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Investigating Total Production and Harvested Area of Paddy in Indonesia Using Grey Forecasting Methodology

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ABSTRACT

The advancement of technology contributed the improvement of Paddy plantation in Indonesia, and it shows increased significantly year by year and irregular cycles which bring suitable data series to accurate forecasting. This paper proposes a GM (1,1) forecasting method with time-series data to predict total production and harvested area of paddy in Indonesia. After collection the real data about the total production and harvested area of paddy in Indonesia from 1996 to 2015, the result show the significant error from the real data and the forecasting result have a positive correlation found between the real data and the forecasting outcome from Grey forecasting method. This correlation related to previous research and study about Grey forecasting stated that with the Grey forecasting method suitable for short-term and long-term prediction.

KEYWORDS: Forecasting, GM (1,1), Grey theory, Harvested, Paddy, Production, Indonesia

I. INTRODUCTION

According to The International Rice Research Institute (IRRI), rice is the most important food for more than 50% of the world's population, and it grew on almost 155 million ha of the world's surface. World rice production in 2008 was approximately 661million tons, with more than 90% produced in Asia. At least 114 countries grow rice. China is the world's largest rice producer, accounting for 30% of total world production, followed by India (22%), Indonesia (9%), and Bangladesh (7%). Cultivated rice (*Oryza sativa*) or paddy is an annual grass that evolved from a semi-aquatic ancestor.

Focus on Indonesia, with the total population beyond 250 million populations, and mostly in Indonesia, the principal foodstuff is rice. Lately, Indonesia seems still import rice from Thailand and Vietnam addressed the total production still lower, and the demand is higher than total production. This research collected data series the total production and harvested area of paddy in Indonesia from 1996 to 2015 on the website of Statistics Indonesia (BPS) [21].

A longitudinal study by Deng [11] stated that the leading systematic study of Grey theory in 1982, which has been standard and applied by numerous academicians. Designated Grey forecast as a capacity forecasting means because of having reasonably low data necessities, and a GM model created from a sample of just four pieces of data. The forecast method is substantial by using the changed Grey rolling modeling mechanism. This rolling modeling mechanism delivers a means to guarantee input data are continuously the most recent values. Additionally, Ma and Yang (2018)[1] demonstrated a novel structure-adaptive intelligent Grey forecasting model with full-order time power terms and its application. While Wang *et al.* (2018)[2] formulated a novel hybrid forecasting system of wind speed, is based on a newly developed multi-objective sine cosine algorithm. Furthermore, Chen *et al.* (2016)[3] in their study proposed a novel Grey wave forecasting technique for predicting metal prices.

In another significant study, Wang *et al.* (2013)[4] designated a Grey forecasting interval-parameter mixed-integer programming approach for integrated electric-environmental management case study of Beijing. Furthermore, Wang and Ghalih (2017)[5] focused on forecasting the total of domestic coffee consumption in Indonesia. They applied the Grey differential model which is called GM (1,1) model of Grey theory to predict the quantity

of domestic coffee consumption in Indonesia from 1990 to 2017. Also, Zeng *et al.* (2018)[6] approached forecasting the output of shale gas in China using an unbiased Grey model and weakening buffer operator.

Meanwhile, Zhen *et al.* (2017)[7] studied a cloud image forecasting approach to solar power. Furthermore, Wang and Ghalih (2017)[8] specified forecast the volume of the total of production of crude oil and condensate in Indonesia. In the other study, Tang and Yin (2012)[9] experimented with forecasting performance of Grey prediction for education expenditure and school enrollment. Wang and Hao (2013)[10] considered an improved Grey multivariable model for predicting industrial energy consumption in China.

Additionally, an expression presenting of rolling modeling data and data of forecast results appearance there are average residual error dissimilar from rolling modeling GM (1,1). This disagreement may be due to the study presents methodologies for projecting the suitably predicts of the total production and harvested area of paddy in Indonesia to get the reference for making the accomplishment strategy for the future by investigating the precision of the Grey forecasting model.

II. METHODOLOGY

A considerable amount of literature has published on Grey theory, developed by Deng [11] in 1982, is suitable for short-term forecasting, and does not rely on a statistical method. The Grey forecasting method has been magnificently applied in many areas of investigation including finance [12], engineering [13][14], agriculture [15] and management[16][17][18][19][20]. However, in this study, focus on the forecasting method is significantly by applying the distorted Grey rolling modelling mechanism. This rolling modelling mechanism delivers a means to guarantee contribution data are always the most recent values.

An expression introducing the comparison of rolling modelling data and fundamental data of forecast results show as Figure 1 and Figure 2. The average residual error different rolling modelling GM (1,1) show as Table 3 and Table 4. Such as, in Method 1: Choose first four continuous data to predict the 5th of the output value, 2nd to 5th continuous data to predict the 6th output value and after that. Besides, in Method 2: forecast the 6th of the production value by adopting first five consecutive data, 2nd to 6th following data to forecast the 7th output value and henceforth.

Likewise, the study presents methodologies for projecting the most accurately predicts of the total production and harvested area of paddy in Indonesia by testing the precision of the Grey forecasting model. Detailed consideration by Deng [11] recommended the Grey system theory to construct a Grey model for forecasting.

Accumulated Generation Operation (AGO): Accumulating obtained systematic regularity discrete the time-series data.

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)) \quad (1)$$

$x^{(1)}$ is $x^{(0)}$ one-order accumulated generating operation (AGO) sequence, that is,

$$x^{(1)} = (\sum_{k=1}^{1} x^{(0)}(k), \sum_{k=1}^{2} x^{(0)}(k), \ldots, \sum_{k=1}^{n} x^{(0)}(k)) \quad (2)$$

Inverse-accumulated generating operation (IAGO): $\hat{x}^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1)$.

Gray Derivatives

$$z^{(1)} = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1) \quad (3)$$

The paramount instruction differential equation of GM (1,1) model is $dx / dt + ax = b$, where t symbolizes the independent variables in the system, a represents the developed coefficient; b is the Grey measured variable, additionally a and b denoted the considerations demanding purpose in the model. When a model is assembled, the differential equation is $x^0(k) + az^{(1)}(k) = b$, including $k = 2,3,\ldots,n$, where a and b denoted replacement substantial number, this differential equation $x^{(0)}(k) + az^{(1)}(k) = b$ is called as GM (1,1) model.

Additionally, accumulated matrix a and b are as below magnify equations:

$$a = \frac{\sum_{k=2}^{n} z^{(1)}(k) \sum_{k=2}^{n} x^{(0)}(k) - (n-1) \sum_{k=2}^{n} z^{(1)}(k) x^{(0)}(k)}{(n-1) \sum_{k=2}^{n} \left[z^{(1)}(k) \right]^2 - \left[\sum_{k=2}^{n} z^{(1)}(k) \right]^2} \quad (4)$$

$$b = \frac{\sum_{k=2}^{n} [z^{(1)}(k)]^2 \sum_{k=2}^{n} x^{(0)}(k) - \sum_{k=2}^{n} z^{(1)}(k) \sum_{k=2}^{n} z^{(1)}(k) x^{(0)}(k)}{(n-1) \sum_{k=2}^{n} [z^{(1)}(k)]^2 - [\sum_{k=2}^{n} z^{(1)}(k)]^2} \quad (5)$$

Whitening Equation:

$$x^{(1)}(k) = \left[x^{(1)}(1) - \frac{b}{a} \right] e^{a} e^{-ak} + \frac{b}{a} = \left[x^{(1)}(1) - \frac{b}{a} \right] e^{-a(k-1)} + \frac{b}{a}$$

$$x^{(1)}(k+1) = \left[x^{(0)}(1) - \frac{b}{a} \right] e^{-ak} + \frac{b}{a}$$, where $x^{(1)}(1) = x^{(0)}(1)$.

Utilize Inverse-accumulated generating operation (IAGO) equation as below:

$$\hat{x}^{(0)}(k+1) = x^{(1)}(k+1) - x^{(1)}(k) = (1 - e^{a}) \left[x^{(0)}(1) - \frac{b}{a} \right] e^{-ak} \quad (6)$$

III. DATA ANALYSIS AND RESULTS

Data collected from Badan Pusat Statistik (BPS-Statistics Indonesia) [21] used to forecast the total production and

harvested area of paddy in Indonesia. This study created results that corroborate the findings of several previous studies in this field. What is noteworthy in Table 1 and Table 2 is that the raw data of the total production and harvested area of paddy in Indonesia from 1996 to 2015.

Likewise, Table 3 and Table 4 are the average residual error from the Grey forecasting until 12 years prediction. Relating the two results, it could see that the result from Grey forecasting to predict the total production and harvested area of paddy in Indonesia have a low error. Interestingly, on an average residual error, only one has a more significant error which is in 9 years prediction about 5.10 % error.

Table 1. The Real Data Total Production

Year	Real Data	Year	Real Data
1996	49339086	2006	54454937
1997	49236692	2007	57157435
1998	50866387	2008	60325925
1999	51898852	2009	64398890
2000	50460782	2010	66469394
2001	51489694	2011	65756904
2002	52137604	2012	69056126
2003	54088468	2013	71279709
2004	54151097	2014	70846465
2005	49339086	2015	75397841

Total Production (Ton)
Data Source: Statistics Indonesia

Table 2. The Real Data Total Harvested Area

Year	Real Data	Year	Real Data
1996	11550045	2006	11786430
1997	11126396	2007	12147637
1998	11730325	2008	12327425
1999	11963204	2009	12883576
2000	11793475	2010	13253450
2001	11499997	2011	13203643
2002	11521166	2012	13445524
2003	11488034	2013	13835252
2004	11922974	2014	13797307
2005	11839060	2015	14116638

Total Harvested Area of Paddy (ha)
Data Source: Statistics Indonesia

Table 3. Average Residual Error the Total Production

Year	Total Error
4	4.56%
5	3.87%
6	4.25%
7	4.53%
8	4.80%
9	5.10%
10	4.25%
11	4.35%
12	4.17%

Table 4. Average Residual Error the Harvested Area

Year	Total Error
4	2.30%
5	2.04%
6	1.92%
7	1.93%
8	1.80%
9	1.75%
10	2.10%
11	2.36%
12	2.58%

An optimum number to forecast of the total production and harvested area of paddy in Indonesia has developed with $\alpha = 0.4$, data series length $m = 4$, and data series step $\triangle = 1$. Slightly worse prediction results obtained with $\alpha = 0.4$, $m = 4$ and $\triangle = 12$, that is with the prediction from the previous years. Such as, in this study, used data on GM (1,1) prediction of the total production of paddy in Indonesia from Table 1 given in Table 3.

Moreover, the results for a four years period the total error ranges start from 4.56 % to 4.17 % in the different years and periods as we can see in Table 3. Also, the lower error is 3.87 % for the 5 years. In contrast to the average residual error the harvested area of paddy in Table 4 relatively more lower than the total production of paddy in Indonesia. Focus on 9 years prediction the total error only 1.75 % and the highest error 2.58% in 12 years prediction.

Furthermore, there was a significant dissimilarity between the two conditions real data for the total production and the harvested area. The total production data is fluctuating, and the harvested area seems to increase slowly. Table 3 and Table 4 compares the average residual error; it illustrated that the total production and the harvested area data significant different. Overall, the average error in harvested area measures that Grey forecasting accurately observed.

Turning now to the Table 5 presents the results obtained from preliminary real data compare with out of sample data from 2006 to 2015. The correlation between real data and out of sample data is remarkable because those data have a small average error which is only 3.87 % error. The most striking consequence of emerging from the data is that from the Grey forecasting result from 1996 to 2005 can be used to predict the value in 2006. Further analysis showed that the average error 3.87 % is the lowest error in Table 3 for 5 years prediction. The single most striking observation to emerge after comparing the data could see in Figure 1.

Table 5. Out of Sample Forecasting and Average Error

Year	Real Data	Year	Real Data	Out of Sample	Average Error
1996	49339086	2006*	54454937	50429356	3.87 %
1997	49236692	2007*	57157435	52068853	3.87 %
1998	50866387	2008*	60325925	57503068	3.87 %
1999	51898852	2009*	64398890	64725066	3.87 %
2000	50460782	2010*	66469394	67822132	3.87 %
2001	51489694	2011*	65756904	70459243	3.87 %
2002	52137604	2012*	69056126	68885310	3.87 %
2003	54088468	2013*	71279709	69811934	3.87 %
2004	54151097	2014*	70846465	72724341	3.87 %
2005	49339086	2015*	75397841	73666337	3.87 %

Total Production (Ton)
Data Source: Statistics Indonesia
*2006-2015 Out of Sample Test

IV. THE EVALUATION

The evaluation of GM (1,1) method in this study referred to predict the total production and harvested area of paddy in Indonesia from 1996 to 2015. The results indicated that the average accuracy of the forecasting model exceeds relatives' low error significantly. The model thus clearly has high prediction validity and is a sustainable goal for forecasting the total production and harvested area of paddy in Indonesia. Substantial evidence of Grey forecasting found when in the fourth year's prediction such shows in Figure 1. It is apparent from Figure 1 that very few average errors indicate. What is noteworthy in Figure 1 is that 3.87 % average error precisely in several years is nearly matching with the real data.

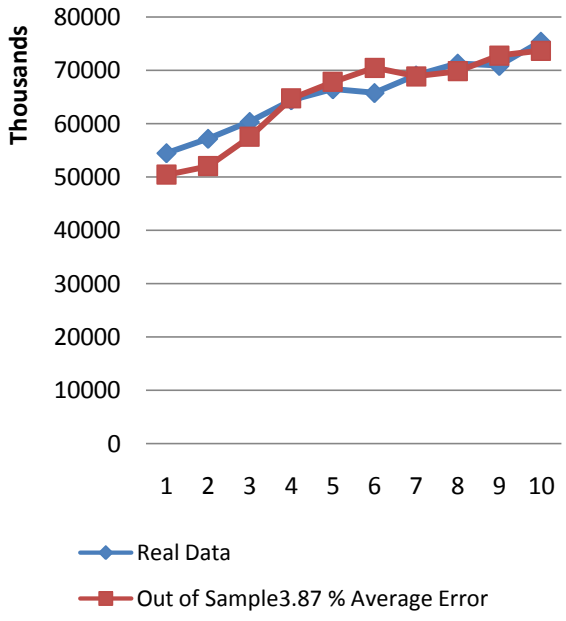

Figure 1. Forecasting Out of Sample the Total Production of Paddy in Indonesia

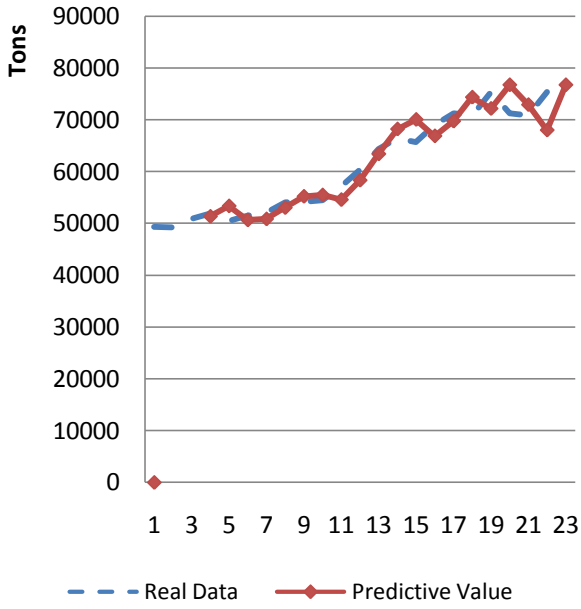

Figure 2. Forecasting the total Production of Paddy in Indonesia

The total production of paddy in Indonesia will continue to increase, and it will drive to make a new plan for road-mapping in the future, and from the forecast, the result can count the total production and harvested area from Indonesia to prepare a better strategy in the future. The consequences also agree with our earlier observations, which demonstrated that result could explain and forecast for instance, in Method 1: choose first four continuous data to predict the 5th of the output value, 2nd to 5th following data to predict the 6th output value.

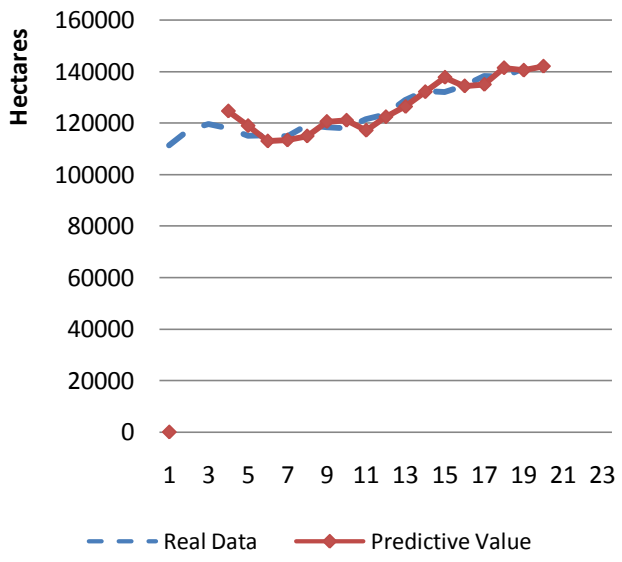

Figure 3. Forecasting the Harvested Area of Paddy in Indonesia

However, in Method 2: Predict the 6th of output value by adopting first five consecutive data, 2nd to 6th continuous data to forecast the 7th output value and henceforth. It seen from the results show that the Grey forecasting model exhibits highest forecast accuracy and the actual average rate at the average residual error of the Grey forecasting model is nearly above 96%. The above information confirms the efficiency of the proposed forecasting model. In such a way, the forecasting method by applying the Grey rolling model is the most precise predictive method to the tendency of the total production and harvested area of paddy in Indonesia.

V. CONCLUSION

The essential structures of the Grey forecasting technique are to determine data series to acquire upcoming prediction numeral using previous numbers such as, in this study using dataset about the total production and harvested area of paddy in Indonesia since 1996 to 2015. In this paper, the Grey system modelling based on the experimental results for forecasting the total production of paddy in Indonesia were examined and showed the number about 4.56 % total error to predict range one until four years. Interestingly, in five years the total error is relatively small about 3.87 %. That indicates the Grey forecasting method not permanently have a real total error in the range fourth years but in another range of the year might have the small total error. Furthermore, the total harvested area of paddy in Indonesia illustrates small residual average error. As a result of the test that conducted that the total production and harvested area of paddy in Indonesia increased year by year according to the real data and the Grey forecast method. In summary, it implies that Indonesia government should make the action plan for the future to develop paddy sectors.

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VII. REFERENCES

1. S. Li, X. Ma, and C. Yang, "A novel structure-adaptive intelligent grey forecasting model with full-order time power terms and its application," *Comput. Ind. Eng.*, 2018.
2. J. Wang, W. Yang, P. Du, and T. Niu, "A novel hybrid forecasting system of wind speed based on a newly developed multi-objective sine cosine algorithm," *Energy Convers. Manag.*, vol. 163, no. January, pp. 134–150, 2018.
3. Y. Chen, K. He, and C. Zhang, "A novel grey wave forecasting method for predicting metal prices," *Resour. Policy*, vol. 49, pp. 323–331, 2016.
4. X. Wang, Y. Cai, J. Chen, and C. Dai, "A grey-forecasting interval-parameter mixed-integer programming approach for integrated electric-environmental management-A case study of Beijing," *Energy*, vol. 63, pp. 334–344, 2013.
5. T.-C. Wang and M. Ghalih, "Evaluation of Grey Forecasting Method of Total Domestic Coffee Consumption in Indonesia," *Int. J. Bus. Econ. Res.*, vol. 6, no. 4, pp. 67–72, 2017.
6. B. Zeng, H. Duan, Y. Bai, and W. Meng, "Forecasting the output of shale gas in China using an unbiased grey model and weakening buffer operator," *Energy*, vol. 151, pp. 238–249, 2018.
7. Z. Zhen, Z. Wang, F. Wang, Z. Mi, and K. Li, "Research on a cloud image forecasting approach for solar power forecasting," *Energy Procedia*, vol. 142, pp. 362–368, 2017.
8. T. Wang and M. Ghalih, "Evaluation of Grey Forecasting Method in Total Indonesian Production Crude Oil and Condensate," no. *Aetms*, pp. 256–261, 2017.
9. H. W. V. Tang and M. S. Yin, "Forecasting performance of grey prediction for education expenditure and school enrollment," *Econ. Educ. Rev.*, vol. 31, no. 4, pp. 452–462, 2012.
10. Z. X. Wang and P. Hao, "An improved grey multivariable model for predicting industrial energy consumption in China," *Appl. Math. Model.*, vol. 40, pp. 5745–5758, 2013.
11. D. Julong, "Introduction to Grey System Theory,"*The Journal of Grey System*, vo. 1, pp. 1-24,1982.
12. N. ming Xie and S. feng Liu, "Discrete grey forecasting model and its optimization," *Appl. Math. Model.*, vol. 33, no. 2, pp. 1173–1186, 2009.

13. Y. S. Lee and L. I. Tong, "Forecasting energy consumption using a grey model improved by incorporating genetic programming," *Energy Convers. Manag.*, vol. 52, no. 1, pp. 147–152, 2011.
14. Y. Sheng-qiang, S. Yan, C. Zu-yun, Y. Bao-hai, and X. Quan, "Establishment of grey-neural network forecasting model of coal and gas outburst," *Procedia Earth Planet. Sci.*, vol. 1, no. 1, pp. 148–153, 2009.
15. S. L. Ou, "Forecasting agricultural output with an improved grey forecasting model based on the genetic algorithm," *Comput. Electron. Agric.*, vol. 85, pp. 33–39, 2012.
16. C. F. Tsai, "Dynamic grey platform for efficient forecasting management," *J. Comput. Syst. Sci.*, vol. 81, no. 6, pp. 966–980, 2015.
17. M. Xia and W. K. Wong, "A seasonal discrete grey forecasting model for fashion retailing," *Knowledge-Based Syst.*, vol. 57, pp. 119–126, 2014.
18. R. B. Carmona Benítez, R. B. Carmona Paredes, G. Lodewijks, and J. L. Nabais, "Damp trend Grey Model forecasting method for airline industry," *Expert Syst. Appl.*, vol. 40, no. 12, pp. 4915–4921, 2013.
19. S. Ene and N. Öztürk, "Grey modelling based forecasting system for return flow of end-of-life vehicles," *Technol. Forecast. Soc. Change*, vol. 115, pp. 155–166, 2017.
20. S. C. Chang, H. C. Lai, and H. C. Yu, "A variable P value rolling Grey forecasting model for Taiwan semiconductor industry production," *Technol. Forecast. Soc. Change*, vol. 72, no. 5, pp. 623–640, 2005.
21. Information on *https://www.bps.go.id/* accessed on 28 March 2018
22. Information on *http://ricestat.irri.org/* accessed on 18 May 2018