Forecasting and Establishing National Rice Production Targets in Indonesia

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Abstract. Since 2018 the Indonesian Central Bureau of Statistics has applied a new method of establishing rice production data; namely, the Area Frame Sampling method, which is considered more objective by analyzing satellite images. This causes rice production historical data becomes very limited due to the method differences that may lead to the need of new forecasting method to predict future rice production and target setting. This study aims to provide recommendations on appropriate : (1) forecasting method to predict national rice production number; and (2) method on setting national rice production targets that can produce a robust, realistic, achievable and accountable number. The Backcasting method was used to overcome the limitations of historical data. Trials on various quantitative methods resulted that the double exponential smoothing method was the most recommended method for predicting future national rice production numbers. This study also suggested to integrate quantitative and qualitative methods in establishing national rice production targets. Production target that exceeds optimistic target numbers requires special programs and efforts to achieve them.

Keywords: Backcasting, double exponential smoothing method, forecasting, rice production target

1 Introduction

It is very important to determine the national production target for a commodity. Especially for the rice commodity which is one of the main food commodities of the Indonesian people. The national rice production target is listed in the Indonesian National Medium Term Development Plan (NMTDP / RPJMN) and is translated into the Indonesian Government Work Plan (GWP / RKP) each year. In practice, the rice production target setting is prioritized at a number that is higher than the previous period's production rate. Therefore, the question arises whether the determination of the national rice production target has resulted a realistic number so that it can be achieved, as well as being accountable or justified.

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To produce a national rice production target number that is robust (strong and sturdy), - at the same time realistic and accountable, qualitative and quantitative methods are needed. The determination of the national rice production target are very dependent on the forecasting practice of rice production for the coming period. Decision making regarding this target number really needs to be supported by a good result/high accuracy of forecasting of the future national rice production.

Forecasting results are said to be correct if the error or difference between the forecast results and the actual value of rice production is very small. Forecasting methods of commodity production generally require historical data at least for the past few years. This quantitative forecasting method requires sufficient historical data. However, since the Indonesian Central Bureau of Statistics made efforts to improve rice data using the Area Frame Sampling method in 2018, historical data on rice production has been very limited.

Since 2018, the Indonesian Central Bureau of Statistics has attempted to improve national rice data using the Area Frame Sampling method. Previously, the harvested area (ha) was calculated using the area approach; Data collection was carried out by the District / City agricultural service officer, with a monthly data collection frequency, as well as the use of estimating the irrigation block system method, and also the use of seeds and eye estimate (BPS 2018). This "eye estimate" method of data collection raised problems because it was considered as subjective measurement. Therefore, the Area Frame Sampling Method exists as an objective measurement solution, with satellite image analysis. The Area Frame Sampling is an area-based survey conducted by direct observation of a sample segment and aims to estimate the area by extrapolating from the sample to the population in a relatively short period (rapid estimate) [1].

Based on the above conditions, a powerful forecasting method is needed - which in this case is able to produce rice production forecasting numbers with high accuracy, as well as a method to overcome the limitations of historical data due to the application of the Area Frame Sampling method - in order to support decision making about the national rice production target number.

The results of rice production forecasting activities can clearly be a very important source of input and basis in setting the national rice production target. The existence of forecasting constraints due to limited historical data as the use of the Area Sampling Method by the Central Bureau of Statistics has pushed relevant parties need to find and apply methods-both quantitative and qualitative which can solve this problem. This study was conducted to find an appropriate forecasting method to predict future national rice production and to recommend an appropriate method for setting the national rice production target.

The objectives of this study are to find out how to do quantitative forecasting with very limited data; to analyze the rice production forecasting method that produces the smallest error value; and to give recommendation to determine rice production targets that are robust, realistic and accountable.

2 Current conditions

The availability of historical data on national rice production owned by the Indonesian Ministry of Agriculture as also released by the Central Bureau of Statistics before 2018 was actually sufficient to analyze trends and serve as the basis to forecast future rice production. Table 1 presents data on Indonesian rice production, harvested area and national rice productivity from 2014 to 2018:

Table 1. Indonesian rice production, productivity and harvested area

Year	Production (ton)	Productivity (ku/ha)	Harvested Area (Ha)
2014	70,846,465	51.35	13,797,307
2015	75,397,841	53.41	14,116,638
2016	79,354,767	52.36	15,156,166
2017	81,148,594	51.65	15,712,015
2018*	83,037,150	51.92	15,994,512

Source: Indonesian Ministry of Agriculture (2018)

Based on data from 2014 to 2018 in Table 1 and Figure 2, it can be seen that rice production and rice harvest area have an increasing trend from year to year. Meanwhile, rice productivity tends to remain constant, which is around 52.14%.

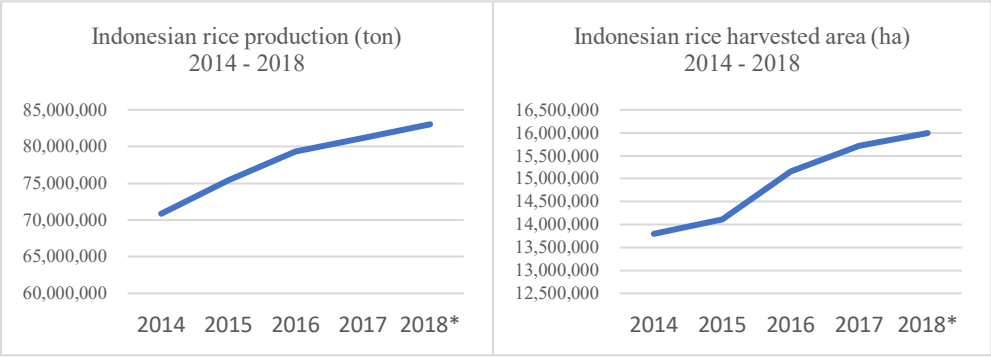

Figure 1. Indonesian rice production and harvested area trends (2014 – 2018)

However, since the Indonesian Central Bureau of Statistics used the Area Frame Sampling method to determine rice production data starting in 2018, historical data on rice production has become very limited (because it has only been presented since 2018). The 2018 rice production data using the Area Frame Sampling Method (BPS 2018) is served on Table 2.

Table 2. Indonesian rice production data obtained by the Area Frame Sample method

Year	Production (ton)	Productivity (ku/ha)	Harvested Area (Ha)
2018	56,537,774	51.85	10,903,835

Source: Indonesian Central Bureau of Statistics (2018)

Based on Table 1 and Table 2, it can be seen that there are a significant data difference in the amount of rice production in 2018.The Ministry of Agriculture data shows that the prediction of rice production in 2018 is 83 million tons, while according to the Area Frame Sampling method from the Central Bureau of Statistics shows that rice production reaches 56.5 million tons (around 30% lower). This difference is comparable to the difference in rice harvest area data which also has the same range of differences (Data on rice harvest area in 2018 according to the Ministry of Agriculture is 15.9 million ha, whereas according to the Area Frame Sampling method from the Central Bureau of Statistics shows the rice harvest area in 2018 is 10.9 million ha).

Because all databases must be officially sourced from the Central Bureau of Statistics data, then since 2018, the rice production data, productivity and rice land area used have been sourced from the Central Bureau of Statistics that applies the Area Frame Sampling method. However, the Central Bureau of Statistics does not provide historical data on rice production, productivity and rice land area using the Area Frame Sampling method before 2018.

In the 4th NMTPD year 2020-2024, it is stated that the target of increasing the availability, access and quality of food consumption with rice production indicators is targeted as follows (Table 3):

Table 3. Rice production target on NMTDP

Year	Rice production target (NMTDP* 2020 – 2024)
2020	61,0 million ton
2024	68,6 million ton

Notes:
*the Indonesian National Medium Term Development Plan
Source: [2]

The rice production target number for year 2020 and 2024 in Table 3 are target numbers based on current data using the Area Frame Sampling method that has been implemented since 2018.

As for the translation of NMTDP in to year 2019 Government Work Plan (GWP), especially in the 2019 GWP Update Substance Matrix, data on the realization and target of rice production are listed as follows (Table 4):

Table 4. National rice production realization and target number based on GWP year 2019 (in million ton)

	Realization 2016*	**Realization 2017***	**Target 2018****	**Target 2019****
National rice production	79,5	81,1	56,5	57,9

Notes:
* source: (1)
** Change in the production target is due to the improvement in the calculation methodology (by Area Frame Sampling method)

In Table 4, it appears as if the rice production target has decreased significantly by 30.3% (from 81.1 million tonnes in 2017 to 56.5 million tonnes in 2018). This can raise big questions, although in fact this is more due to differences in data collection methods.

3 Methodology

This study was conducted in September - October 2019 and involved primary and secondary data. Primary data was obtained through in-depth discussions with related parties (Ministry of Agriculture staffs). Meanwhile, the

secondary data obtained was historical data on national rice production, rice data based on the Area Frame Sampling method from the Central Bureau of Statistics (2018), NMTDP 2020-2024 and RKP 2019. NMTDP (National Medium Term Development Plan) is a development planning document compiled for a period of five years and is an elaboration of the vision, mission and programs of the President-elect based on the 20-year National Long-Term Development Plan (NLTDP) [3], while the GWP (Government Work Plan) is a national planning document for a period of 1 (one) year [4].

There are four quantitative forecasting models that were tested and simulated in this study, namely: Moving average; Weighted moving average; Exponential smoothing; and Double Exponential Smoothing (Holts Linear Trend). The error rate of the forecasting model is done by finding the Mean Square Error (MSE) value; Mean Square Error (RMSE); and Mean Absolute Percentage Error (MAPE).

The software used for data processing and forecasting was Microsoft Excel, with add-ins "Real Stats" which could be obtained by downloading online at the http://www.real-statistics.com/ page. The research framework of this study is presented in Figure 2:

Quantitatively, the determination of optimistic targets for the future period is quantitatively carried out by adding the forecast results for year i with the RMSW (Root Mean Square Error) value of the forecasting method. Meanwhile, the pessimistic target for the future period is quantitatively carried out by subtracting the forecasting result in year *i* from the RMSW value of the forecasting method. Qualitatively, targeting can be done by using several alternative methods which will be discussed in the Result and Discussion section.

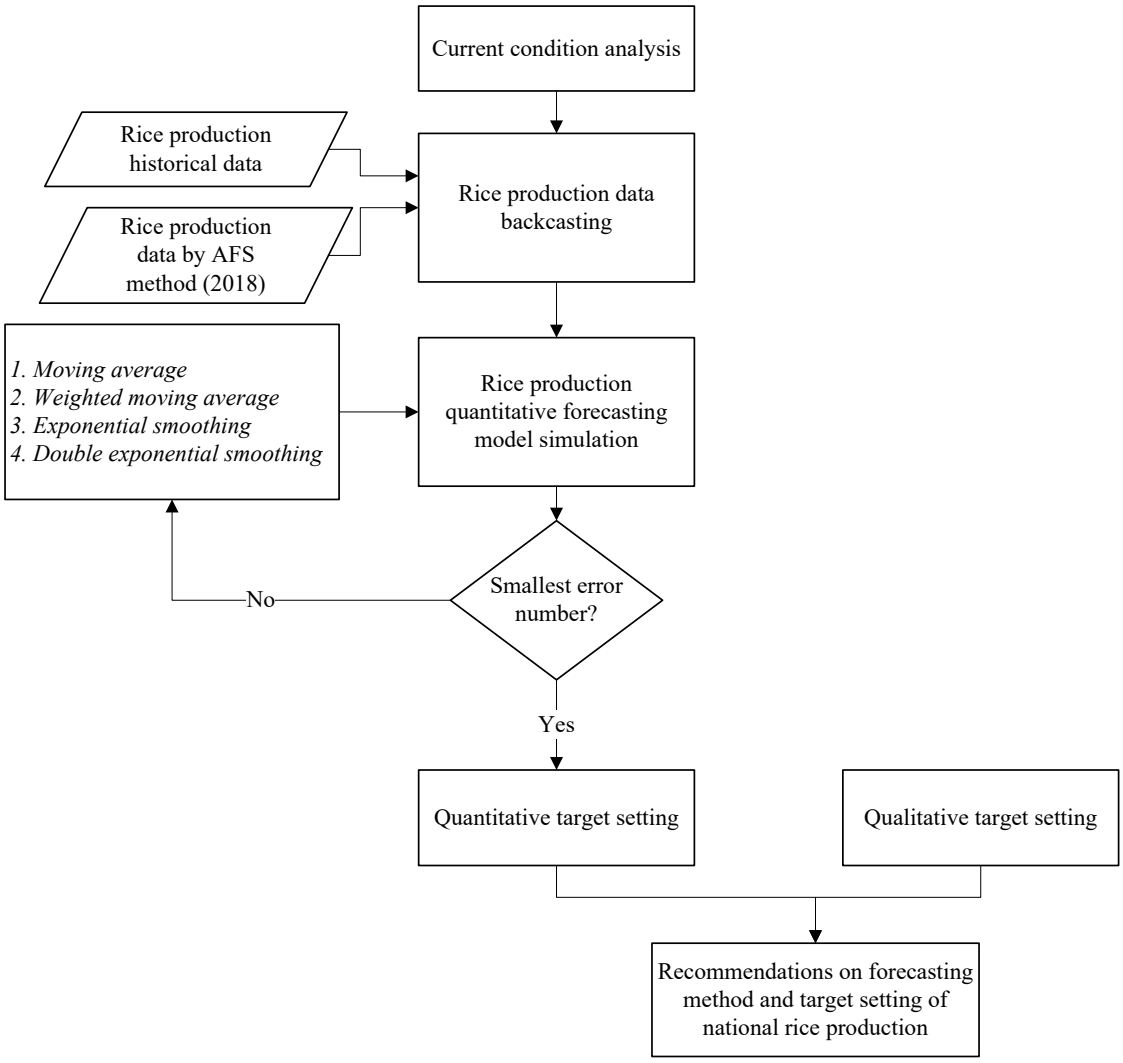

Figure 2. Research framework

4 Result and Discussion

Targets are objectives that have been set to be achieved [5]. Target setting is very important, especially if the target concerns national important food commodities; which one of them is rice. The targets set can be an indicator of success, can increase the cohesiveness / solidity of the team involved in

achieving them, can help related parties understand their respective roles in the organization in more depth, and can also help evaluate the milestones set.

Doran [6] explained that there are five criteria for setting goals / targets, abbreviated as SMART, namely:

(1) Specific - the target must be made specific; (2) Measurable - targets have criteria that can be used to measure progress; (3) Achievable or attainable - the target must be realistic and achievable, in this case the target set is neither too easy nor too difficult to achieve; (4) Relevant - targets can encourage teams and organizations to be more advanced, and targets are aligned with other targets; and (5) Time bound - the target has a deadline.

The five criteria pose a challenge in setting the national rice production target; namely determining the number of rice production that needs to be achieved in the future. Determining targets, of course, is not just about determining a number which is always higher than the current actual production number. Therefore, it is expected that the production target number is a number that is robust (strong and sturdy), realistic / achievable and at the same time accountable.

As with production target setting activities, forecasting activities also seek to find forecast result numbers for future production. By definition, forecasting is a prediction / forecasting activity in the future based on past and present data, and generally uses trend analysis. Forecasting is carried out based on factual, objective conditions, predicting what might happen in the future, assuming other factors have the same pattern (ceteris paribus).

In contrast to forecasting activities, the process of setting production targets includes subjective expectations / judgments. Target setting cannot be separated from designing what is expected to happen rationally, supported by the important role of resources and strategies. Target setting is also derived from the organization's vision, mission, objectives, strategy and roadmap.

4.1 National rice production forecasting

Production forecasting is an important activity because this activity is a process of predicting future conditions that will affect performance, behavior and output. Forecasting is opportunity based - where there is a possibility of right or wrong. One of the benefits of forecasting is that it is the key to the planning process. Forecasting results can form the basis for consideration of setting targets that are both realistic and challenging to achieve.

Forecasting is based on collecting data either externally or internally, and analysis is carried out based on past and present data using mathematical models. In addition to this quantitative model, there is also a qualitative model

for forecasting where forecasting involves subjective intuitive predictions. In forecasting, there is no single method that is superior, so that often mathematical models and qualitative models are combined in its implementation. The best forecasting method is a method that can produce the smallest error value or the difference between the forecast value and the actual value. Therefore, it is necessary to simulate / process trial and error of various forecasting methods so that the best forecasting method can be found.

Several forecasting models with a quantitative approach include the naïve method, moving average, weighted moving average, exponential smooting, holt/linear trend and many more. All methods with this quantitative approach use historical data as the basis for their forecasting activities. The amount of historical data required depends on the forecasting method used and the errors that result from that method. The more historical data used does not guarantee the results of the forecasting method will be better.

Limited historical data problem on rice production due to the implementation of the Area Frame Sampling method since 2018 can be solved by doing data "backcasting". Backcasting is actually a planning method that starts from defining the desired future conditions then working backward to identify achievements and programs related to the specified future conditions [7]. In statistics and data analysis, backcasting can be interpreted as the opposite of forecasting; where forecasting is a prediction of the future value of the dependent variable based on the known value of the independent variable. Meanwhile, backcasting is a prediction of the value of the independent variable that may exist, to explain the known value of the variable [8].

Backcasting Data

To obtain rice production data for the past 4-5 years, backcasting efforts were used from rice production data for 2018 (after the application of the new method; ASF method).

$$K_{i-1} = A_{i-1} * \propto_i \qquad (1)$$

$$\text{where } \propto_i = \frac{K_i}{A_i}$$

Notes:

K_i = estimated rice production data (using the ASF method) in year *i*

A_i = Actual data of rice production in year *i* (Data source: Indonesian Ministry of Agriculture)

$\propto_i$ = rice production constanta year *i*

Thus, the new rice production data estimates (using the ASF method) are obtained for the past few years as follows (Table 5):

Table 5. Rice production historical data by ASF method data backcasting

Year	Production number (ton)
2014	49,246,205
2015	52,364,300
2016	54,769,131
2017	55,542,269
2018*	56,537,774

Source: [1], data processed

Forecasting calculations

Forecasting on national rice production can then be carried out after sufficient historical data on rice production is available. Historical data has been obtained in Table 5 using backcasting data efforts. In this study, forecasting efforts are carried out using various quantitative forecasting methods; namely moving average, simple moving average, exponential smoothing and holts linear trend. Of all the methods that were tried out, the method that produced the smallest error / difference between the forecast and the actual data was chosen. This effort was made by comparing the MSE, RMSE and MAPE values of each method. The results of forecasting using various quantitative methods are presented in Table 6.

The weights used in the Weighted Moving Average method from year -3 to year -1 are 0.2, 0.3, and 0.5, respectively. Based on Table 6, it can be seen that the smallest forecasting error (error rate is only 2.6%) is obtained by using the double exponential smoothing method. With this method, forecasts can be generated for the next several years. Based on the results of these calculations, it is advisable to use the double expnential smoothing method for forecasting rice production.

Table 6. Rice production number forecast using various forecasting methods

Year	*Production Number (ton)*	*Simple moving Average*	weighted moving average	Exponential smoothing	Double Exponential Smoothing
2014	49,246,205			49,246,205	
2015	52,364,300			49,246,205	49,246,205
2016	54,769,131			52,364,300	53,782,141
2017	55,542,269	52,126,545	52,943,097	54,769,131	56,635,771
2018*	56,537,774	54,225,233	54,674,734	55,542,269	56,911,677
2019**		**55,616,391**	55,885,394	56,537,774	57,737,164
2020**					58,936,553
2021**					60,135,943
2022**					61,335,333
2023**					62,534,723
2024**					63,734,112
n		3	3		
α				1	1
β					0.455
MSE		8,507,505,124,496	5,113,307,174,196	4,273,625,660,712	3,008,054,077,813
RMSE		2,916,763	2,261,262	2,067,275	1,734,374
MAPE		5.12%	3.99%	3.37%	2.60%

Notes:
* forecast data source: [1]
** forecasting result

4.2 Quantitative target setting and calculation

Quantitatively, the determination of production targets can be calculated based on forecasting results so that optimistic and pessimistic targets can be obtained. The results of rice production forecasting that show an upward trend / trend are the production values that are assumed to be obtained without taking special actions / efforts. While the optimistic and pessimistic target values can be obtained by adding or subtracting the deviation value, using following formula:

Optimistic target for year *i* = forecast result for year *i* + RMSE for year *i*
Pessimistic target for year *i* = forecast result for year *i* - RMSE for year *i*

Based on this formula, the rice production target until 2024 is presented in Table 7 below:

Table 7 Rice production target setting

Year	*Rice Production*	*Forecasting result Double exponential smoothing*	*Optimistic Target*	*Pesimistic Target*	*NMTDP Target*
2014	49,246,205				
2015	52,364,300	49,246,205			
2016	54,769,131	53,782,141			
2017	55,542,269	56,635,771			
2018*	56,537,774	56,911,677			
2019**		57,737,164	59,471,538	56,002,789	
2020**		**58,936,553**	**60,670,928**	**57,202,179**	**61,000,000**
2021**		60,135,943	61,870,317	58,401,569	
2022**		61,335,333	63,069,707	59,600,959	
2023**		62,534,723	64,269,097	60,800,348	
2024**		**63,734,112**	**65,468,487**	**61,999,738**	**68,600,000**
α		1			
β		0.45			
MSE		3,008,054,077,813			
RMSE		1,734,374			
MAPE		2.60%			

Notes:
* forecast data source: [1]
** forecasting result

Table 7 also presents the rice production targets based on the NMTDP. In 2020 the rice production target according to the NMTDP is 61 million tons. This number is only slightly different from the optimistic forecast target of 60.67 million tonnes. As is known, this optimistic forecasting number is obtained by adding the forecasted number for 2020 rice production with the RMSE value.

Meanwhile, in 2024, the target production is targeted at 68.6 million tons based on the NMTDP. This number is 4.78% higher than the optimistic target value. To reach the target number above this optimistic target number, it is clear that special efforts are needed. For example, by running programs in the field of agricultural cultivation which are estimated to increase the amount of rice production, increase the area of harvested land, provide superior seeds, and increase the number of agricultural extension agents.

4.3 Qualitative target setting

Apart from quantitative methods, production target setting can also be done qualitatively. There are several qualitative methods of targeting, the two most common of which are the jury of executive opinion and the Delphi method.

Jury of executive opinion

In this method, targeting is carried out by a small group of experts (for example: high-level managers of an organization / company) who come together and estimate demand together. These experts combine managerial experience with statistical models in the process of making decisions about production targets. With this method, decisions about production target numbers can be obtained in a relatively fast period of time, but sometimes this method cannot be separated from the thinking of certain groups.

Delphi Method

Target setting using this method involves several parties; namely decision makers, staff and respondents (generally consisting of experts). The Delphi method can be a solution for the emergence of "certain group thinking" that occurs in the jury of executive opinion method. In the Delphi method, experts collect their respective opinions closely, so they tend to be free to express their ideas and opinions regarding the target they want to set. Opinion gathering can take place iteratively, and the staff is tasked with recapitulating incoming opinions from experts.

Based on descriptions of quantitative methods and qualitative methods, the determination of rice production targets can be carried out based on forecast data. The target setting method combines quantitative and qualitative methods in order to produce a rice production target number that is robust, achievable (realistic), accountable (can be justified), as well as quite challenging to achieve. The target number that exceeds the optimistic target number can be achieved by implementing special efforts and programs so that this target number can be achieved.

5 Conclusion

Based on the research results, there are several conclusions as follows:

1) Precise forecasting methods need to be known to estimate the amount of production in the future. The results of the forecasting will become one of the bases for determining the national rice production target. To overcome the limitations of past data due to the use of new methods (Area Frame Sampling method) in determining rice production number by Indonesian Central Bureau of Statistics, a backcasting method can be used so that rice data from the past four to five years can be obtained.
2) Based on the trial results of various quantitative methods, the double exponential smoothing (Holts Linear Trend) method is the most recommended method for predicting future rice production, as well as combining quantitative and qualitative methods in the application of national rice production targets.
3) The national production target number that exceeds the optimistic target number requires special programs and efforts in achieving it.

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