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Analysis of the Potential of Rice and Corn in Supporting Food Availability

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A region's agricultural sector plays a strategic role in fulfilling its food needs with ideal nutrition. The potential of cereal commodities, specifically rice and corn, was identified based on the production level and competitiveness by district in Buleleng Regency, Indonesia. The regency's potential to provide and support food security was also determined through a quantitative descriptive analysis of the Location Quotient (LQ), Shift Share Analysis (SSA), Localization Coefficients, and Levels of Food Availability by utilizing secondary data on cereal commodity production and population numbers over the course of 10 yr (2012–2021). Results showed that Sawan, Seririt, and Sukasada districts were able to meet rice consumption needs through the availability of the crop as well as its production, the same potential for corn was exhibited in Gerokgak district. Also, in 2021, the shortage of cereal commodities due to low domestic production has been addressed through supplies from other regions such as Tabanan and Gianyar Regencies, or areas outside the province of Bali. Therefore, this study recommended that paddy fields be optimally utilized by increasing the planting index and choosing superior varieties to increase productivity. All stakeholders should continually support the efforts of paddy production in Buleleng Regency.

Keywords: cereal commodities, regional potential, food security, food availabi**lity**

INTRODUCTION

The continuous increase of the global population comes the challenge of providing food security, which consequently impacts the global economy (Codjoe et al. 2016; Liu 2018; Vidyarini et al. 2021). Food security is defined by four dimensions, such as food availability, access, utilization, and stability (Lawlis et al. 2017; Subramaniam et al. 2022). Food availability consists of three elements, namely production, allocation, and exchange (Mozumdar 2012). Food access is ensured when all households and all individuals within those households have sufficient resources to obtain appropriate foods through production, purchase, or donation. Adequate utilization refers to the ability of the human body to ingest and metabolize food (Gross et al. 2000) and is an essential element related to dietary value, social value, and safety (Mozumdar 2012). Stability refers to the temporal determinant of food and nutrition security and affects all three physical elements (Gross et al. 2000). Every dimension of food security, namely food availability, accessibility, utilization, and stability, can be improved with better logistics (Subramaniam et al. 2022). The principal capital in realizing food availability is the wealth of various resources, the availability of technology, and the development of strategic partnerships with various stakeholder components (Godfray and Garnett 2014).

Food diversity has been used to ensure food security (Martin and Molin 2019) and may be done by mapping the potential for food in each region (Sumantra and Martiningsih 2022). Regional agriculture plays a strategic role in meeting food needs with ideal nutrition (Martin and Molin 2019; Vidyarini et al. 2021) besides its significance in environmental, economic, and social aspects (Bisaga et al. 2019). Agricultural progress makes an essential contribution to food security, liveability, food adequacy and nutrition, improvement of health status, national security and defense stability, and the quality of human resources in the present and future (Dumasari 2020).

Approaches to enhancing food resilience show progression from more ecologically-based methods at small scales to more socially-based interventions at larger scales (Bullock et al. 2017). At the field scale, approaches include, a) development of conservation and rehabilitation of agricultural land (Auliyani 2020; Sumantra and Martiningsih 2022); b) preservation of water resources and management of irrigation water (Sumantra et al. 2023); c) development and provision of superior seeds and increased productivity through genetic improvement (Yadav et al. 2015); d) improved cultivation technology (Saiz-Rubio and Rovira-Mas 2020); and e) increased efficiency of post-harvest handling and processing (Kumar and Kalita 2017). At regional to global scales, resilient food systems will be achieved by coordination and implementation of resilience approaches among farms, advice to farmers, and targeted research (Bullock et al. 2017). Other strategies include food price stability and provision of government rice reserves as well as cooperation with government and private business entities in providing other food buffer reserves to be utilized in the event of a supply shortage or price fluctuations (Sumantra 2021). More recently, inter-governmental processes have emphasized the importance of sustainability for conserving the environment, natural resources, and agro-ecosystems (Sumantra and Wijaya 2021).

Indonesia's Badan Pusat Statistik (Central Bureau of Statistics for Buleleng 2022) reported that the total area of Buleleng Regency was 1365.88 km^2, or 24.25% of the total area of Bali Province. Additionally, the population of Buleleng Regency in 2021 was 806 830 people, with a positive population growth rate of 2.51% per yr. The Gross Regional Domestic Product (GRDP) value of Buleleng Regency at current prices in 2021 reached 33.34 trillion rupiahs. It was found that this value reached 15.17% of the total GRDP value of Bali Province. Nominally, the GDP value of Buleleng Regency has increased by 31.12 billion rupiahs (Rp) from the GRDP value based on current prices for Buleleng Regency in 2020, with a value of 33.31 trillion rupiahs (Rp). The increase in GRDP was influenced by increased production in many business fields and inflation. The contribution of agriculture, forestry, and fisheries to GRDP in 2021 increased compared to 2017 which resulted from an increase in production value in 2021 due to post-pandemic economic recovery. This increase was driven by horticultural crops, annual plantations, and fisheries, which roles were predicted to increase in 2021, while the contribution of food crops continued to decrease due to the decrease in the area of agricultural land and the slow increase in prices for food crop products.

Cereal commodities are the main food crops produced in Buleleng Regency. Over the last ten years, the production of cereal commodities has fluctuated and tended to decrease due to land conversion—especially paddy fields, due to their use for tourism facilities (Sumantra et al. 2020). From 2012 to 2021, there was a decrease in paddy field. There has been a decrease in paddy fields from 2012 to 2021, worth 2021.70 ha. The need for food consumption, especially cereal commodities, which are the staple food of the people, continues to increase due to high population growth. In 2021, the normative need for cereal commodities will reach 85 089.48 tons.

The consumption value used refers to the 2018 National Food and Nutrition Widyakarya standard, which is the ideal value consumed. Moreover, cereal commodities were marketed within the regency. Therefore, the normative need for cereal commodities in 2020 is 83 524.01 tons, resulting in an increase in demand in line with the increase in population to 85 089.48 tons. This study aimed to identify the potential of cereal commodities based on the production basis and competitiveness per sub-district, as well as analyzed the level of availability in supporting food security in Buleleng Regency.

MATERIALS AND METHODS

This study adopted a descriptive research design; Buleleng Regency in Bali Province, Indonesia has the most significant area and largest population, hence the selection of the district as the study area. Data were collected from field study and direct observation, and were described with the aid of figures and tables. Secondary data on population and production value of cereal commodities from 2012 to 2021 were obtained from the Agriculture Office and the Central Bureau of Statistics of Buleleng Regency.

Analysis of Location Quotient (LQ)

The Location Quotient is a metric used to measure the relative concentration or specialization of economic activity in an area which can be a cluster, city, region, or province (Niyimbanira 2018). LQ analysis is an indirect approach to determine whether a sector is a base or non-base sector. This analysis compares the ability of a region to produce a commodity with other regions that produce the same commodity (Rustiadi 2011). The data used in the LQ analysis are district cereal commodity production data in Buleleng Regency with the following formula:

$$LQ = (Si/S)/(Ni/N)$$

where LQ = The magnitude of the location coefficient of food commodities; Si = Total (production) of commodity i

in each district; *S* = Total (total production) of food at the district level; *Ni* = Total production of commodity i at the district level; and *N* = The total production of food commodities at the district level.

LQ figures indicated that LQ > 1 showed that the commodities included were essential having a comparative advantage, LQ < 1 indicated that these commodities included were non-base, and LQ = 1, indicated that these commodities can only meet the needs of the region itself.

Shift Share Analysis (SSA)

The national growth effect describes how much district industrial growth is accounted for by the overall economic health of the district as well as the overall growth or decline impacting the local industry (Leigh and Blakely 2017). Shift Share Analysis (SSA) is a quantitative technique commonly used to analyze regional economic structure changes relative to higher administrative areas' economic structure as a comparison or reference. Shift share analysis consists of three components: regional growth, proportional shift, and differential shift. The relationship between the three components is formulated according to Rustiadi (2011) as follows:

$$SSA = \underbrace{\left(\frac{X..(t1)}{X..(t0)} - 1\right)}_{a} + \underbrace{\left(\frac{X.j(t1)}{X.j(t0)} - \frac{X..(t1)}{X..(t0)}\right)}_{b} + \underbrace{\left(\frac{Xij(t1)}{Xij(t0)} - \frac{X.j(t1)}{X.j(t0)}\right)}_{c}$$

where a = shares component; b = proportional shift component; c = differential shift components; *X..* = The total activity value of harvested area/planted area/ commodity production in the total area; *X.j* = The total activity value of harvested area/planted area/commodity production in the total area; *Xij* = The activity value of a specific harvested area/planted area/production in a specific unit area; *t*1 = final yr point; and *t*0 = starting yr point.

A positive net shift value indicates progressive commodity production growth, whereas a negative net shift value indicates slow growth.

Cereal Commodity Localization Analysis

The level of distribution of cereal commodities in Buleleng Regency can be seen from the considerable value of the localization coefficient. The basic principle of localization coefficient analysis (α) is a value that gives an idea of whether an economic sector or economic activity is localized in a specific area or spreads over several regions. According to Mamondol (2014), the formulation of the localization coefficient (α) is as follows:

$$\alpha = \sum_{i=1}^{j} abs\left(\left(\frac{Si}{Ni}\right) - \left(\frac{S}{N}\right)\right)$$

where α = localization coefficient is positive, *Si* = total (production) of commodity *i* in each district, *S* = total number (production) of food commodities at the district level, *Ni* = total (production) of commodity *i* at the district level, and *N* = the total number (production) of district food commodities.

The number α indicates that $\alpha \geq 1$ is the location of concentrated food activities, $\alpha < 1$ is the location of food distribution activities.

Analysis of Food Availability Levels

The level of food availability is calculated based on the ratio of normative consumption to the net production of cereal commodities. Net production is approximated from production figures after deducting waste used for seeds and feed. Calculation of the net food production using the formula:

$$P\text{Net} = P - P\ (s + f + w)$$

where *P*Net = net production, *P* = actual production, *s* = seed conversion value, *f* = feed conversion value, and *w* = scattered conversion value.

The ratio of normative consumption to food availability based on net production value shows the level of food adequacy. The ability to provide pagan materials is determined according to Kurniawan (2015) based on the following formula:

$$Iav = F/Cnorm$$

$$F = P/(Tpop \times 365)$$

where *Iav* = food availability ratio; *Cnorm* = Normative consumption of cereals (289 gr/capita/d); *F* = Availability of cereal food (gr/capita/d); *P* = Production of rice/maise cereals (g); and *Tpop* = Number of Population (person).

Food adequacy status based on the ratio of normative consumption per capita to food availability can be seen in Table 1.

Joint Analysis (Superimposed) of Regional Potential and Level of Food Availability

Analysis using a spatial approach for regional potential and the level of food availability was carried out through an overlay and spatial join process assisted by ArcGIS 10.8 Software. Combined analysis through the overlay of LQ, SSA, and food availability levels can describe the potential of the region and the level of food availability in supporting food security in Buleleng Regency.

Table 1. Food adequacy status based on normative consumption ratio to cereal food availability.

Indicator	Range	Qualification
The ratio of normative consumption per capita to the availability of cereal food	≥ 1.5	High Surplus
	1.25 – 1.50	Moderate Surplus
	1.00 – 1.25	Low Surplus
	0.75 – 1.00	Low Deficit
	0.50 – 0.75	Moderate Deficit
	< 0.50	High Deficit

Source: Food Security Council, World Food Program 2009.

RESULTS AND DISCUSSION

Area-Based Potential of Cereal Commodity Production in Buleleng Regency

Cereal commodities have a comparative advantage at certain district levels because the share of production at the district level is higher than at the district level. Hence, the LQ coefficient was > 1. On the other hand, cereal commodities that do not have a comparative advantage in certain districts caused by share production were lower than the district level. This refers to the calculation of the LQ value which is a division between share sub-district production of share district production. The share of rice commodities in Buleleng Regency was 0.81, and the share of corn commodities was 0.19. The LQ value of cereal commodities for each district was described in Table 2.

The comparative advantage of cereal commodities shows that these commodities are produced through the dominance of the carrying capacity of natural resources (Akhmadi and Antara 2019). Based on the data in Table 2, the rice production base areas with rice LQ values of > 1 were Seririt, Busungbiu, Banjar, Sukasada, Buleleng, and Sawan Districts. In 2021, Sawan District had the largest paddy field are with 2218 ha, followed by Sukasada District with 1546 ha, Seririt with 1539 ha, Buleleng with 1537 ha, Banjar with 618.3 ha, Gerokgak with 542 ha, Busungbiu with 536 ha, and Kubutambahan with 481 ha.

Table 2. LQ value of cereal commodities in Buleleng Regency based on 2021 production values.

District	Rice (t)	Corn (t)	Total	LQ Rice	LQ Corn
Gerokgak	3322.45	20422.40	23744.85	0.17	4.69
Seririt	18730.61	351.80	19082.41	1.20	0.10
Busungbiu	7808.03	0.00	7808.03	1.22	0.00
Banjar	7437.35	154.30	7591.65	1.20	0.11
Sukasada	16356.89	608.70	16965.59	1.18	0.20
Buleleng	17848.09	80.10	17928.19	1.22	0.02
Sawan	27077.03	0.00	27077.03	1.22	0.00
Kubutamba-han	7823.44	1560.90	9384.34	1.02	0.91
Tejakula	0.00	2026.70	2026.70	0.00	5.45
Total	106403.89	25204.90	131608.79		

Source: Buleleng Regency Agriculture Office 2022.

The area that was unable to produce rice was Tejakula District because there was no paddy field. The corn production base areas with corn LQ values of > 1 were Gerokgak, Kubutambahan, and Tejakula Districts. The corn production base area was an area with dominant dry land.

Growth Potential of Cereal Commodity Production in Buleleng Regency

The production of cereal commodities in Buleleng Regency from 2012 to 2021 was fluctuating and tended to decrease (Fig. 1). The growth potential of cereal commodity production in Buleleng Regency is seen from the total growth value, proportional shift, and differential shift through production comparisons in 2021 and 2012.

The total growth of cereal commodity production in Buleleng Regency tended to decrease with a negative Regional Growth Rate value of -0.17, showing that the production of cereal commodities in Buleleng Regency in 2021 was less than in 2012. The decline in the production of cereal commodities occurred in almost every district, especially rice-producing districts. The proportional shift for the rice commodity had a negative value of -0.03, indicating that rice production decreased in 2021 compared to production in 2012. The decline in the value of rice production was affected by the conversion of paddy fields (Sumantra et al. 2020). The conversion of paddy fields was marked by a decrease in the area of paddy fields from 2012 to 2021 of 2021.7 ha. Reduced agricultural land area indirectly affects food availability (Sumantra et al. 2020; Sumantra and Martiningsih 2022), and dependence on food imports will increase (Primdahl et al. 2013). It is necessary to preserve agricultural land through social, cultural, environmental, and economic approaches to protect rice fields (Battisti et al. 2018) and increase the contribution of land use research by various divisions by adopting local wisdom (Liu et al. 2018). The protection of sustainable food agricultural land has been

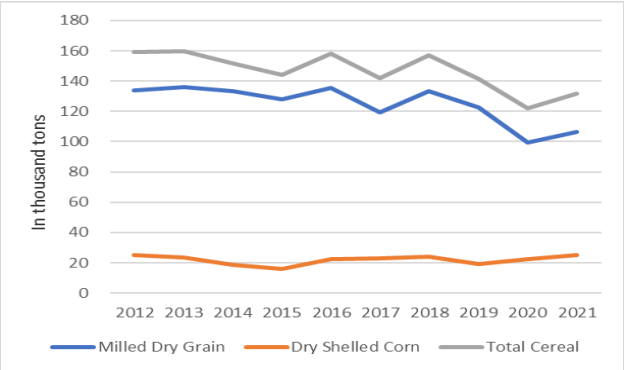

Fig. 1. Production of cereal commodities in Buleleng Regency in 2012-2021.

mandated by the Bali Regional Regulation Spatial Plan. However, there is still a need for its orderly and strict implementation (Norken et al. 2015; Sumantra and Martiningsih 2022).

Regional growth is positive for corn-producing areas such as Gerokgak and Tejakula Districts. The proportional shift for the corn commodity had a positive value of 0.18, indicating that corn production in Buleleng Regency increased from 2012 to 2021.

Differential shift or competitiveness of rice and corn commodities was compared from the district area to the regency area in 2021 and 2022. The differential shift's value shows the district area's competitiveness in producing the same commodity (Akhmadi and Antara 2019). Rice had a differential shift with a positive value in Gerokgak, Seririt, Buleleng, and Kubutabahan Districts, while corn had a differential shift with a positive value in Gerokgak and Tejakula Districts.

The value of the net shift in rice commodities was positive for Seririt, Buleleng, and Kubutambahan Districts, which indicated that the production of rice commodities in these districts was growing progressively (Table 3). The net shift value for rice commodities was negative in Busungbiu, Banjar, Sukasada, and Sawan Districts, which indicated that rice commodity production in these districts was growing slowly. The value of the net shift in the corn commodity was positive in the Gerokgak and Tejakula Districts, indicating that the corn commodity's production was experiencing progressive growth. The progressive growth of corn commodities occurs in corn-producing areas, showing that these regions can maintain the growth rate of corn production yearly.

Potential for Concentration of Cereal Commodity Production in Buleleng Regency

The level of agglomeration or concentration of rice and corn cereal commodity production can be seen through their localization coefficients. A localization coefficient value of more than or equal to one indicates that commodity cultivation is concentrated. In contrast, a localization coefficient value of less than one indicates that commodity production is spread between districts. Centralized or dispersed commodity production depends on infrastructure and available land that meets technical requirements (Manyamsari et al. 2019).

Table 3. Cereal commodity net shift value based on production value in 2012 and 2021.

No	District	Cereal Commodity Net Shift	
		Rice	Corn
1	Gerokgak	0.00 -	0.25 Progressive
2	Seririt	0.09 Progressive	- 0.49 Slow
3	Busungbiu	- 0.20 Slow	0.00 -
4	Banjar	- 0.04 Slow	- 0.18 Slow
5	Sukasada	- 0.06 Slow	0.18 Progressive
6	Buleleng	0.03 Progressive	- 0.15 Slow
7	Sawan	- 0.11 Slow	0.00 -
8	Kubutambahan	0.17 Progressive	- 0.31 Slow
9	Tejakula	0.00 -	0.50 Progressive

The concentration level of cereal commodities in Buleleng Regency can be seen from the value of the localization coefficient of rice and corn. The average value of the rice commodity localization coefficient was 0.25 ($\alpha < 1$), indicating that rice production is spread across several districts. The distribution of rice production follows the distribution of paddy fields in Buleleng Regency. Tejakula District does not have paddy fields, so there is no rice production in this district.

Corn commodity was produced in several districts, especially in Gerokgak District. The average localization coefficient for corn was 1.43 ($\alpha > 1$), indicating that corn production was concentrated in one area—Gerokgak District. The value of corn production in Gerokgak District was calculated to be more than 80% of the total corn production in the Buleleng Regency.

Regional Potential based on Joint Analysis (Superimposed)

Based on the LQ and SSA analyses, the potential of cereal commodity areas showed that there were 2 rice production base areas with progressive production growth—Seririt and Buleleng Districts, while the two corn production areas with progressive production growth were Geokgak and Tejakula Districts. Kubutambahan District was a corn production base area and a non-rice production base area, but corn production growth was slow, while rice production growth was progressive. This indicates that there was a shift in corn production to rice production in Kubutambahan District. Sukasada District was a rice production base area and a non-corn production base area, but rice production growth was slow, while corn production growth was progressive. This indicated a shift in rice production to corn production in Sukasada District (Fig. 2).

Level of Food Availability in Buleleng Regency

The level of food availability for cereal commodities was measured by calculating the ratio of availability to the normative consumption value of cereal commodities. According to Hanafie (2010), normative consumption is the level of consumption of nutrients that should be fulfilled to live a healthy, active, and productive life. The normative consumption value of cereal commodities based on the XI National Conference on Food and Nutrition (2018) is 289 g/d. The value of the ratio of food

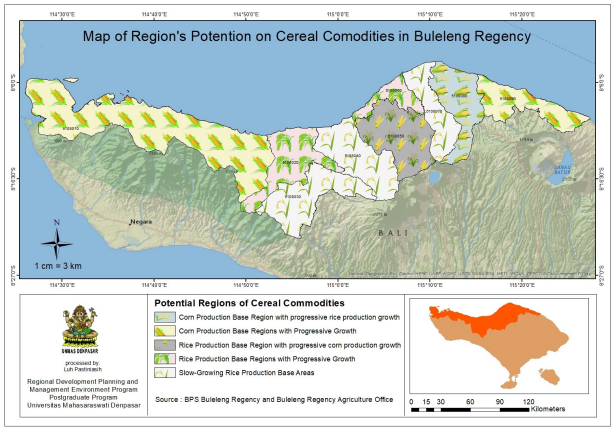

Fig. 2. Map of potential cereal commodity areas in Buleleng Regency.

availability > 1 indicates that the area was a surplus of cereal food. Conversely, if the value of the availability ratio was < 1, then the area was a deficit of cereal food (Table 4).

The level of food availability for cereal commodities as a staple food decreased yearly. Buleleng Regency experienced a surplus of cereal commodities from 2012 to 2019, but its value continued to decline. In 2020 and 2021, Buleleng Regency was predicted to experience a low deficit for the cereal commodity. This was because of the production of cereal commodities, especially rice, which tends to decrease in production fluctuations. In addition, consumption needs increased due to a surge in population in 2020 with a population growth rate of 2.33%. Partially, the value of rice production in 2020 and 2021 was predicted to be unable to meet the normative consumption needs of the population, with rice sufficiency levels of 0.70 and 0.73, respectively. Rice production tended to decrease with reduced paddy field area due to the conversion to non-paddy fields. This can be seen from the reduction in paddy fields from 2012 to 2021—11039 ha to 9017.3 ha. The same observations could be made for years 2020 and 2021 (Fig. 3). Control over changes in land use needs to be addressed in addition to controlling population numbers and increasing production through the application of modern agricultural technology. This is in line with the observations of Crist et al. (2017) who noted that the population and its growth rate contribute significantly to the ability of the land to produce food and maintain biodiversity.

The level of availability of cereal commodities in Gerokgak and Sawan Districts was found to be in a high surplus condition. Food availability in Gerokgak District is supported by high net production of dry-shelled corn at 17992 t, making this district the center and production base for corn commodities due to its progressive production growth. Sawan District, on the other hand, had the highest rice production area in Buleleng Regency at 15810 t, however, production growth in this area was observed to be slow.

Seririt and Sukasada Districts were in a low surplus condition due to the level of food availability. The production of rice and dry-shelled corn supports food availability in these districts, which were also considered rice production base areas with relatively high rice production values of over ten thousand tons, however, production growth was slow. It can be a threat because of the possibility of reduced rice production in the coming year, with impact to the food availability level for cereal commodities.

The level of availability of cereal commodities in the other five districts were, 1) Busungbiu and Kubutambahan districts were in a low deficit, 2) Buleleng District was in a moderate deficit, and 3) Banjar and Tejakula districts were in a high deficit. The deficit condition indicates that the production of cereal commodities in the region is unable to meet the normative consumption needs of the population. Buleleng district had a relatively high rice production value of 10422 t. However, it cannot meet the population's normative consumption needs due to the

Table 4. Level of food availability in Buleleng Regency based on normative consumption.

Year	Total Population	Net Rice Production (tons)	Iav Rice	Net Corn Production (tons)	Iav Corn	Iav Total Cereal	Status
2012	634300	78260	1.17	21973	0.33	1.50	Moderate Surplus
2013	638300	79577	1.18	20726	0.31	1.49	Moderate Surplus
2014	642300	77916	1.15	16207	0.24	1.39	Moderate Surplus
2015	646200	74861	1.10	13963	0.20	1.30	Moderate Surplus
2016	649200	78984	1.15	19982	0.29	1.45	Moderate Surplus
2017	653310	69583	1.01	20283	0.29	1.30	Moderate Surplus
2018	657110	77875	1.08	20966	0.30	1.38	Moderate Surplus
2019	660600	71452	1.03	16867	0.24	1.27	Moderate Surplus
2020	791810	58074	0.70	19694	0.24	0.93	Low Deficit
2021	806650	62129	0.73	22206	0.26	0.99	Low Deficit

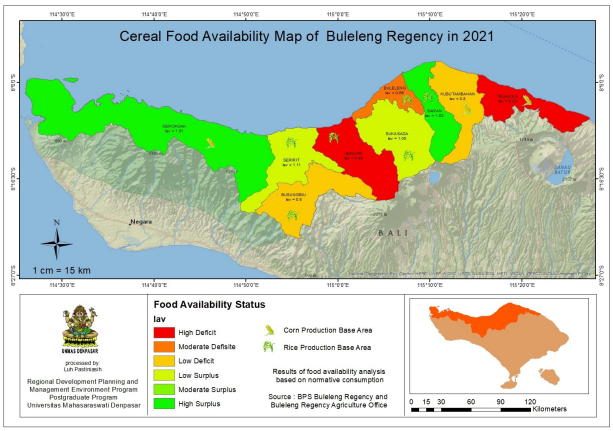

Fig. 3. Map of the level of availability of cereal commodities in Buleleng Regency in 2021.

high population in the district. Buleleng District had the densest population reaching 3233 people/km^2. This is because many migrants live in the Singaraja City, the district capital of Buleleng.

In 2021, the availability of cereal commodities, especially rice sourced from domestic production, was able to meet the consumption needs of the population in Buleleng Regency. The net production of rice for food in 2021 was 62129 t, while the need for rice consumption was 85089 t, resulting in a shortage of rice commodities of 22960 t. The shortage in rice availability was met with supplies from other areas, such as Tabanan and Gianyar Regencies or areas outside the Province of Bali. Tabanan and Giayar Regencies are rice production base areas with increasing regional growth (Akhmadi and Antara 2019). The Province of Bali is close to the Provinces of East Java and West Nusa Tenggara (NTB), which are connected by sea transportation, causing smooth trade traffic for various types of products, including food products (Antara and Sumarniasih 2020).

CONCLUSION

The six districts of Buleleng Regency, Indonesia, Buleleng and Seririt were found to have higher competitiveness and more progressive rice production growth, while for the corn production growth, Gerokgak, Kubudindingan, and Tejakula have a higher competitiveness and were more progressive. The level of availability of cereal commodities in Buleleng Regency was predicted to be deficit in 2021, and supplies may come from other areas such as Tabanan and Gianyar Regencies, or areas outside Bali Province, to meet Buleleng Regency's normative consumption needs. Additionally, based on the regional mapping of rice availability, the value of the net shift in rice was positive in Seririt, Buleleng, and Kubutambahan, while the same value was negative in Busungbiu, Banjar, Sukasada, and Sawan. For corn, the net shift value was positive in Gerokgak and Tejakula. These results implied that the utilization of available paddy fields must be optimized by increasing the planting index and choosing superior varieties to increase productivity. All stakeholders should also continually support the efforts of paddy production in Buleleng Regency.

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