The impact of covid-19 pandemic on food sufficiency in Bantul Yogyakarta – Indonesia

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Abstract. Bantul is one of regencies in Special Region of Yogyakarta Indonesia which prone to geological disaster such as earthquakes and tsunami. Bantul likewise risky regency to Coronavirus Disease 2019 (COVID-19) pandemic due to the immense tourism and student urbanization. This study was aimed to explore the supply and demand behavior of rice (staple food) during the COVID-19 pandemic period in Bantul regency. Dynamic modeling software (Powersim 10) was applied in this study. The modeling used series data 2010 to 2019 produced by Statistic Agency of Bantul which include rice production, population, urbanization, and rice field area data. The COVID-19 pandemic was assumed taken place throughout 2020. The validation model adopted MAPE (Mean Absolute Percentage Error). This study proved the rising of the rice demand in 2020 was 145,131.25 ton while the production was 115,988.47 ton, so the COVID-19 pandemic caused Bantul regency was deficiency of rice 29.142,78 ton. The surplus of rice reoccurs in 2021 to 2026 and Bantul was deficiency of rice 573.51 ton in 2027.

1. Introduction
The Covid-19 pandemic caused by coronavirus has presented a real threat to health around the world since it spread in early December 2019 [1]. The Covid-19 pandemic came quickly, where the government and the public were not ready to deal with. These conditions have never been faced and are different from the catastrophic conditions of earthquakes, floods, or volcanic eruptions of a localization nature. However, this condition has already hit all parts of the world at the same time.

 Suppressing and reducing public transmission, reducing the burden on the health care, while providing the best care for patients, most regions and countries have enacted extraordinary public health measures with unprecedented social and economic interventions [2]. Community-based measures include actions taken by central, local governments, and corporate to protect vulnerable groups, employees, and residents as a whole. These measures include interventions in the workplace, education centers, public transportation, spiritual and cultural venues, among others that aimed at reducing transmission through behavioral changes that can be managed by health care capacity [3].

The prevention of covid-19, such as lockdown imposed by the government/community, is a consequence of the COVID-19 pandemic. These results in almost all community activities outside the home being avoided or stopped. Lockdown efforts significantly affect the supply chain, leading to a
reduction in economic growth. The Covid-19 pandemic created a major shift in terms of food access, food security, and food loss [4]. Especially in the consumption subsystem, the Covid-19 pandemic has a short-term impact on people's behavior by 29.8% [5] to 54.5% [6].

Under this overall framework, this study was aimed to explore the supply and demand behavior of rice (staple food) during the COVID-19 pandemic period in Bantul regency.

2. Methodology

2.1. Research methods
This research used a dynamic model approach built with two subsystems of rice supply and demand during the covid-19 pandemic. Rice availability subsystem analysis is based on the ability of rice fields that provide rice in the Bantul Regency. The data used include population, urbanization, rice field area starting from 2010-2019, and per capita rice consumption. The Covid-19 pandemic is assumed to occur throughout 2020. The data obtained from the Central Bureau of Statistics (BPS), the Department of Agriculture and Food Crops Bantul Regency, and the Tourism Office of the Special Region of Yogyakarta Province.

2.2. Model validation
The MAPE (Mean Absolute Percentage Error) test used to determine the suitability of the simulation result data with the actual data with the following formula:

\[ MAPE = \frac{1}{N} \sum \left| \frac{X_m - X_d}{X_d} \right| \times 100 \% \]  

Where MAPE represents the value of Mean Absolute Percentage Error, \( X_m \) is the simulation data, \( X_d \) is actual data and \( n \) is the amount of data/period.

2.3. Model Simulations and Assumptions
The scenarios presented in this study are two, the scenario of no pandemic and the pandemic scenario. These scenarios were established to distinguish two temporal frameworks: without the COVID-19 pandemic and the COVID-19 period. The simulation results of these scenarios make it possible to determine the impact of COVID-19 on the availability of rice in Bantul.

The software used in the dynamic model analysis is Powersim 10. Simulations began in 2010 and the government policy scenarios from 2020 to 2050. While the assumptions built are:

a. The area of rice fields as a baseline used rice field area data in 2010 is 15,465 hectares [7].
b. Crop index is the average ratio of harvest area with an area of irrigation planting in 2010-2019 of 2.34 [7, 8].
c. Rice productivity is the production of dried grain rice harvest per hectare amounting to 60.18 quintals/hectare and rice conversion 64.27% [8].
d. Consumption of rice per capita per year of Bantul Regency amounted to 91.58 kg [8].
e. The baseline population used was 909,539 in 2010 [7].
f. Population growth rate from 2010 to 2019 was 1.3% [7, 8].
g. The number of baseline travelers used was 1,496,626 in 2010, with an occupancy period of 2.39 days [7].
h. The rate of growth of tourists in the period 2010-2019 averaged 11.6 % per year [7, 8].
i. Covid-19 pandemic lasts for one (1) year (2020).
j. During the Covid-19 pandemic, tourist visits to tourist sites are considered none.

3. Results and discussion
Bantul Regency is located between 07º44'04" 08º00'27" South Latitude and 110º12'34" - 110º31'08" East Longitude. To the east, it is bordered by Gunungkidul Regency, to the north bordering Yogyakarta Province.
city and Sleman Regency, to the west bordering Kulon Progo Regency, and to the south bordering the Indonesian Ocean. Administratively Bantul Regency consists of 17 sub-districts and 75 villages [8].

3.1. Model

Based on the results of the study, the conceptual model of rice supply and demand in the Bantul Regency present in Figure 1. In the conceptual model, there are two loops, namely the supply and demand loop. The bidding loop is influenced by the area of rice fields, the level of productivity, the impact of climate deftness, and land conversion. The rice demand loop is influenced by the population, the level of per capita consumption, and the impact of disasters.

**Figure 1.** Causal loop diagram of rice availability model in Bantul

**Figure 2.** Flow chart simulation of rice availability system in Bantul Regency, D.I. Yogyakarta
The Causal Loop Diagram (CLD) of the rice supply sub-system is developed into a dynamic system-based model that is more complex in the form of a Stock and Flow Diagram (SFD). The results of the development of the rice supply model in Bantul Regency is presented in figure 2.

3.2. Model validation

Model validation is performed on the mods used in the simulation. The validation results are shown in Table 1. Table 1 shows that the validation test for population change and consumption amount shows a very high level of accuracy (very precisely indicated MAPE values are 0.18% and 1.81% respectively, while for rice production changing the accuracy rate is quite good (right) with a MAPE value of 8.36%. Based on this, the model that formed can be used to perform scenarios and generate simulation values that are close to the actual state.

| Year | Population Actual | Simulation 919,356.87 | Rice Production Actual 113,749.59 | Simulation 129,749.59 | Rice Consumption Actual 83,295.58 | Simulation 84,194.70 |
|------|-------------------|------------------------|-------------------------------|----------------------|-------------------------------|----------------------|
| 2010 | 909,539.00        | 919,356.87             | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2011 | 922,104.00        | 932,453.00             | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2012 | 934,674.00        | 945,851.70             | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2013 | 947,072.00        | 959,573.00             | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2014 | 959,445.00        | 973,639.16             | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2015 | 971,511.00        | 988,074.92             | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2016 | 983,527.00        | 1,002,907.83           | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2017 | 995,264.00        | 1,018,168.59           | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2018 | 1,006,692.00      | 1,033,891.40           | 129,749.59                    | 83,295.58            | 84,194.70                    |
| 2019 | 1,018,402.00      | 1,050,114.45           | 129,749.59                    | 83,295.58            | 84,194.70                    |

MAPE (%) 0.18 8.36 1.81

Source: BPS Bantul Regency and the data is processed

3.3. Simulation

Based on MAPE test results that the rice availability model in Bantul Regency is valid, furthermore to be able to determine the impact of the covid-19 pandemic on rice availability in Bantul run two scenarios, namely:

3.3.1. Scenario 1: without covid-19 pandemic. The trend pattern of rice availability resulted in simulated scenarios without the Covid-19 pandemic graphically presented in figure 3. In this scenario, no policy is applied to the rice production and consumption subsystem in Bantul. It assumed that no disaster occurred during the simulation period. There is no rice demand pressure in Bantul.

In Figure 3, it is seen that the availability of rice in Bantul in the period 2019-2026 is in surplus condition, meaning rice production is sufficient to meet the needs of the community until 2026. However, from 2027 to 2050 Bantul has a shortage of rice (deficit condition). The decline in rice balance sheet affected the rice independence index in Bantul. In the period 2020-2026 (6 years) Bantul rice self-sufficiency index decreased drastically to 1.46 percent.
Figure 3. Conditions of availability and needs of rice on dynamic models without covid-19 pandemic

3.3.2. Scenario 2: there is a covid-19 pandemic. The trend pattern of shifting the availability curve and rice needs in Bantul Regency during the Covid-19 pandemic is presented in figure 4.

Figure 4. Results of simulating the availability and needs of rice during the Covid-19 pandemic in Bantul.

Table 2. Rice production, consumption, and balance sheet scenarios in Bantul

| Year | Rice Production Scenario 1 | Rice Consumption Scenario 1 | Rice Production Scenario 2 | Rice Consumption Scenario 2 | Balance Sheet Scenario 1 | Balance Sheet Scenario 2 |
|------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------|--------------------------|
| 2019 | 119,796.57                  | 96,185.93                  | 23,610.65                   | 22,496.47                   |
| 2020 | 116,593.25                  | 97,724.78                  | 18,868.48                   | 29,142.78                   |
| 2025 | 112,898.32                  | 106,346.19                 | 6,552.13                    | 6,229.45                    |
| 2026 | 109,879.45                  | 108,299.70                 | 1,579.75                    | 2,860.58                    |
| 2027 | 110,242.65                  | 110,347.87                 | 105.22                      | 573.51                      |
| 2050 | 89,349.66                   | 232,949.54                 | 143,599.88                  | 130,230.73                  |

Source: Dynamic model analysis with Powersim 10 (2020)

In figure 4 it seems that the Covid-19 pandemic caused a strong shock to the rice demand system in Bantul. The availability of rice in the period 2010-2019 still shows surplus conditions. However, during the pandemic year (2020), rice demand soared to exceed Bantul’s ability to provide rice supply, resulting in Bantul running a rice deficit in the pandemic year. Rice production pressures took place during the
2020 pandemic year so that in the normal year the availability of rice in Bantul returns to surplus until 2026. The production, consumption, and balance sheet behavior of rice in Bantul in scenarios 1 and 2 present in table 2.

Based on table 2, it is seen that in scenario 1 (2019-2026) the availability of rice in Bantul is in surplus condition, but this condition continues to decrease by 9.03% during the period or surplus of rice remaining 6.7% when compared to the surplus condition in 2019 as 23,610.65 tons. Along with the decrease in rice production, the rate of demand for rice for consumption is increasing. The percentage increase in rice demand is higher than the decrease in rice production in the same period, which is 12.6%. The high percentage increase in rice demand, as well as decreased production capability, caused Bantul to run a deficit of 105.22 tons in 2027 and so in subsequent years.

While in scenario 2, the availability of rice in Bantul that is under intense pressure due to the impact of the Covid-19 pandemic is the consumption subsystem. The Covid-19 pandemic had an impact on people's consumption in the pandemic year rise to 145,131.25 tons or an increase of 49.38 percent compared to the simulated conditions without the Covid-19 pandemic (97,724.78 tons, consumption of scenarios without pandemic). So, the balance sheet of rice availability is under intense pressure and has a rice deficit reaching 29,142.78 tons. The current pandemic deficit can be suppressed with the adequacy of rice stocks from 2019 before the Covid-19 pandemic appeared. Furthermore, in 2021 the condition of rice surplus regains until 2026. Meanwhile, the deficit starting in 2027, amounting to 573.51 tons. The conditions in which rice production can no longer keep pace with the increase in rice consumption are in effect until 2050.

Therefore, it is necessary to take strategic measures to suppress factors that influence the increase in demand for rice consumption and encourage the implementation of policies that can increase rice production.

4. Conclusion and remarks

Covid-19 pandemic provides a strong shock to the rice demand system in Bantul. During the pandemic year (2020), rice demand soared to exceed Bantul's ability to provide rice supply, Bantul running deficit in the pandemic year. For further research, dynamic models are needed that can monitor consumption behavior with a daily time span, in order to obtain more detailed results.

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