8153	0.183	54	June, 2016	8141	8282	1.731
26	February, 2014	8163	8157	0.073	55	July, 2016	8140	8287	1.805
27	March, 2014	8149	8161	0.147	56	August, 2016	8134	8291	1.930
28	April, 2014	8155	8166	0.134	57	September, 2016	8101	8296	2.407
29	May, 2014	8159	8170	0.134	58	October, 2016	8085	8301	2.671

Table 3: Predicting NP in the Village by Using MLMPP

t	Month, Year	EP	t	Month, Year	EP	t	Month, Year	EP
60	December, 2016	8310	68	August, 2017	8346	76	April, 2018	8382
61	January, 2017	8314	69	September, 2017	8350	77	May, 2018	8387
62	February, 2017	8319	70	October, 2017	8355	78	June, 2018	8391
63	March, 2017	8323	71	November, 2017	8359	79	July, 2018	8396
64	April, 2017	8328	72	December, 2017	8364	80	August, 2018	8400
65	May, 2017	8332	73	January, 2018	8369	81	September, 2018	8405
66	June, 2017	8337	74	February, 2018	8373	82	October, 2018	8410
67	July, 2017	8341	75	March, 2018	8378	83	November, 2018	8414
						84	December, 2018	8419

Table 4: Validation of the MLMPP and Population Prediction in T = 20000

	t	Month, Year	P(0)	NP or EP = G(59)	$\varepsilon t\%$
Validation of Method	59	November, 2016	8042	8305	2.797
Population Prediction	20000		8042	68495	

Table 5: The Average Value for Asymptotically Stable Point

r_a	$(\alpha-\beta)_a$	Case 1	K	$r_aK \div (r_a-(\alpha-\beta)_a)$
0.00061941	-0.00054752	> 0	129040	68495

Table 6: The EP and ARP (= $\varepsilon t\%$) by Using LM

T	Month, Year	NP	EP	$\varepsilon t\%$	t	Month, Year	NP	EP	$\varepsilon t\%$
1	January, 2012	8043	8047	0.049	30	June, 2014	8156	8183	0.331
2	February, 2012	8043	8051	0.099	31	July, 2014	8168	8188	0.244
3	March, 2012	8029	8056	0.336	32	August, 2014	8174	8193	0.232
4	April, 2012	8047	8061	0.173	33	September, 2014	8162	8198	0.441
5	May, 2012	8046	8065	0.236	34	October, 2014	8173	8202	0.354
6	June, 2012	8061	8070	0.111	35	November, 2014	8153	8207	0.662
7	July, 2012	8057	8075	0.223	36	December, 2014	8144	8212	0.834
8	August, 2012	8064	8079	0.186	37	January, 2015	8155	8217	0.760
9	September, 2012	8056	8084	0.347	38	February, 2015	8155	8221	0.809
10	October, 2012	8055	8089	0.422	39	March, 2015	8159	8226	0.821
11	November, 2012	8038	8094	0.696	40	April, 2015	8157	8231	0.907
12	December, 2012	8044	8098	0.671	41	May, 2015	8161	8236	0.919
13	January, 2013	8062	8103	0.508	42	June, 2015	8164	8240	0.930
14	February, 2013	8057	8108	0.632	43	July, 2015	8166	8245	0.967
15	March, 2013	8077	8112	0.433	44	August, 2015	8163	8250	1.065
16	April, 2013	8090	8117	0.333	45	September, 2015	8163	8255	1.127
17	May, 2013	8110	8122	0.147	46	October, 2015	8174	8260	1.052
18	June, 2013	8124	8126	0.024	47	November, 2015	8154	8264	1.349
19	July, 2013	8141	8131	0.122	48	December, 2015	8160	8269	1.335
20	August, 2013	8154	8136	0.220	49	January, 2016	8146	8274	1.571
21	September, 2013	8159	8141	0.220	50	February, 2016	8138	8279	0.503

22	October, 2013	8162	8145	0.208	51	March, 2016	8139	8284	0.552
23	November, 2013	8161	8150	0.134	52	April, 2016	8137	8288	1.855
24	December, 2014	8160	8155	0.061	53	May, 2016	8154	8293	1.704
25	January, 2014	8168	8160	0.097	54	June, 2016	8141	8298	1.928
26	February, 2014	8163	8164	0.012	55	July, 2016	8140	8303	2.002
27	March, 2014	8149	8169	0.245	56	August, 2016	8134	8308	2.139
28	April, 2014	8155	8174	0.232	57	September, 2016	8101	8312	2.604
29	May, 2014	8159	8179	0.245	58	October, 2016	8085	8317	2.869

Table 7: Validation of the LM

	T	Month, Year	P(0)	NP or EP = G(59)	$\varepsilon t\%$
Validation of Method	59	November, 2016	8042	8322	3.00

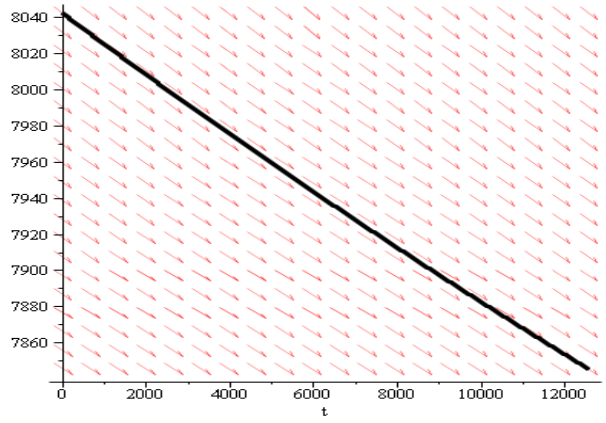


Fig. 4: Graph of Simulation.

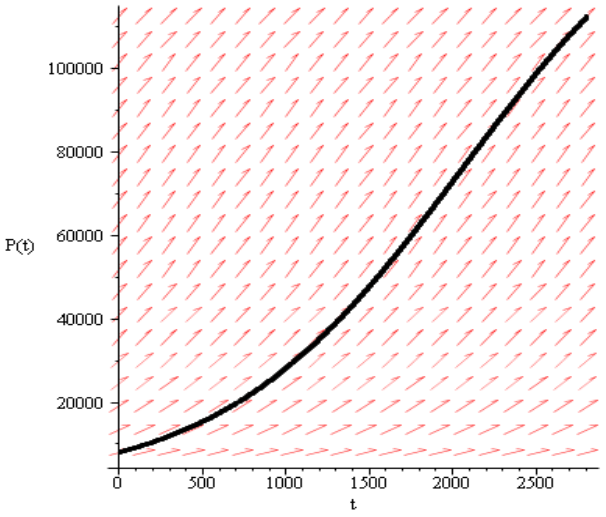


Fig. 5: Graph of Simulation 2.

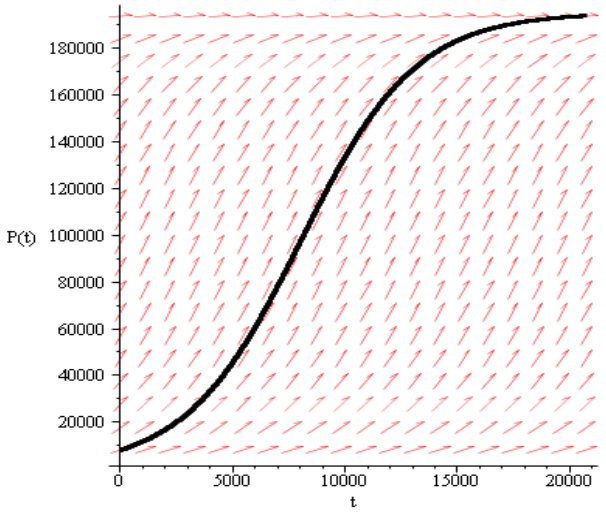


Fig. 6: Graph of Simulation 3.

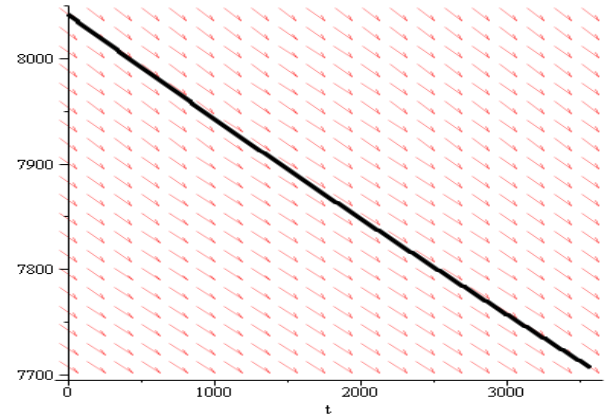


Fig. 7: Graph of Simulation 4.

Simulation 3: According to the output by using P (0) = 8042, r =0.00039197, K = 129040, α – β = 0.00065097 and t = 20747, the NP =193964 is obtained. In other words, Simulation 3 is the Case 2 r - (α - β) < 0. By using Maple 13 software we have graph of simulation 3 is given in Fig. 6. From the Fig. 6, if P (0) = 8042 then P(t)=193964. Hence, both of the NP results from Simulation 3 and GM gives the same result which is 193964. The graph of Simulation 3 increases because P(0) = 8042 < 195293 the asymptotically equilibrium point (195293). It gives the same result with the Case 2: r - (α - β) < 0 as shown in Fig. 6 where $P(0) < -\frac{rK}{r-(\alpha-\beta)}$.

Simulation 4: According to the output by using P (0) = 8042, r =0.00001763, K = 129040, α – β = 0.00050201 and t = 3572, the NP = 7707 is obtained. In other words, Simulation 4 is the Case 2 r - (α - β) < 0. By using Maple 13 software we have graph of simulation 4 is given in Fig. 7. From the Fig. 7, if P(0) = 8042 then P(t)=7707. Hence, both of the NP results from Simulation 4 and GM gives the same result, which is 7707. The graph of Simulation 4 decreases because P (0) = 8042 > 7707 the asymptotically equilibrium point (4697). It gives the same result with the Case [2] r - (α - β) < 0 as shown in Fig. 7 where $P(0) > -\frac{rK}{r-(\alpha-\beta)}$.

6. Conclusion

In this paper, the proposed modified logistic model named MLMPP is given by equations (14) and (15) for the cases r - (α - β) > 0 and Eq (15) if r - (α - β) < 0 respectively. The solutions yielded for MLMPP's models (14) and (15) by using the SVM are described by equations (16) and (17) respectively. While the MLMPP's solutions for models (14) and (15) by using AEPM are equations (17) and (19) respectively. According to the data of the Village in December, 2011 until November, 2016 through the GM, the average ARP for the estimation by using MLMPP is 0.61376782% which is less than LM (0.69512286%). Thus, MLMPP is better than LM to predict the NP in Village. According to the model of validation the ARP of MLMPP is 2.79737591% which is slightly lower than the ARP of LM (3.00779799%). In other words, MLMPP is better than LM for predicting the future NP in Village. The NP in Village through the AEPM for long-term behavior approaches 68495 persons. According to the findings of simulation for the MLMPP, the outputs of the population

able to estimate the results similarly to the solutions of equations (14) and (15).

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