Analysis of carrot production development in Karo Regency North Sumatera

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Abstract. This research was conducted to predict the value of carrot production in Karo Regency North Sumatera in 2020-2021 by using Autoregression Moving Average model through some testing stages: 1). stationarity of carrot production data for 2017-2019. In this study, the data were declared stationary through a differentiation process (1st difference) with an Augmented Dicky-Fuller (ADF) value of < 0.05. 2). Furthermore, testing the model through the value of Autocorrelation Function (ACF) and Partial Correlation Function which decreased sharply (Cut Off) at the 2nd lag, so that the possible models compiled were AR1, AR2, MA1 and MA2. 3). It was decided to use the MA1 model, then it was obtained the results of carrot production in Karo Regency, North Sumatera 2020-2021 with a positive trend, which revealed the increasing of carrot production. The highest prediction occurred in December 2021, amounting to 8,580.67841 tons.

1. Introduction

Agriculture in Indonesia can be said as the driving force of the national economy. Apart from producing foodstuffs to meet people's needs, agriculture is also being a priority sector to be developed. The agricultural sector is divided into five sub-sectors, namely the food crops and horticulture sub-sector, animal husbandry, plantation, fishery, and forestry sub-sector. One of the agricultural sub-sectors is the food crops and horticulture sub-sector. Horticultural plants also play a role as a source of community nutrition, job providers and support for agro-tourism and agro-industrial activities. Horticulture is a branch of agriculture that deals with the intensive cultivation of plants proposed for human food, medicine and fulfillment of satisfaction [1]. Thus, horticultural crops are very important because they involve meeting the nutritional needs of the community that must be fulfilled. But sometimes the need for horticultural plants is difficult to fulfil due to various factors such as natural and non-natural factors. Natural factors are usually things that are difficult to predict and control by humans, but the impact caused by them can be minimized. For that it is very necessary to maintain availability by controlling production. Production control will maintain the availability of a product in order abundance of production.

One of the horticultural commodities is that has increased consumption every year, especially in Sumatera Utara is carrots. Figure 1 shows a figure of the average monthly consumption of carrots in the province of North Sumatera from 2017 to 2019 in order to explain the increased consumption of carrots:

Carrots are biennial plants (12-24 months life cycle), which store large amounts of carbohydrates for these plants to flower in the second year. Flower stems grow to about 1 m tall, with white flowers,
and a sweet, unpleasant taste. The edible part of the carrot is the tuber or root. Carrots are known in almost every country, including Indonesia. This vegetable is quite popular among the people. In almost every area, carrots are sold in the market, so they are easy to obtain. It is not surprising that in Indonesia, carrots are better known to the public than other root vegetables such as turnips. According to Central Bureau of Statistics data, carrots are a seasonal vegetable crop of fibrous tubers with the highest production, with a production of 609,634 tons in 2018, beating other root vegetables, like turnips. The following (Table 1) is data on provinces with the largest carrot production in Indonesia in 2018.

![Figure 1. Average monthly consumption of carrots in North Sumatera.](image)

| Province          | Production |
|-------------------|------------|
| West Java         | 163,224    |
| Central Java      | 153,058    |
| East Java         | 72,583     |
| North Sumatera    | 56,254     |
| South Sulawesi    | 37,273     |
| Bengkulu          | 36,943     |
| North Sulawesi    | 32,797     |
| West Sumatera     | 31,271     |
| Lampung           | 5,839      |
| South Sumatera    | 3,857      |

Table 1 shows that North Sumatera is the province producing the largest carrot outside Java, which amounted to 56,254 tonnes in 2018. North Sumatera is a province with very good condition and geographic location for horticultural crops. This can be proven by the high contribution of agriculture to North Sumatera's GRDP, which is 20%. The area with the highest carrot production is Karo Regency, which is 51,208 tons in 2018, meaning that more than 90% of carrot production comes from Karo Regency based on Central Bureau of Statistics data in 2018.

North Sumatera is also the province with the fourth largest population after West Java, East Java and Central Java, and in 2019, the total population is 14,908,036. This large population is directly proportional to high household consumption. North Sumatera itself, it is recorded to increase every year. North Sumatera carrot consumption is 0.17 kg per capita/month [3]. The increase in consumption should also be accompanied by production in order to meet the required consumption. A number of economists put forward various definitions of production but in principle they have the same meaning. The definition of production economically is to produce a number of outputs. Regarding this, the
authors further express the opinions of experts as follows: production is all activities in creating and adding utility to goods and services [4]. In addition, production can also be defined as an activity to produce goods or services or an activity adding values to the use or benefits of an item. Furthermore, production is an activity or process transforming input into output [5]. Karo District is a contributor to 90% of carrot production in North Sumatera province. When viewed in the last 3 years, carrot production in Karo district has continued to increase, even there has been a quite significant increase in 2019, namely 48,092, 51,208 and 91,984 tons. In order to continue to ensure the availability of carrots, it is necessary to forecast the future production. Prediction is a process of systematically estimating something that is most likely to happen in the future based on past and present information owned, so that the error (the difference between something that happens and the predicted results) can be minimized. Predictions do not have to provide definite answers to events that will occur, but rather try to find answers as close as possible to what will happen [6].

There are various methods that can be used to forecast the future, depending on the type of data and data patterns you have. In general, forecasting uses quantitative data, namely time series data, which is expected to be a picture of the future. It must be realized that there is no absolute best method of forecasting. Forecasting can only describe what will happen in the future, not explain why it happens. Therefore, based on the considerations, to predict carrot production data in Karo district for 2021 in this study, it used the ARMA (autocorrelation moving average) method. This study aimed to predict carrot production in Karo district, North Sumatera, with the hope that this research could help the government in making policy.

2. Materials and methods
This research was conducted using quantitative forecasting method, in which the quantitative forecasting method was a forecasting method involving statistical analysis of past data. The quantitative forecasting method of one-range time series model is a forecasting method focusing on observing a sequence of data patterns of a certain variable chronologically, for example naive techniques, smoothing, decomposition, trends, Box Jenkins methodologies such as ARMA and ARIMA [7]. The data used in this study were secondary data on the time series of carrot production in Karo Regency, North Sumatera from 2017 to 2019. The data were obtained from the Karo Regency Agriculture Office and the North Sumatera Province Food Crops Service.

Then the data would be forecast using the ARMA (Autoregression moving average) method. In carrying out the forecasting using the ARMA method, there were several steps that must be done first, namely the identification of a stationary model. The stationarity of the data could be seen through the Root Test with a probability value of > 0.05. If the Unit Root Test at the level obtained a value of > 0.05. Data that is not stationary will cause the forecast results to be inaccurate and there is a concern that they will be spurious regression by subtracting the production period t from the previous period. Therefore, it must be re-stationary by means of differentiation. The stationary data can be formulated as below:

\[ Y_t - Y_{t-1} = \rho Y_{t-1} + u_t \]  
\[ \Delta Y_t = \delta Y_{t-1} + u_t \]

Furthermore, finding the best model to predict was conducted by looking at the smallest value of Akaike info criterion and Schwarz criterion between models. Research data processing used Eviews 10 software. AR and MA models are formulated as below:

\[ (Y_t - \delta) = \alpha 1(Y_{t-1} - \delta) + u_t \]  
\[ Y_t = \mu + \beta_0 u_t + \beta_1 u_{t-1} \]
3. Results and discussion

3.1. Data stationary test
The following is the results of the data stationary test with the 1st difference because the data was not stationary at the level.

Table 2. Data stationarity test.

| Augmented Dickey-Fuller test statistic | t-Statistic | Prob.* |
|---------------------------------------|-------------|--------|
|                                       | -5.420614   | 0.0001 |

Test critical values:
- 1% level: -3.639407
- 5% level: -2.951125
- 10% level: -2.614300

*MacKinnon (1996) one-sided p-values.

Table 2 shows the probability value of Augmented Dickey-Fuller (ADF) 0.0001 < alpha of 0.05, it is concluded that the data was stationary at the 1st difference level.

3.2. Model determination
Determination of the model was done by looking at the value of the Autocorrelation Function (ACF) and Partial Correlation Function (PACF) whether there was Cut Off or Dying down.

Table 3. ACF and PACF values.

| Autocorrelation | Partial Correlation | AC   | PAC   | Q-Stat | Prob |
|-----------------|---------------------|------|-------|--------|------|
| -. | -. | 1 | -0.128 | -0.128 | 0.6223 | 0.430 |
| -. | -. | 2 | -0.159 | -0.178 | 1.6161 | 0.446 |
| -. | -. | 3 | 0.116 | 0.073 | 2.1621 | 0.539 |
| -. | -. | 4 | 0.006 | 0.005 | 2.1637 | 0.706 |
| -. | -. | 5 | -0.314 | -0.297 | 6.4186 | 0.268 |
| -. | -. | 6 | 0.165 | 0.089 | 7.3998 | 0.266 |
| -. | -. | 7 | -0.032 | -0.105 | 7.6877 | 0.361 |
| -. | -. | 8 | -0.183 | -0.139 | 9.2910 | 0.318 |
| -. | -. | 9 | 0.173 | 0.123 | 10.781 | 0.291 |
| -. | -. | 10 | 0.096 | -0.003 | 11.258 | 0.338 |
| -. | -. | 11 | -0.271 | -0.171 | 15.206 | 0.173 |
| -. | -. | 12 | 0.022 | -0.076 | 15.234 | 0.229 |
| -. | -. | 13 | -0.011 | -0.185 | 15.241 | 0.293 |
| -. | -. | 14 | -0.135 | -0.071 | 16.357 | 0.292 |
| -. | -. | 15 | 0.113 | 0.067 | 17.184 | 0.308 |
| -. | -. | 16 | 0.106 | -0.043 | 17.945 | 0.327 |

The Table 3 shows a sharp decline (Cut Off) on the 2nd lag, meaning that there was a possibility in AR1, AR2, MA1, and MA2. Furthermore, determination of the best model was conducted to do forecasting.

The determination of the smallest values of Akaike Info Criterion (AIC) and Schwarz Criterion (SC) was used to see the comparison of the best models. The following is a table of AIC and SC values. Table 4 shows the smallest AIC and SC values in the AR2 and MA1 models, namely the same values of 17.55750 and 17.64636. As the consequence, the AR2 or MA1 model were taken for the forecasting need.
### Table 4. AIC and SC values.

| Model | AIC   | SC    |
|-------|-------|-------|
| AR 1  | 17.62654 | 17.75985 |
| AR 2  | 17.55750 | 17.64638 |
| MA 1  | 17.55750 | 17.64638 |
| MA 2  | 17.61521 | 17.74852 |

### 3.3. Forecasting

It is known that the best models obtained were AR2 and MA1, so researchers arbitrarily took one of the models used in forecasting, namely the MA1 model, then gained the carrot production forecasting for Karo Regency, North Sumatera in 2020-2021, which is informed in the table.

### Table 5. Forecasting carrot production in Karo Regency in 2020-2021.

| Year | Month | Production forecasting |
|------|-------|-------------------------|
| 2020 | January | 6,908.041064 |
|      | February | 6,980.764426 |
|      | March    | 7,053.487789 |
|      | April    | 7,126.211152 |
|      | May      | 7,198.934515 |
|      | June     | 7,271.657878 |
|      | July     | 7,344.381241 |
|      | August   | 7,417.104604 |
|      | September| 7,489.827967 |
|      | October  | 7,562.551329 |
|      | November | 7,635.274692 |
|      | December | 7,707.998055 |
| 2021 | January | 7,780.721418 |
|      | February | 7,853.444781 |
|      | March    | 7,926.168144 |
|      | April    | 7,998.891507 |
|      | May      | 8,071.61487 |
|      | June     | 8,144.338232 |
|      | July     | 8,217.061595 |
|      | August   | 8,289.784958 |
|      | September| 8,362.508321 |
|      | October  | 8,435.231684 |
|      | November | 8,507.955047 |
|      | December | 8,580.67841 |

The Table 5 shows carrot production in Karo Regency, North Sumatera in 2020-2021, which demonstrates a positive trend, namely the increasing of carrot production with the highest forecasting results occurred in December 2021. The forecasting value is not a certain evidence. It is the result of an evidence prediction through operating the best model.
4. Conclusions
Based on the forecasting results, it can be concluded; firstly, the best models in this example were AR2 and MA1 with AIC and SC values of 17.55750 and 17.64636, respectively. Secondly, Carrot production in Karo Regency, North Sumatera in 2020-2021 had positive trend, meaning an increasing of carrot production, with the highest forecasting result occurred in December 2021, amounting to 8,580.67841 tons.

References
[1] Zulkarnain 2009 Dasar–Dasar Hortikultura [Horticulture Basics] (Jakarta, Indonesia: PT Bumi Aksara)
[2] Badan Pusat Statistik Indonesia [BPS-Statistics of Indonesia] 2019 Indonesia dalam Angka 2019 [Indonesia in Figures 2019] (Jakarta, Indonesia: Badan Pusat Statistik Indonesia [BPS-Statistics of Indonesia])
[3] Badan Pusat Statistik Provinsi Sumatera Utara [BPS-Statistics of Sumatera Utara Province] 2019 Sumatera Utara dalam Angka 2019 [Sumatera Utara in Figures 2019] (Medan, Indonesia: Badan Pusat Statistik Provinsi Sumatera Utara [BPS-Statistics of Sumatera Utara Province])
[4] Assauri S 2006 Manajemen Pemasaran: Dasar, Konsep dan Strategi [Marketing Management: The Basics, Concepts and Strategies] (Jakarta, Indonesia: PT Rajagrafindo Persada)
[5] Mas’ud F 2004 Survai Diagnosis Organisasional: Konsep dan Aplikasi [Organizational Diagnostic Survey: The Concepts and Applications] (Semarang, Indonesia: Badan Penerbit Universitas Diponegoro [Universitas Diponegoro Publishing Agency])
[6] Herdianto 2013 Prediksi Kerusakan Motor Induksi Menggunakan Metode Jaringan Saraf Tiruan Bakpropagation [Forecasting of Induction Motor Damage Using Bakpropagation Neural Network Methods] Master Thesis (Medan, Indonesia: Universitas Sumatera Utara)
[7] Firdaus M 2006 Analisis Deret Waktu Satu Ragam [One-Way Time Series Analysis] (Bogor, Indonesia: IPB Press)

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