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Comparison of Milne-Simpson Method and Hamming Method in Logistic Equation Settlement on Pert Prediksi the People of Bandar Lampung City

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Abstract. Milne-Simpson method and Hamming method are a numerical method that can be applied in the calculation of population prediction in the future as a reference government in building an area. Beginning with the calculation of growth rates with logistic equations then processed into the fourth-order Runge-Kutta method. The recalculation process continues to search for the smallest error between the Milne-Simpson method and the Hamming method. Error calculation is done with population growth rate 5.2% with step size h = 1 and capacity of Bandar Lampung city 1.500.000 soul. Numerical solutions show population growth annually and Milne-Simpson method is the best method seen from the smaller error than the Hamming method error.

1. Introduction

The amount of price is one of the factors in the development planning to be done or minimized negatively on society. In planning it required data with calculations to predict the number of residents who will in the following years. This problem can be solved using nonlinear differential equations is logistic model according to Verhults [1]. Analysis can be analytic. But often therein. The numerical method can be used as an alternative. In numerical there are two methods: one step method and multi steps method. Multi-step method which then in many journals is Adam Bashforth-Moulton method, Milne-Simpson method and Hamming method [2]. Based on the methods that are widely used in some media used to predict population growth. Therefore the author of Milne-Simpson method and Hamming method in an alternative Logistic Equation on population growth prediction of Bandar Lampung City [3].

2. Materials and Methods

Population data from 2010 to 2015 is obtained from BPS Lampung website [4]. The nonlinear diffusion equation was applied to the prediction of population growth of Bandar Lampung City through logistic equation which begins by calculating population growth rate and determining capacity of Lampung City Capacity. The calculation by Runge Kutta Method of order 4 is done analytically to get 4 initial solution followed by calculating predictors and corrector of the Milne-Simpson method and the Hamming method on the fourth approximation and continued numerical computation until the 1st approximation [3]. An error of the Milne-Simpson method and the Hamming method to compare the best method are shown [5].

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3. Result and Discussion

Table 1. Number of residents of Bandar Lampung City

Year	Total Population
2010	885.363
2011	904.322
2012	923.175
2013	942.039
2014	960.695
2015	979.287

Population growth rate [1]:

$$m = \frac{1}{t} ln \frac{P(t)}{P_0} \quad (1)$$

$$m = 0.052$$

Furthermore assumed capacity Lampung Bandar Lampung city that is *K* = 1,500,000

The step size *h* is determined by the following formula:

$$h = \frac{b-a}{n} \quad (2)$$

$$h = 1$$

Logistics equation of population of Bandar Lampung City:

$$\frac{dP}{dt} = 0,052P\left(1 - \frac{P}{1.500.000}\right) \quad (3)$$

Determination of initial solution by Runge-Kutta method of order 4 [6]:

$$k_1 = hf\ (x_n, y_n) \quad (4)$$

$$k_2 = hf\left(x_n + \frac{h}{2}, y_n + \frac{k_1}{2}\right) \quad (5)$$

$$k_3 = hf\left(x_n + \frac{h}{2}, y_n + \frac{k_2}{2}\right) \quad (6)$$

$$k_4 = hf\ (x_n + h, y_n + k_3)$$

$$y_{n+1} = y_n + \frac{1}{6}(k_1 + 2k_2 + 2k_2 + k_4) \quad (7)$$

For *x* = 0 and *y* = 885.363

$$k_1 = f(0; 885.363)$$

$$k_1 = 0,052 * 885.363\ \left(1 - \frac{885.363}{1.500.000}\right)$$

$$k_1 = 18.864,798$$

$$k_2 = 18.773,189$$

$$k_3 = 18.773,649$$

$$k_4 = 18.676,386$$

$$y_1 = 885.363 + \frac{1}{6}(18.864,798 + 2 * 18.773,189 + 2 * 18.773,649 + 18.676,386)$$

$y_1 = 904.135{,}476$
$y_2 = 922.892{,}868$
$y_3 = 941.521{,}088$

Completion of logistic equations by Milne-Simpson method [6]:

$$Predictor: y_{n+1} = y_{n-3} + \frac{4h}{3}(2f_{n-2} - f_{n-1} + 2f_n)$$

$$Corrector: y_{n+1} = y_{n-1} + \frac{h}{3}(f_{n-1} - 4f_n + f_{n+1})$$

Specifies the prior value of $f_n(x_n, y_n)$

For x = 0 and y = 885.363
$f_0(x_0, y_0)$ = (1; 885.363)
$f_0(x_0, y_0) = 0{,}052 * 885.363\ (1 - \frac{885.363}{1.500.000})$
$f_0(x_0, y_0) = 18.864{,}798$
$f_1(x_1, y_1) = 18.676{,}398$
$f_2(x_2, y_2) = 18.463{,}746$
$f_3(x_3, y_3) = 18.228{,}415$
$f_4(x_4, y_4) = 17.983{,}442$

Table 2. Table of Numerical Solution Results Method Milne-Simpson

Year	T	Predictor	Corrector	Error
2010	0	-	885.363	0
2011	1	-	904.135,476	0
2012	2	-	922.892,868	0
2013	3	-	941.521,088	0
2014	4	959.157,508	959.158,485	2.803e-08
2015	5	977.023,424	977.479,580	2.372e-08
2016	6	994.759,500	994.577,451	2.057e-08
2017	7	1.012.321,121	1.011.863,645	1.627e-08
2018	8	1.028.800,678	1.028.988,367	1.202e-08
2019	9	1.045.480,306	1.045.924,212	8.066e-08
2020	10	1.061.919,827	1.061.742,583	4.213e-08

Solving Logistic Equations With Hamming Method [7]:

$$Predictor: y_{n+1} = y_{n-3} + \frac{4h}{3}(2f_{n-2} - f_{n-1} + 2f_n)$$

$$Corrector: y_{n+1} = -\frac{y_{n-2}}{8} + \frac{9y_n}{8} + \frac{3h}{8}(-f_{n-1} + 2f_n + f_{n+1})$$

For x = 0 and y = 885.363
$f_0(x_0, y_0)$ = (1; 885.363)
$f_0(x_0, y_0) = 0{,}052 * 885.363\ (1 - \frac{885.363}{1.500.000})$
$f_0(x_0, y_0) = 18.864{,}798$
$f_1(x_1, y_1) = 18.676{,}398$
$f_2(x_2, y_2) = 18.463{,}746$
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Table 3. Table of Predicted Results Using the Hamming Method

Year	T	Predictor	Corrector	error
2010	0	-	885.363	0
2011	1	-	904.135,476	0
2012	2	-	922.892,868	0
2013	3	-	941.521,088	0
2014	4	959.157,508	959.685,487	2.903e-08
2015	5	977.023,424	976.984,999	2.700e-08
2016	6	994.759,500	994.536,101	2.485e-08
2017	7	1.012.321,121	1.012.052,616	2.246e-08
2018	8	1.028.800,678	1.029.337,518	1.772e-08
2019	9	1.045.480,306	1.045.419,399	1.283e-08
2020	10	1.061.919,827	1.061.725,846	7.842e-08

4. Conclusions

Milne-Simpson method and Hamming method can be used as a method of solving nonlinear ordinary differential equations and Comparing the error of the Milne-Simpson method and the Hamming method is known that the Milne-Simpson method error is less than the Hamming method error. Thus, the best method in population growth prediction of Bandar Lampung City is by using Milne-Simpson method.

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