Spatial projection of food needs and food availability in Purworejo District

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Abstract. Food needs and food availability is a factor in measuring food security. Conditions of availability and demand for food always changes every year, because it is influenced by several factors. Uncertainty of supporting factors regarding food availability (such as land area, climate and others) as well as the population that continues to increase which has an impact on amount of food needs, can cause an imbalance in the region's food adequacy conditions. This study aims to project the availability and need for food until 2030 in Purworejo District. The study was conducted using quantitative methods that were analyzed descriptively and spatially. The study uses data on population, agricultural production and the value of rice consumption obtained through the Central Statistics Agency (BPS). The results show that the projected availability and demand for rice in 2030 shows an increase in both the amount of availability and food needs. Total food availability increased by 1.27 percent from 2018, while total food demand increased by 3.78 percent from 2018. Spatially, there was an increase in the number of sub-districts included in the "low" classification of food availability in 2030, namely Purworejo, Gebang and Bruno Sub-district, while the districts that have the highest food needs from 2018 to 2030, still occur in Purworejo District.

1. Research Background

Rice is the main staple food for the population in Asia, so the availability of rice is one of the important aspects in meeting energy needs and maintaining socio-economic stability and development. According to [1], food availability is part of the upstream system that must be controlled to achieve food security in an area. The food security system in Indonesia includes 4 sub-systems namely; 1) the availability of food with sufficient types and quantities for the population, 2) distribution, 3) fulfilling nutritional adequacy, so that it has an impact on 4) the nutritional status of the population [2]. The concept of food availability refers to the amount and type of food available, both from domestic production, imports and food reserves [1], [3]. Some factors that affect food availability include food production, access to natural resources, climate, land management and markets. These factors affect the amount of food availability, especially rice, from the availability of domestic products [4]. The availability of domestic food that is able to meet the demand for food, or the amount of availability equal to the amount of food needs, can be called food security in terms of the independence of a region [5].

Food availability is always related to food needs. The increase in food needs is generally influenced by the population. In addition, an increase in food demand is an implication of
economic growth, increased purchasing power and changes in food tastes in the community [3]. Fluctuating conditions of food availability are caused by competition in productive land use, thus affecting production and productivity in food supply. That is what causes the condition of food sufficiency in an area often changes.

Purworejo District is one of the rice-producing regions in Central Java. Data from the Central Statistics Agency show that the availability of rice in Purworejo District was more dominant, experiencing a surplus from 2009 to 2018. The following is a graph of the trends in rice food demand and availability in Purworejo District (Fig. 1).

The availability of rice always moves at a positive rate from 2009 to 2013. However, the rate of movement fluctuated in 2014 to 2018. The most decline in rice availability in Purworejo District occurred in 2015 to 2016, where conditions worsened in 2017. The decrease in availability was caused by climate anomaly factors in 2017, in the form of Cempaka and Dahlia cyclones. In addition, the data also shows that the area of paddy fields has decreased by more than 1,000 hectares or 2.3 percent from the previous area [6]. Uncertain food supply conditions, due to increased production accompanied by physical factors degradation and land changes can result in an unsustainable production system [7]. Also supported by conditions of increased food demand due to population growth, then food sufficiency will be disrupted, even one day unable to meet human needs anymore [8].

The availability and need of rice in Purworejo District are important to know spatially. It aims to support and enhance the potential of the region that can be developed through aspects of food production. In addition, areas that have the potential to be developed will contribute to other regions. This study aims to determine the spatial distribution of rice availability, rice needs, adequacy of rice and also projections until 2030 in Purworejo District.

2. Data and Methods

The research area is in Purworejo District, Central Java, which has 16 districts. The study was conducted with quantitative methods analyzed descriptively and spatially. The study uses secondary data such as population, harvested area, and district rice production in 2009 to 2018 obtained through the publication of Kabupaten Purworejo Dalam Angka by the Central Statistics Agency (BPS). Other data used are the value of the conversion of rice to rice and the value of the need for rice consumption per year determined by BPS.

The adequacy of rice is analyzed by knowing the conditions of rice availability and needs, spatially in 16 sub-districts, Purworejo District. The availability of rice is assumed to be the result of domestic rice production without the availability of imported rice. The availability of rice can be calculated using the following formula [9].
\[
R_{net} = (P_x(1-S-F-W)) \times C
\]

**Description:**
- \(R_{net}\): Net rice production (tons/year)
- \(P\): Production of MPD (ton/year)
- \(S\): Use for seeds (0.9%)
- \(F\): Use for feed (0.44%)
- \(W\): Scattered (5.4%)
- \(C\): Value of conversion of rice to rice (62.74%)

The conversion of grain to rice is 62.74\%, which means that every 100 kg of milled dry rice (GKG), will produce 62.74 kg of rice. The need for rice is the amount of rice consumption needed to meet the nutritional needs of the community. The need for rice is assumed to have the same amount of consumption average for each person which is 113.48 kg/capita/year by Central Statistic Agency, so that the need for rice can be spatially calculated using the following formula.

\[
K_B = J_P \times 113.48 \text{ kg/capita/year}
\]

**Description:**
- \(K_B\): Consumption of rice (tons/year)
- \(J_P\): Total population (inhabitants)

The condition of rice sufficiency is assumed by the difference between the amount of rice available and demand (tons/year), assuming that the population has the same accessibility capability in reaching food [8], [10]. The difference will show the plus and minus values, where the plus value is assumed to be a surplus condition and the minus value is a deficit condition. Food availability and needs are classified into three classes namely "High", "Moderate" and "Low" which function to analyze the spatial distribution of regional conditions. Projections of rice availability and demand are carried out until 2030 using an exponential method for calculating growth rates. The following formula is the rate of growth with an exponential method.

\[
r = \frac{1}{t} \times \ln \left( \frac{P_t}{P_0} \right)
\]

\[
P_t = P_0 \times e^{rt}
\]

**Description:**
- \(r\): Growth rate (%)
- \(t\): the period between \(P_t\) and \(P_0\)
- \(P_t\): Final year
- \(P_0\): Early year
- \(e\): Constants (2.7182)

The use of exponential methods for growth rates is assumed because the population continues to change at any time, through the process of birth, death and migration, so that the projected data obtained is more accurate. Numerical data processing is done using Microsoft Excel, while spatial data processing uses ArcGIS software.

3. Results and Discussion

3.1. Food Availability (Rice)

Food availability is one of the factors that can affect national’s stability. Based on these conditions, food availability becomes an important aspect that must be considered in carrying out development (Santosa and Sudrajat, 2017). Domestic food availability is determined from the production of
Milled Dry Grain (MDG). MDG production will be directly proportional to food availability. Following are data on food availability per subdistrict in Purworejo District in 2018 (Table 1).

| Subdistrict | Food Availability 2018 (ton/year) | % Food Availability |
|-------------|-----------------------------------|---------------------|
| Grabag      | 18226.86                          | 9.39                |
| Ngombol     | 26173.06                          | 13.49               |
| Purwodadi   | 18578.59                          | 9.57                |
| Bagelen     | 2890.11                           | 1.49                |
| Kaligesing  | 873.36                            | 0.45                |
| Purworejo   | 8522.62                           | 4.39                |
| Banyuurip   | 18499.79                          | 9.53                |
| Bayan       | 11924.06                          | 6.14                |
| Kutoarjo    | 12589.62                          | 6.49                |
| Butuh       | 17585.27                          | 9.06                |
| Pituruh     | 16105.60                          | 8.30                |
| Kemiri      | 9204.78                           | 4.74                |
| Bruno       | 7480.70                           | 3.85                |
| Gebang      | 8519.11                           | 4.39                |
| Loano       | 7863.61                           | 4.05                |
| Bener       | 9037.28                           | 4.66                |
| Total       | 194074.43                         | 100.00              |

The results showed that the total of food availability in Purworejo District reached 194,074.43 tons/year, with the highest food availability is in Ngombol Subdistrict and the lowest food availability is in Kaligesing Subdistrict. Food availability in Ngombol Subdistrict is 26,173 tons/year or 13.49 percent of the total food availability in Purworejo District. Food availability in Kaligesing Subdistrict only reached 873 tons/year or around 0.45 percent of the total food availability in Purworejo District. One of the factors that influence the amount of food availability is the physical characteristics of the region, following is a distribution map of food availability in Purworejo District in 2018.

Figure 2. Food Availability Map of Purworejo District in 2018.
Physical characteristics of the region are aspects that affect physical factors to support food production, so it can increase the amount of food availability, especially domestic availability [1]. Food availability classification is based on the percentage of total food availability in the district. The "high" class is in the southern and western parts of Purworejo District. the "moderate" class is spread in the Central and North of Purworejo District, while the "low" class is in the eastern part of Purworejo District.

Spatially, the "high" class is due to the region being dominated by flat relief, which allows paddy fields to develop optimally. Flat relief areas provide great potential in the form of ease in cultivating agricultural land, both from the existence of physical supporting factors (land and water resources) and land management systems. In contrast to the "moderate" class and the "low" class, the area has relief that varies from bumpy to steep. This condition will require large operations for the provision of agricultural land, especially in land management systems and irrigation flows. Land management in these reliefs requires mechanical effort to minimize the slope so that agricultural land remains conserved. Cultivation of agriculture in the area can only be done with rain-fed paddy fields that rely on rain, so the results obtained depend on certain supporting factors of production.

In addition, a wider paddy field and water resources that are easily accessible to land, will produce more rice production so that food availability will be higher. Ngombol Sub-district has the most dominant paddy field area, while Bagelen Sub-district and Kaligesing Sub-district have the narrowest paddy field area[6]. The current condition of food availability is one of projection factors to determine food availability condition in the future. The following is a projection of food availability in Purworejo District in 2020, 2025 and 2030 (Fig. 3).

Food availability is projected to increase from 2020 to 2030. In 2030, food availability will reach 196,552,56 tons/year or increase 1.27 percent of the total availability in 2018. The rate of food availability growth is small within a period of 10 years. It is possible that there is a change in the food availability class from the previous year. Following is the spatial distribution of food availability in Purworejo District in 2030 (Fig. 4).
The projected of food availability in 2030 shows that there are several subdistricts that have experienced changes in availability class. The "low" class increased to 5 subdistricts namely Kaligesing, Bagelen, Purworejo, Gebang, and Bruno Subdistricts, while the "high" class was in the same subdistrict in 2018 namely Ngombo, Grabag, Banyuurip, Purwodadi, Butuh, and Pituruh Subdistricts.

a. Food Needs (Rice)
Food availability will always have an impact on the conditions of meeting food needs. Rice is main food to meet food needs in Purworejo District. The main factor that affecting the amount of food needs is the large population in the region. The more population that lives in a region, the greater the demand for food that must be met. The following is a graph of population trends in Purworejo District (Fig. 5).

Figure 5. Graph of Population Trends in Purworejo District.

The average population has increased from 2010 to 2018. The most significant increase in population occurred from 2011 to 2012. The decline in population only occurred once from 2012 to 2013, which is usually influenced by 2 main factors namely mortality and population migration. This is consistent with the data Kabupaten Dalam Angka which shows that the number of deaths increased by 25 percent and population migration increased by 73 percent from the previous year [11], [12]. The population of Purworejo District is not evenly distributed. Population buildup occurs in Purworejo Subdistrict with the narrowest area in the district. Following are total population and food needs per subdistrict in Purworejo District in 2018 (Table 2).
Table 2. Total Population and Food Needs Per Subdistrict in Purworejo District in 2018.

| Subdistrict | Total Population 2018 (Inhabitants) | Food Needs (ton/year) |
|-------------|-------------------------------------|-----------------------|
| Grabag      | 43922                               | 4984.27               |
| Ngombl      | 31709                               | 3598.34               |
| Purwodadi   | 37536                               | 4259.59               |
| Bagelen     | 29576                               | 3356.28               |
| Kaligesing  | 29987                               | 3402.92               |
| Purworejo   | 85420                               | 9693.46               |
| Banyuurip   | 41201                               | 4675.49               |
| Bayan       | 47025                               | 5336.40               |
| Kutoarjo    | 59934                               | 6801.31               |
| Butuh       | 39961                               | 4534.77               |
| Pituruh     | 47048                               | 5339.01               |
| Kemiri      | 52140                               | 5916.85               |
| Bruno       | 44581                               | 5059.05               |
| Gebang      | 41034                               | 4656.54               |
| Loano       | 35589                               | 4038.64               |
| Bener       | 49814                               | 5652.89               |
| Total       | 716477                              | 81305.81              |

The total population of Purworejo District in 2018 reached 716,477 inhabitants, with Purworejo Subdistrict as the subdistrict with the most population i.e. 85,420 people or 11.92 percent and Bagelen Subdistrict as the subdistrict with the least population i.e. 29,576 people or 4.13 percent of total population. The population in Purworejo Subdistrict is largely triggered by the status as the central of government and the central of economic. The region with this status has more complete public facilities than other regions. This is an attraction for the community, to be used as a supporting factor in carrying out daily economic activities [13]. This easiness is one of the factors that causes population buildup in Purworejo Subdistrict.

The increase in population is also directly proportional to the increase in food needs. Fulfillment of food needs in Purworejo District on average is still dominated through rice food, Purworejo Subdistrict is the region with the highest food needs, reaching 9,693.46 tons/year and Bagelen Subdistrict is the region with the smallest food needs of 3,356.28 tons/year. Increasing population from year to year, can provide projections for future food needs. Food demand projection is one form of anticipating the fulfillment of food needs, so that it can be used as a basis for policy making to overcome these problems. The following is a projection of the food needs in Purworejo District in 2020, 2025 and 2030 (Figure 6).

![Figure 6. Graph of Food Needs Projection in Purworejo District.](image-url)
Food needs projections from 2020 to 2030 continue to increase with an average growth rate of 1.9 percent per year. The food needs in 2030 increased to 3.7 percent from 2018. Spatially, the increase in food needs occurred in all subdistricts, following is the spatial distribution of projected food needs per subdistrict in Purworejo District in 2030 (Figure. 7).

![Food Needs Distribution Map of Purworejo District in 2030](image)

**Figure 7. Food Needs Distribution Map of Purworejo District in 2030**

Food needs projections classification is based on the percentage of food needs per subdistrict from the total food needs in Purworejo District. The "high" class is in Purworejo Subdistrict, as the only subdistrict with the most food needs. Then, there are 7 subdistricts that are included in the "moderate" class, namely Bruno, Pituruh, Kemiri, Bayan, Kutoarjo, Grabag and Bener, and 8 other subdistricts fall into the "low" class, namely, Butuh, Gebang, Loano, Kaligesing, Banyuurip, Bagelen, Ngombol and Purwodadi.

**b. Food Sufficiency (Rice)**

Food sufficiency is assumed that the availability of rice can meet the needs of the population and by assuming that the population has the same ability in accessibility (purchasing power). The sufficiency of rice in 2018 shows the condition of rice surplus. However, the ability of each district to meet rice needs through domestic production is different. The following is the condition of rice sufficiency per sub-district in Purworejo District in 2018 (Table 3).

| Sub-district   | Rice Sufficiency (ton/year) | Description |
|----------------|-----------------------------|-------------|
| Grabag         | 13242,59                    | Surplus     |
| Ngombol        | 22574,72                    | Surplus     |
| Purwodadi      | 14319,00                    | Surplus     |
| Bagelen        | -466,18                     | Deficit     |
| Kaligesing     | -2529,57                    | Deficit     |
| Purworejo      | -1170,84                    | Deficit     |
| Banyuurip      | 13824,30                    | Surplus     |
| Bayan          | 6587,66                     | Surplus     |
| Kutoarjo       | 5788,31                     | Surplus     |
| Butuh          | 13050,50                    | Surplus     |
| Pituruh        | 10766,60                    | Surplus     |
| Kemiri         | 3287,94                     | Surplus     |
| Bruno          | 2421,64                     | Surplus     |
| Gebang         | 3862,58                     | Surplus     |
| Loano          | 3824,97                     | Surplus     |
| Bener          | 3384,39                     | Surplus     |
| Total          | 112768,62                   | Surplus     |
In 2018, there were 3 sub-districts that experienced rice deficit conditions, namely Bagelen, Kaligesing and Purworejo Sub-district. Purworejo Sub-district was the region with the highest deficit compared to the other two districts. This is influenced by an imbalance between the needs and availability of rice. However, this imbalance can be overcome through policy by distributing rice from surplus sub-districts to deficit sub-districts. The condition of the surplus in each sub-district is different, so it is classified to find areas that have large surpluses and able to distribute the rice. Following is the distribution of rice surplus/deficit per district in Purworejo District in 2018 (Fig. 8).

![Food Surplus-Deficit Map of Purworejo District in 2018](image)

**Figure 8.** Food Surplus-Deficit of Purworejo District in 2018.

Classification is based on the percentage of rice surplus to the total amount of surplus in Purworejo District. Ngombol sub-district is the only sub-district which belongs to the "high surplus" class, while there are 5 sub-districts with the "medium surplus" class and 7 sub-districts including the "low surplus" class. Ngombol sub-district can be used as one of the candidates in meeting the needs of rice in the deficit sub-district.

Food sufficiency projections in 2030 are also calculated to anticipate future conditions. Based on the projected needs and availability in 2030, there was no change in the region of rice deficit in 2018 until 2030, but the amount of rice deficit (tons/year) increased (Table 4). The increase in the amount of rice deficit is inversely proportional to the total rice surplus in Purworejo District. The total surplus in Purworejo District decreased from 2020 to 2030. This was indicated by the increase in the amount of rice needed in regions that experienced deficits, which were higher (such as Purworejo and Kutoarjo Sub-districts) than the amount of increased rice availability in areas experiencing surpluses (such as Ngombol Sub-district). Decreasing the total amount of surplus in the district, still able to meet the needs and achieve conditions of food sufficiency in the sub-district through the distribution of surplus areas to deficit areas, but this needs to be anticipated through the program and policy making by the government for further projections.
| Sub-district | Rice Sufficiency in 2020 (ton/year) | Description | Rice Sufficiency in 2025 (ton/year) | Description | Rice Sufficiency in 2030 (ton/year) | Description |
|--------------|-----------------------------------|-------------|------------------------------------|-------------|------------------------------------|-------------|
| Grabag       | 13682.23                          | Surplus     | 14834.31                           | Surplus     | 16066.11                           | Surplus     |
| Ngombol      | 23650.25                          | Surplus     | 26544.14                           | Surplus     | 29756.28                           | Surplus     |
| Purwodadi    | 14435.77                          | Surplus     | 14731.82                           | Surplus     | 15033.85                           | Surplus     |
| Bagelen      | -633.72                           | Deficit     | -1021.34                           | Deficit     | -1368.82                           | Deficit     |
| Kaligesing   | -2602.91                          | Deficit     | -2773.64                           | Deficit     | -2928.50                           | Deficit     |
| Purworejo    | -1778.32                          | Deficit     | -3149.68                           | Deficit     | -4336.82                           | Deficit     |
| Banyuurip    | 13836.38                          | Surplus     | 13866.20                           | Surplus     | 13895.44                           | Surplus     |
| Bayan        | 6529.78                           | Surplus     | 6384.40                            | Surplus     | 6238.03                            | Surplus     |
| Kutoarjo     | 5821.14                           | Surplus     | 5904.05                            | Surplus     | 5988.12                            | Surplus     |
| Butuh        | 13060.50                          | Surplus     | 13085.09                           | Surplus     | 13109.09                           | Surplus     |
| Pituruh      | 10806.13                          | Surplus     | 10905.50                           | Surplus     | 11005.63                           | Surplus     |
| Kemiri       | 3395.83                           | Surplus     | 3674.59                            | Surplus     | 3966.67                            | Surplus     |
| Bruno        | 1984.22                           | Surplus     | 983.69                             | Surplus     | 101.99                             | Surplus     |
| Gebang       | 3346.79                           | Surplus     | 2174.88                            | Surplus     | 1152.23                            | Surplus     |
| Loano        | 4063.75                           | Surplus     | 4699.40                            | Surplus     | 5394.20                            | Surplus     |
| Bener        | 3377.76                           | Surplus     | 3360.61                            | Surplus     | 3342.63                            | Surplus     |
| Total        | 112675.01                         | Surplus     | 112431.06                          | Surplus     | 112172.70                          | Surplus     |

4. Conclusion

The distribution of rice availability in Purworejo District from 2018 to 2030 has changed. The availability of total rice has increased by 1.27 percent, while the need for rice has increased by 3.78 percent from 2018. Spatially, there has been a change in the status of rice availability in several sub-districts, such as the addition of the number of sub-districts included in the low classification, namely Purworejo, Gebang and Bruno. The same is the case with availability, the need for rice has increased in number in all sub-districts. However, spatially, Purworejo Sub-district recorded as the district with the highest rice demand from 2018 to 2030.

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