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Indonesian Grain Production Forecasting, Moving Average Method, and Exponential Smoothing

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ABSTRACT: National food security requires grain for food adequacy, which is then processed into rice as a cereal product, one of the most dominant food commodities for the majority of Indonesian people. The analysis of the ratio normative consumption per capita to cereal production shows that 39.66% of districts in Indonesia experience a deficit in food availability, partly due to population growth which an increase has not matched in cereal production. The purpose of this research is to perform forecasting on the amount of grain production as a reference in formulating a strategy for supplying grain to the population to fulfil the staple food consumption needs of the Indonesian population. This research method uses secondary data on grain production in Indonesia with a range of 2000-2021, and forecasting is carried out until 2024. The data source comes from the Central Statistics Agency (BPS), and data processing uses SPSS (Statistical Package for Social Science). Forecasting techniques use four methods: simple moving average, weight moving average, exponential smoothing and double exponential smoothing. Forecasting results for grain production in 2000-2024 were below actual production, and the peak of production increase occurred in 2017 and then decreased production until forecasting in 2024. The lowest values for MAD, MSE and MAPE were for forecasting results using the WMA method.

Keywords: food security, availability, forecasting, grain

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INTRODUCTION

Food fulfilment is part of the fundamental rights guaranteed in the 1945 Constitution of the Republic of Indonesia as a basic component for realizing quality human resources, according to the explanation in Food Law No. 18 of 2012. Food is defined as everything originating from biological sources of agriculture, plantation, forestry, fishery, animal husbandry, water and water products, both processed and unprocessed, which are intended as food or drink for human consumption, including food additives: food raw materials and other materials used in preparing, processing and or making food or drinks. Food and nutrition security is a condition of fulfilling food and nutrition for the state down to individuals, which is reflected in the availability of sufficient food (Kementerian HAM RI, 2021; Kementerian HAM RI, 2015). Indonesia's food security rating based on the Global Food Security Index (GFSI) for 2021 is 59.2, which is in the 69th position out of 113 countries. This value has decreased from the previous two years (2020 of 61.4 and 2019 of 60.4), with Indonesia's 2024 GFSI target of 96.8 (GFSI, 2021; Kementan, 2019).

National food security requires grain to meet food adequacy. Grain, then processed into rice, is one of the most dominant food commodities for most Indonesians; rice is a food ingredient that is easily converted into energy and contains sufficient nutrition for the body. The availability of grain in Indonesia based on BPS data for 2021 is 54.42 million tons, with achievement of 116.2% when compared to the 2024 target (target 46.8

million tons) (Kementan, 2021; BPS, 2021) and the global target of the SDGs in 2030 for the second SDGs goal is "to end hunger, achieve food security and good nutrition, and promote sustainable agriculture"(Bappenas, 2021).

Triple burden malnutrition is a problem that is currently experienced by Indonesia, with the prevalence of stunting in children under five at 24.4% (SSGI 2021), wasting 7.1% (SSGI 2021), anemia in pregnant women 48.9% (Riskesdas 2018) and obesity aged over 18 years 21.8% (Riskesdas 2018) (Kemenkes RI, 2021; Kemenkes RI, 2018). More than two-thirds (69%) of households were classified as food insecure (had insufficient access to adequate food) (Osei et al., 2010). Address malnutrition needs to be moved on to food security and nutritional-specific interventions (Chakona & Shackleton, 2018; Hidayat et al., 2020). The impact of the COVID-19 pandemic on efforts to improve nutrition and health is a new challenge for the government in achieving the Sustainable Development Goals (SDGs), especially the second goal. The most significant impact is the weakening of the food security and health systems, which causes widening inequality of access and a decrease in the quality of services. Individuals from higher-income groups are also more susceptible to being overweight and obese (HLPE, 2020). The crises make large numbers of vulnerable households have reduced the quality and quantity of foods they consume and are at risk of increased malnutrition (Brinkman et al., 2010). Agriculture is the people's main livelihood source (Pandey et al., 2016).

The Food Security Agency of the Ministry of Agriculture compiled a Food Security and Vulnerability Atlas (FSVA) to assess food availability through the ratio of normative consumption per capita to production calculated by dividing per capita normative consumption per day (300 g) against the average net availability of main cereals and tubers per day. The analysis of the ratio of normative consumption per capita to cereal production in 2020 shows that 60.34% of districts in Indonesia have a surplus, and 39.66% of districts experience a deficit in food availability (Kementan, 2021). The deficit in food availability was partly due to population growth which was not matched by the increased production of cereals and tubers. Indonesia's population in 2020 will reach 270.203.917 people, an increase of 1.25 per cent compared to the population in 2010 (BPS, 2021). Ups and downs in rice production are generally linked with food security as it contributes more than 50% of the grain requirement and more than 30% of the calorie requirement (Dhungel & Acharya, 2017). Please find out the amount of food available through grain production. It is necessary to forecast the amount of grain production in the future to become a reference in preparing a strategy for supplying grain to the population to meet the basic food consumption needs of the entire Indonesian population.

MATERIALS AND METHODS

This study uses secondary data on grain production in Indonesia with a range of 2000-2021. The data source comes from the Central Statistics Agency (BPS), and data processing uses SPSS (Statistical Package for Social Science). Forecasting techniques are carried out using a quantitative approach; this method is arranged in a systematic and standard way that seeks to minimize forecasting errors. Forecasting grain production using four methods: simple moving average, weight moving average, exponential smoothing and double exponential smoothing(Yudaruddin, 2019).

1. The simple moving average (MA) is a forecasting method using past data and then summing it up and calculating the average to find out some information that might occur. The MA method

cannot follow rapid changes because after there has been a change in circumstances, the pattern should have changed, but according to this method, historical data that occurred before the change is still used, so the forecasting results may not be good.

2. Weighted Moving Average (WMA) is a forecasting method that gives more weight to the most recent data and reduces the weighting to past data.
3. Exponential Smoothing (St)is a time data forecast method for variable data that can be extended to support data with a systematic trend or seasonal component.
4. Double Exponential Smoothing (St_d) is used to estimate time series data with a linear trend.

The best forecast is a forecast that can minimize errors within the tolerable limit. The accuracy of the results of the forecasting method is measured using a forecasting error tool to ensure that the method works correctly. In this study, three measurement tools were used that could be used to conclude forecasting errors, namely the Mean Absolute Deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Percent Error (MAPE) methods.(Heizer J & Render B, 2015).

1. MAD is the average absolute value of forecasting errors (disregarding the positive and negative signs). This value is calculated by taking the sum of the absolute values of individual forecasting errors (deviations) and dividing by the number of data periods (n).
2. MSE is the average of the squared differences between the predicted and observed values, governing significant forecasting errors because the errors are squared.
3. MAPE is calculated as the average absolute difference between the forecasted and actual values, expressed as a percentage of the actual values.

RESULTS AND DISCUSSION

Production forecasting is an important activity because this activity is the process of predicting future conditions that will affect performance, behaviour and output. Forecasting is based on chance, and there is a possibility of being right or wrong. One of the benefits of forecasting is that it is a vital part of the planning process. Forecasting results can be a basis for consideration for setting targets that are realistic and challenging to achieve.

The five criteria in setting goals/targets for an activity abbreviated as SMART, are: (1) Specific – targets must be made specific; (2) Measurable - targets have criteria that can be used to measure progress; (3) Achievable or achievable - targets must be realistic and achievable, in this case, the targets set are not too easy or too difficult to achieve; (4) Relevant - targets can encourage teams and organizations to move forward, and targets are aligned with other targets; and (5) Time-bound - targets have deadlines (Wauters, 2013). These five criteria are a challenge in setting national grain production targets, namely determining the amount of grain production that needs to be achieved in the future. Setting a target is not just a number that is always higher than the current production rate. It is hoped that the production target figure is a solid (strong and sturdy) figure, realistic/achievable and at the same time accountable. As with production target-setting activities, forecasting activities also try to find forecast results for future production. Forecasting is a prediction activity in the future based on past and present data using trend analysis. Forecasting is done based on factual, objective conditions, predicting what might happen in the future, assuming other factors have the same pattern.

Forecasting is based on external and internal data collection, and analysis is carried out based on past and present data using mathematical models. Forecasting data using

four methods are presented in Table 1. The highest grain production data in the 2000-2021 period was in 2017, which amounted to 81.15 million tons of grain and experienced a decrease in production the following year. The condition of the Covid 19 pandemic gradually in the last two years was also followed by a decrease in grain production. In the end, this was also reflected in the forecasting results for grain production, which showed a decrease in production.

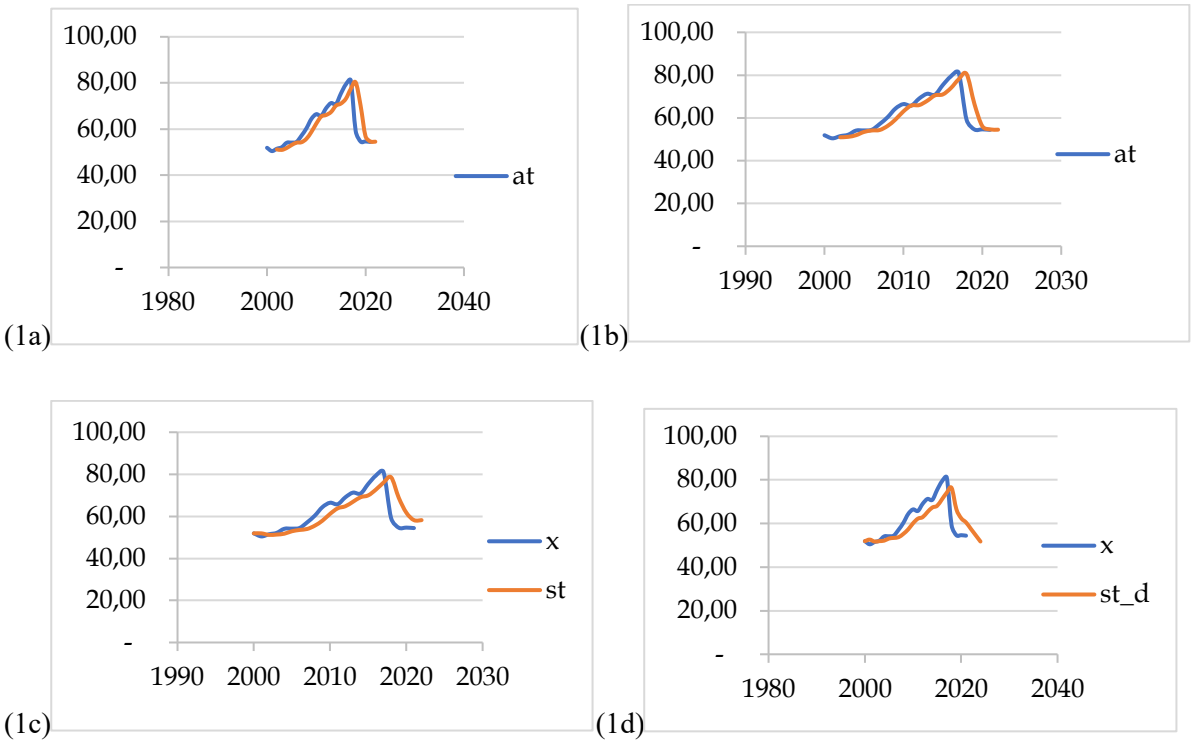
Graph 1 illustrates the results of forecasting grain production in 2000-2024, and it can be seen that, in general, the increase in forecasting grain production is below the actual production and the peak of the increase in production occurred in 2017 and then decreased production up to forecasting in 2024. Data on MAD, MSE and MAPE can be seen in Table 2. The lowest values for MAD, MSE and MAPE are in the casting results using the WMA method.

Table 1. Forecasting of Indonesian Grain Production in 2000-2024

Year	Grain Production (Million Tons)				
	Actual*	Simple Moving Average	Weighted Moving Average	Exponential Smoothing	Double Exponential Smoothing
2000	51,90	0	0	51,90	51,90
2001	50,46	0	0	51,90	52,62
2002	51,49	51,18	50,94	51,18	51,72
2003	52,14	50,98	51,15	51,33	51,92
2004	54,09	51,81	51,92	51,74	52,14
2005	54,15	53,11	53,44	52,91	53,11
2006	54,45	54,12	54,13	53,53	53,39
2007	57,16	54,30	54,35	53,99	53,73
2008	60,33	55,81	56,26	55,58	55,26
2009	64,40	58,74	59,27	57,95	57,32
2010	66,47	62,36	63,04	61,17	60,11
2011	65,76	65,43	65,78	63,82	62,22
2012	69,06	66,11	65,99	64,79	62,92
2013	71,28	67,41	67,96	66,92	65,28
2014	70,85	70,17	70,54	69,10	67,34
2015	75,40	71,06	70,99	69,97	68,11
2016	79,35	73,12	73,88	72,69	71,07
2017	81,15	77,38	78,04	76,02	74,13
2018	59,20	80,25	80,55	78,58	76,33
2019	54,60	70,17	66,52	68,89	66,56
2020	54,65	56,90	56,14	61,75	62,42
2021	54,42	54,63	54,63	58,20	60,49
2022		54,53	54,49	56,31	57,57
2023					54,65
2024					51,73

*Source: BPS

Graph 1. Forecasting results for Indonesia's grain production in 2000-2024



Description: (1a) at actual data, Ft 2_MA: MA method forecasting results; (1b) at actual data, Ft2_WMA: WMA method forecasting results; (1c) x: actual data, st: a result of forecasting method St: (1d) x: actual data, st_d: a result of forecasting method St_d

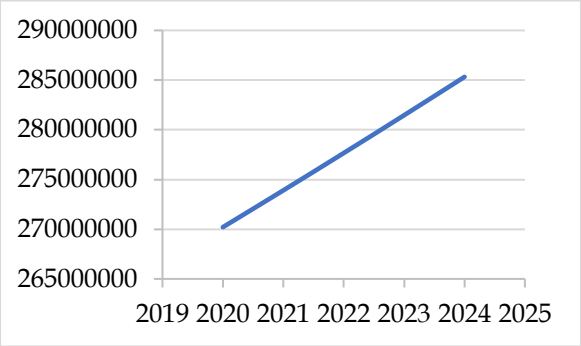
Forecasting using the average method considers the entire time series and fluctuations, in the average technique only takes a set of observed values and calculates the average, then uses this average as an estimate. In contrast, the smoothing method uses a weighted approach. The best forecasting method is the method that can produce a nominal error value or the difference between the forecast value and the actual value. Therefore, it is necessary to conduct a simulation/trial and error process of various forecasting methods to find the best one. Forecasting of grain production in this study used four methods, and based on the graphs, it appears that there is a similar pattern for each method's forecasting. The best forecasting results are the methods with the least error rate and are supported by the greatest forecasting value. The parameters to determine the best method are the MAD, MSE and MAPE values closest to zero. The MAD, MSE, and MAPE values closest to zero of the four methods are the weighted moving average methods.

Table 2. MAD, MSE and MAPE values

Forecasting Method	MAD	MSE	MAPE
Simple Moving Average	4,18	43,6	6,75
Weighted Moving Average	3,74	37,43	6,04
Exponential Smoothing	4,62	42,26	7,44
Double Exponential Smoothing	5,11	43,11	8,05

Food security policy is mainly about ensuring the availability, accessibility, and utilization of rice in society. Policy objectives focus on ensuring high prices for paddy farmers to produce rice, achieving a certain level of self-sufficiency in rice and ensuring a stable and high quality of rice to the consumers (Bala et al., 2014). The amount of grain production is closely related to the population because grain is needed to fulfil the population's staple food consumption. The results of forecasting the total population of Indonesia can be seen in Graph 2.

Graph 2. Forecasting of Indonesia's Population in 2020-2024



In 2024 the forecast for Indonesia's grain production is 51,73 million tons. The conversion rate of grain to rice is 64,02%, so based on the 2024 grain forecasting, the forecast for rice production in 2024 is 33,12 million tons (Amalia et al., 2018). The continuity of the life of the Indonesian people still requires food staples, especially rice. Even though a small portion of the middle and upper class of society may have started to reduce their consumption of rice and shift their consumption patterns from rice to bread or vegetarianism, until now, rice is still the number one commodity. Rice is one of the staple foods that continually appears on the daily menu of Indonesian people. Rice is the most significant energy source for body growth because it contains the primary sources of calories and protein. Conditions like this make rice commodities have a strategic role in determining food security.

Food production, especially rice, needs to be increased towards food security, and strategies for overcoming nutritional problems must also increase the accessibility and quality of food consumed by the population (Hwalla et al., 2016; Naher et al., 2014). Most countries protect their rice farmers and provide high-price support, but high rice prices hurt most people experiencing poverty. Continued efforts to stabilize rice prices are understandable politically and desirable economically, but much more open trade regimes for rice will help food security throughout the region (Timmer, 2014).

Rice is a staple food for over 90% of Indonesia's population (BPS, 2019). Forecasting of domestic rice production continues to decline from year to year, although it tends to a sloping rate of decline. On the other hand, Indonesia's population growth accelerated rapidly. Namely, 1,19% per year in the 2016-2020 period and the forecasted population for 2024 will reach 285.320.882 people. With this fact, Indonesia's total rice consumption will continue to increase.

CONCLUSION

The exact forecasting method needs to be known to estimate the future production amount. The forecasting results will be one of the bases for setting national rice production targets. Based on the results of testing various quantitative methods, the weighted moving average method is a method that produces the smallest error value in forecasting future rice production and can be used as a reference for implementing national rice production targets. It needs to build stakeholders' capacity and equip them to address the challenges hindering the achievement of food and nutrition security now and into the future.

REFERENCES

Amalia RR, Prasetyo OC, & Hartini M. (2018). *Konversi Gabah Ke Beras Tahun 2018*. Citra Mawana Patamaro.

Bala, B. K., Alias, E. F., Arshad, F. M., Noh, K. M., & Hadi, A. H. A. (2014). Modelling of food security in Malaysia. Simulation Modelling Practice and Theory, *47*, 152–164. https://doi.org/10.1016/j.simpat.2014.06.001

Bappenas. (2021). *KEPMEN PPN/Kepala Bappenas Nomor 24/M.PPN/HK/10/2021 tentang Penetapan Rencana Aksi Nasional Pangan dan Gizi Tahun 2021-2024*.

BPS. (2019). *Konsumsi Bahan Pokok 2019*. BPS.

BPS. (2021). *Badan Pusat Statistik*. https://www.bps.go.id/

Brinkman, H. J., De Pee, S., Sanogo, I., Subran, L., & Bloem, M. W. (2010). High food prices and the global financial crisis have reduced access to nutritious food and worsened nutritional status and health. Journal of Nutrition, *140*(1). https://doi.org/10.3945/jn.109.110767

Chakona, G., & Shackleton, C. M. (2018). Household Food Insecurity along an Agro-Ecological Gradient Influences Children's Nutritional Status in South Africa. Frontiers in Nutrition, 4(January). https://doi.org/10.3389/fnut.2017.00072

Dhungel, S. ., & Acharya, P. (2017). Role of Rice in Food and Nutrition Security in Nepal. In Rice Science and Technology in Nepal(A historical,socio-cultural and technical compendium). Cdd, 77–85.

GFSI. (2021). Rankings and trends Explore the year-on-year trends for the Global Food Security Index. Figures are from the annual baseline model (September 2021). https://impact.economist.com/sustainability/project/food-security-index/Index

Heizer J, & Render B. (2015). *Manajemen Operasi: Manajemen Keberlangsungan dan Rantai Pasok. Terjemahan oleh Hirson Kurnia, Ratna Sarawati dan David Wijaya.* (11th ed.). Salemba Empat.

Hidayat, A. A. A., Marini, G., & Tyas, A. P. M. (2020). Factors affecting nutritional status in children aged 6–24 months in Lamongan regency, Indonesia. Open Access Macedonian Journal of Medical Sciences, 8(E), 291–295. https://doi.org/10.3889/oamjms.2020.3666

HLPE. (2020). Food security and nutrition: building a global narrative towards 2030. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

Hwalla, N., El Labban, S., & Bahn, R. A. (2016). Nutrition security is an integral component of food security. Frontiers in Life Science, 9(3), 167–172. https://doi.org/10.1080/21553769.2016.1209133

Kemenkes RI. (2018). *Riset Kesehatan Dasar 2018. Badan Penelitian dan Pengembangan Kesehatan Kemenkes RI.*

Kemenkes RI. (2021). *Buku Saku Hasil Studi Status Gizi Indonesia (SSGI) Tingkat Nasional, Provinsi dan Kabupaten/Kota Tahun 2021*.

Kementan. (2019). *Rencana Strategis Direktorat Jenderal Holtikultura Tahun 2020-2024.* (Dirjen Holtikultura).

Kementan. (2021). *Peta Ketahanan dan Kerentanan Pangan Food Security And*

Vulnerability Atlas 2021 (Badan Ketahanan Pangan).

Kementerian HAM RI. (2015). *Peraturan Pemerintah Republik Indonesia Nomor 17 tahun 2015 tentang Ketahanan Pangan dan Gizi.*

Kementerian HAM RI. (2021). *Undang-Undang Republik Indonesia Nomor 18 tahun 2012 Tentang Pangan*.

Naher, F., Barkat-e-Khuda, Ahmed, S. S., & Hossain, M. (2014). How nutrition-friendly are agriculture and health policies in Bangladesh? Food and Nutrition Bulletin, 35(1), 133–146. https://doi.org/10.1177/15648265140 3500114

Osei, A., Pande, P., Spiro, D., Nielson, J., Shrestha, R., Talukder, Z., Quinn, V., & Haselow, N. (2010). Household food insecurity and nutritional status of children aged 6 to 23 months in Kailali District of Nepal. Food and Nutrition Bulletin, 31(4), 53–71. https://doi.org/10.1201/97813153657 49-4

Pandey, V. L., Mahendra Dev, S., & Jayachandran, U. (2016). Impact of agricultural interventions on the nutritional status in South Asia: A review. Food Policy, 62, 28–40. https://doi.org/10.1016/j.foodpol.201 6.05.002

Timmer, C. P. (2014). Food Security in Asia and the Pacific: The Rapidly Changing Role of Rice. *Asia and the Pacific Policy Studies, 1(1*), 73–90. https://doi.org/10.1002/app5.6

Wauters, B. (2013). SMART or not : are simple management recipes useful to improve performance in a complex world ? A critical reflection based on the experience of the Flemish ESF Agency . December, 42. https://www.researchgate.net/public ation/321768940

Yudaruddin R. (2019). Forcasting*: Untuk Kegiatan Ekonomi dan Bisnis*. RV Pustaka Horizon.